

Vaccine education and promotion

Edited by

Graça S. Carvalho and Carlos Alberto De Oliveira Magalhães Júnior

Published in

Frontiers in Public Health



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ISSN 1664-8714
ISBN 978-2-8325-6337-3
DOI 10.3389/978-2-8325-6337-3

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Vaccine education and promotion

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Citation

Carvalho, G. S., Júnior, C. A. D. O. M., eds. (2025). *Vaccine education and promotion*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-6337-3

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OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 13 April 2025
ACCEPTED 14 April 2025
PUBLISHED 29 April 2025

CITATION
Carvalho GS and Júnior CAdOM (2025)
Editorial: Vaccine education and promotion.
Front. Public Health 13:1610968.
doi: 10.3389/fpubh.2025.1610968

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Editorial: Vaccine education and promotion

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KEYWORDS

determinants of vaccination, vaccination hesitancy, vaccination among students, health education, health promotion

Editorial on the Research Topic Vaccine education and promotion

This editorial highlights key developments in the Public Health Research Topic “Vaccine education and promotion.” This critical area aims to inform and encourage vaccination by providing accurate scientific information and implementing effective vaccination programs, emphasizing their benefits, safety, and role in preventing infectious diseases. A total of 39 manuscripts were submitted for consideration. Following a rigorous peer-review process and revisions based on expert feedback, 29 (74.3%) were accepted for publication. Among these, 14 explore the determinants of vaccination, eight examine vaccine hesitancy and seven address vaccination among students.

1 Determinants of vaccination

The determinants of vaccination are diverse but can be broadly categorized into three groups (1): (i) Contextual factors, including historical, socio-cultural, environmental, health system/institutional, economic, and political influences; (ii) Individual and group influences, such as perceptions of vaccines and the impact of social or peer environments; (iii) Vaccine- and vaccination-specific Research Topic, factors directly related to the vaccine or the act of vaccination itself. Vaccination uptake also varies across risk populations, with distinct determinants potentially influencing behavior in each group (2). As such, a thorough understanding of these factors is essential for designing targeted interventions to improve immunization coverage (3). The 13 papers included in this section, *Determinants of Vaccination*, are organized across three Research Topic:

1.1 Seven papers look at communication and engagement for vaccination

[Chang et al.](#) compared USA public vaccination decisions for newly-developed and established vaccines, and recognized the need for clear communication and community engagement as critical strategies for addressing public concerns and misinformation;

Rahman et al. looked at the perceptions of Nigerian persons with disabilities regarding the COVID-19 pandemic and the vaccine and identified the need for culturally and religiously sensitive communication strategies, and tailored educational programs by social workers; Xu et al. analyzed “vaccine science popularization” in the Chinese social media Weibo during the COVID-19 pandemic where publishers were divided into individuals, organizations, media, government, and scientists, and verified that Weibo scientists’ arguments were those that more positively influenced the effect of vaccine popularization; Hijazi et al. identified the Israeli Ministry of Health communication strategies regarding vaccines during COVID-19 pandemic and how healthcare workers shaped their professional socialization processes within the health system, leading to a reliance on established communication strategies and informational channels; Shumba et al. analyzed community health volunteers experiences of implementing COVID-19 *Vaccine education and promotion* in Kenya during the pandemic, showing they contributed to the high uptake of primary vaccines and boosters; Wrenger et al. used a protocol (INFORMed) in Germany to identify the wish for advice in hesitant and no-hesitant new-born’s parents and the comparison of parents in terms of their respective information needs; and Smith et al. addressed a community engagement framework that can provide a roadmap to navigate the dynamic and multifaceted nature of equity-related work by paving the way for meaningful interventions to mitigate health disparities.

1.2 Four papers look at socioeconomic discrepancy

Tao et al. found substantial racial and socioeconomic disparities in influenza vaccination uptake among United States adults aged 65 years or older; Zhao et al. investigated the extent of influenza vaccine coverage in south China adults aged 60 years or older and identified the factors influencing vaccine uptake; Ramphul et al. identified areas in Texas, USA, with high and low HPV vaccination rates and explored differences in neighborhood characteristics, showing that vaccination coverage rates depend on the community’s income level; and Ye and Ting Su explored the factors related to public health campaigns, in Wuxi region of China, that can improve vaccination rates in low socioeconomic groups and rural areas, to contributing to better public health strategies.

1.3 Three papers look at children’s immunization

Alami et al. analyzed the Canadian survey about parents/guardians’ perspectives on influenza immunization and identified the main factors influencing low rates of children’s vaccination, such as residing in rural areas, lower parental education and lower household income; Dires et al. looked at the factors influencing childhood immunization status in East Africa, which varied among countries and regions, and found that mothers attending antenatal care played a key role in children’s vaccination; and Assefa et al. evaluated the determinants of pneumonia conjugate vaccine (PCV) dropout among children

aged 12–23 months in Ethiopia and identified the significant factors influencing PCV dropout, such as having a health card, having received the PCV 2 vaccinations, and region.

2 Vaccination hesitancy

Vaccine hesitancy refers to the delay in acceptance or outright refusal of vaccines despite the availability of vaccination services; it is a complex and context-specific phenomenon that varies across time, location, and type of vaccine (4). It has been linked to declining vaccination coverage and a heightened risk of outbreaks and epidemics of vaccine-preventable diseases (5). The eight papers in the *Vaccination Hesitancy* section are distributed across two Research Topic:

2.1 Five papers address vaccination hesitancy in the community

Osaghae et al. leveraged long-standing community-academic partnerships in two cities to develop a curriculum for interventions to decrease COVID-19 vaccine hesitancy within Black communities in the USA; Muis et al. examined the effectiveness of three different messages for persuading Canadian individuals to get vaccinated against COVID-19, and the role that emotions play in persuasion, verifying that emotions mediated relations between vaccine confidence/hesitancy and willingness; Pauly et al. identified COVID-19 vaccine hesitant groups from adolescence to late adulthood and explored their motivations for and against vaccination in a nationwide Luxembourgish population, being the vaccination hesitancy higher in the younger age groups; Zilver et al. studied barriers and facilitators for Netherlander pregnant women’s choice and motivation regarding vaccination against COVID-19 during pregnancy, verifying that they needed clear, unambiguous information concerning health consequences, particularly for their offspring; and Wang et al. conducted a qualitative survey using Vaccine Hesitancy Determinants Matrix and 5C model to understand and improve Herpes zoster vaccination rates among middle-aged and older adults in China.

2.2 Three papers address parents’ vaccination hesitancy

Low et al. investigated parents’ vaccine hesitancy rates in Malaysia and Singapore, and explored whether these rates were associated with parents’ health beliefs, having found that the prevalence of perceived parental vaccine hesitancy was higher in Malaysia; Handayani et al. conducted a study in Indonesia aiming to develop guidance for in-depth interviews for a future qualitative study based on a cross-sectional quantitative study of parents with school-age children and found a significant association between parents’ intention to vaccinate their children and the perceived benefits and perceived barriers to vaccination; and Suragh et al. conducted a study on vaccine hesitancy among USA white parents with higher education and socioeconomic

statuses, showing they had reliance on information from specialized doctors and scientists, distrust in public health authorities, high risk perception of COVID-19 vaccines, and low risk-perception of COVID-19 disease.

3 Vaccination among students

Vaccination among students is a critical public health concern, as this population often lives, studies, and socializes in close contact, increasing the risk of infectious disease transmission (6). Students may face unique barriers to vaccination, including lack of awareness, limited access to healthcare services, or misconceptions about vaccine safety and necessity (7). Understanding the specific drivers and challenges of vaccination in student populations is essential for developing effective strategies to improve uptake and prevent outbreaks in educational settings (6). The seven papers in the *Vaccination Among Students* section are distributed across two Research Topic:

3.1 Four papers address students' perceptions about vaccination

Simonovic et al. compared USA and Israeli college students' vaccine attitudes, emotions, and behavior, having found that Israeli (vs. American) participants reported higher perceived ambiguity, worry, fear, and anger, and lower perceived severity; Song et al. explored the circumstances of college students in China's ethnic minority regions concerning their awareness, attitudes, and practices related to the HPV vaccine, aiming to provide a scientific basis for future health education and HPV vaccine promotion; Li et al. investigated the awareness of HPV and its vaccine among college students in Zhengzhou (China), and to explored the factors influencing their awareness of HPV vaccine, to understand college students' willingness to receive the vaccine; and Schlopsna and Scheersoi conducted a study involving interviews with Germany secondary school students, experienced educators, and vaccination experts, showing focal areas of students' interest in the topic and the value of involving students in lesson planning.

3.2 Three papers address school teaching on vaccination

Gaspi et al. identified and analyzed Brazilian primary school children's social representations of vaccination, showing the need to prevent children's fear of needles at the first vaccination experience and the importance of discussing the subject of vaccination in science teaching; Kwella et al. conducted a study in German school biology classes to enable students to engage in an in-depth examination of the vaccination complex socio-scientific issue

and promoted enhancement of their argumentation and decision-making skills; and Martínez-Pena et al. presented a design on vaccination for secondary education teaching, in Spain, to develop students' integral understanding of vaccines role and to apply critical ignorance as part of criticality to avoid vaccine hesitancy and raise trust in science.

The research presented in these 29 papers published in the Public Health Research Topic "*Vaccine education and promotion*" came from 15 countries of the various continents, demonstrating how live and pertinent is this field of research worldwide, presenting different approaches and perspectives that enrich this large, contemporary and relevant research field, which is still open to wide-ranging and diverse future research.

Author contributions

GC: Conceptualization, Data curation, Supervision, Validation, Writing – original draft, Writing – review & editing. CJ: Conceptualization, Validation, Writing – review & editing, Data curation.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was financially supported by the Research Unit UID/317 (Research Centre on Child Studies of the University of Minho, CIEC) of the Portuguese Foundation for Science and Technology (FCT) and by Brazilian CNPq (Process 447784/2014-5) and CAPES.

Conflict of interest

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The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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OPEN ACCESS

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RECEIVED 07 February 2024

ACCEPTED 16 April 2024

PUBLISHED 02 May 2024

CITATION

Muis KR, Kendeou P, Kohatsu M and
Wang S (2024) “Let’s get back to normal”:
emotions mediate the effects of persuasive
messages on willingness to vaccinate for
COVID-19.

Front. Public Health 12:1377973.

doi: 10.3389/fpubh.2024.1377973

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“Let’s get back to normal”: emotions mediate the effects of persuasive messages on willingness to vaccinate for COVID-19

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Objective: We examined the effectiveness of three different messages for persuading individuals to get vaccinated against COVID-19, and the role that emotions play in persuasion.

Methods: Four hundred-thirty-six participants reported their concern about the COVID-19 pandemic and confidence/hesitancy toward vaccines. Participants were randomly assigned to one of three text conditions: (1) self-interest: a persuasive message that focused on how much of a “serious threat COVID-19 is to you,” and to get vaccinated to “protect yourself”; (2) self-interest + altruistic: a persuasive message that focused on the “threat to you and your community” and to get vaccinated to “protect you and your loved ones”; (3) self-interest + altruistic + normal: a persuasive message that included (2) but added “This is the only way we can get back to a normal life.”; and, (4) a baseline control: no text. After reading, participants reported their emotions toward COVID-19 vaccines and their willingness to get vaccinated.

Results: Individuals in the self-interest + altruistic + normal condition were more willing to get vaccinated compared to the control condition and self-interest + altruistic condition. However, there were no differences in willingness between the self-interest + altruistic + normal condition and the self-interest condition. Moreover, emotions mediated relations between vaccine confidence/hesitancy and willingness.

Conclusion: A message that focuses on “getting back to normal” can achieve important public health action by increasing vaccine uptake to protect the population. Future work is needed across multiple countries and contexts (i.e., non-pandemic) to assess message effectiveness.

KEYWORDS

COVID-19 vaccine, vaccine hesitancy, persuasion, public education messaging, emotions

Introduction

At the start of the COVID-19 pandemic, governments worldwide implemented extreme social distancing and quarantine measures to protect the most vulnerable and to help manage healthcare service demand. The need for a vaccine to protect the world population from the deadly virus took center stage, and so too did the anti-vaccination movement (1). Vaccines are an ideal public health strategy to prevent disease but vaccine hesitancy has become problematic

due to numerous factors including complacency, inconvenience, lack of confidence, and mistrust in authorities (2). Vaccine hesitancy or resistance is defined as a position wherein an individual is uncertain about taking a vaccine or is completely against taking a vaccine, whereas vaccine acceptance is defined as the position wherein an individual accepts vaccines or actively demands them (3).

One method by which health authorities have attempted to combat vaccine hesitancy is through social persuasion (4). Social persuasion includes prompting, compelling, or inducing a change in people's beliefs, understanding, behaviors, attitudes, or reactions toward something (5). Research has shown that positive messages designed to increase perceived value, importance, and effectiveness for engaging in social measures are better at changing people's perceptions and prompting them to take action compared to neutral or negative messages (6, 7). Research has also shown how effective persuasive messages are in changing perceptions and behavioral intentions [e.g., (8, 9)]. Of particular relevance, in the context of COVID-19, research has shown that public education health messages that focus on both public and personal benefits ("protect yourself, protect others") are more effective than addressing personal benefits alone ("protect yourself") in increasing behavioral intentions like social distancing and wearing masks (10–12).

Indeed, several studies have been conducted to examine COVID-19 vaccine hesitancy in terms of worldwide rates of hesitancy, personal characteristics of hesitant individuals, and reasons for being hesitant [e.g., (3, 13–15)]. For example, drawing from large samples in Ireland and the United Kingdom (UK), Murphy et al. (3) found that 35 and 31%, respectively, of these samples were vaccine hesitant/resistant. For personal characteristics, they found that women and individuals in lower income brackets were more hesitant/resistant. For psychological variables, they found that vaccine hesitant/resistant individuals espoused a lower level of trust in health care professionals, scientists, and the government; had more negative attitudes toward immigrants, lower levels of altruism, stronger religious beliefs, were less agreeable, held higher levels of conspiratorial beliefs and higher internal locus of control. Finally, they found that individuals who were more hesitant/resistant were less likely to get information about COVID-19 from television, radio newspapers, and government agencies, but were more likely to obtain information from social media.

Head et al. (14) reported similar results with regards to vaccine intention whereby individuals who espoused liberal political views and altruistic beliefs had greater intentions to get vaccinated whereas individuals who were less educated were less likely to get vaccinated. Interestingly, intention to vaccinate significantly increased when individuals were told that health experts strongly recommended getting vaccinated against COVID-19. Although several studies have explored causal mechanisms for changing perceptions and behavioral intentions, relatively few have examined the role that emotions play in social persuasion, which is considered a key factor in social persuasion (6, 7, 16–18). Theoretically, it is essential to understand what factors facilitate or constrain social persuasion to ensure that messages are designed that effectively prompt individuals to get vaccinated. Accordingly, the purpose of this research was to explore the role of emotions on the effects of persuasive messages in increasing vaccine intentions specific to COVID-19 and to explore the effects of different kinds of messages on social persuasion more broadly.

Social persuasion

Governments and individuals have engaged in social influence through persuasion as a widespread civil means of social control (4). Persuasion uses reason and emotion to sway individuals to change their attitudes and behaviors (5). Theorists agree that individual characteristics (e.g., personal relevance, motivation) and message characteristics (e.g., source credibility, argument structure) play significant roles in persuasion (19, 20). Specifically, as Petty and Cacioppo (20) argued in their Elaboration Likelihood Model (ELM), it is imperative to engage individuals in deeper processing of the message for long-lasting change to occur (21). To promote deeper processing, researchers have developed persuasive messages (22), which are designed to challenge individuals' beliefs and provide them with new information. In the context of a COVID-19 vaccine, a persuasive message may be a text that challenges individuals' beliefs about the seriousness of the pandemic and the importance of getting vaccinated. Highly persuasive messages must provide ample evidence to support the arguments raised, come from credible sources like experts, use powerful language (23), and draw an emotional response from readers (22).

Messages that are more positive (8, 9, 24), include more factual information (8, 9, 25, 26), and refer to sources that are more credible are more likely to increase willingness to change behaviors, and actually change those behaviors, compared to messages that include a more negative tone, less factual information, and less credible sources. Additionally, evidence from research on disease prevention has shown that messages that target both self-interested (i.e., protect yourself) and altruistic (i.e., protect others) motivations are effective in motivating individuals to vaccinate (27, 28). Why might this be the case? Emotions may play a role in social persuasion.

The role of emotions in social persuasion

Emotions play an important role in individuals' learning, motivation, attitudes, and performance (29, 30). Emotions are defined as multifaceted phenomena that consist of affective, cognitive, motivational, physiological, and expressive components (31). For example, anxiety that an individual has about vaccines may consist of feelings of uneasiness (affective), worry about allergic reaction to a vaccine (cognitive), need to avoid vaccines (motivation), sweaty palms and increased heart rate (physiological), and tense facial expression [expressive; (32)]. Emotions can also be described according to their valence (positive versus negative), arousal (activating versus deactivating), and object focus (e.g., social emotions, topic emotions, epistemic emotions, achievement emotions).

Research has shown that positive emotions, like joy, may increase effortful processing of information (33) whereas negative emotions, like frustration, may reduce effortful processing of information given that negative emotions can draw attentional resources away from the task an individual may be engaged in (34). When it comes to processing of textual information specifically, Bohn-Gettler (35) proposed that emotions influence reading comprehension wherein positive emotions, like hope, result in an increase of assimilative processing, like elaboration, to integrate new information into existing knowledge structures. However, when individuals experience higher positive emotions, they may ignore information that is inconsistent

with their beliefs, which decreases the likelihood of individuals changing their beliefs when they are challenged (36, 37). This suggests that context needs to be taken into consideration as positive emotions do not always result in improved processing of information.

Moreover, when information is inconsistent with beliefs, this can trigger threat appraisals that prompt intense negative emotions like fear, anxiety, and anger (38). When this occurs, individuals may want to protect their beliefs and avoid negative emotions and, as such, ignore belief-inconsistent information. This may result in individuals learning less from those texts, if at all, particularly about controversial topics (36). However, negative emotions can also prompt accommodative processing (35). Specifically, information that is inconsistent with beliefs may trigger surprise (a neutral emotion) (39), followed by confusion, frustration, or anxiety (40). An individual may interpret these negative emotions as indicating that something is not quite right (40). When this occurs, individuals may engage in accommodation of belief structures or existing knowledge so that new information can be better incorporated.

In the context of COVID-19, researchers around the globe reported that individuals felt anger toward the lockdowns and removal of freedoms, and sadness about the number of people who died (41). Moreover, the World Health Organization (2) indicated that pandemic fatigue had become a major concern for adherence to the measures that were put in place to slow the spread of the virus. Given pandemic fatigue and the negative emotions associated with the pandemic, it may be necessary to create a persuasive message that addresses positive and negative emotions simultaneously so that individuals will process the information and change their beliefs about vaccines to protect themselves (self-interest) and others (altruistic). Moreover, to address pandemic fatigue, it may be the case that messages that focus on “getting back to normal” in addition to protecting oneself and others may be the most effective means by which to encourage individuals to engage in vaccine uptake. Arguably, if individuals can be persuaded that engaging in vaccine uptake will allow the world to get “back to normal,” this may increase joy, hope, and relief, and reduce anger.

To date, limited research has been done on the role of emotions in social persuasion (7), but some research has explored emotions in the context of the COVID-19 pandemic. To illustrate, Heffner et al. (42) examined positive versus negative emotions and willingness to engage in social isolation via a threatening (e.g., millions will die) or altruistic text (e.g., “save millions of lives”). They found that both texts increased willingness to isolate, but that the threatening text was highly arousing and moderately unpleasant whereas the altruistic text was moderately arousing and fairly pleasant. In another study, Pfattcheicher et al. (18) reported that empathy predicted willingness to engage in social distancing and wearing a face mask, which were key social distancing and protective measures against contracting COVID-19.

More research is needed to better understand whether and how emotions facilitate or constrain social persuasion and what types of messages are more effective than others in persuading individuals to get vaccinated. Fostering joy, hope, relief, and empathy and decreasing anger may be necessary to increase intentions to get vaccinated, particularly those who are vaccine hesitant or resistant. More importantly, individuals who are vaccine hesitant or resistant may need to be persuaded that vaccination is the only way to “get back to normal.” To date, although studies have been conducted to explore the

efficacy of persuasive messages to get vaccinated [see (43–45)], our insight on the role of emotionally-driven persuasive messages on vaccine hesitancy remains limited. As such, the goal of this research was to develop a powerful, credible message to persuade individuals to get vaccinated for COVID-19 by reducing negative emotions and increasing positive emotions to foster more elaborative processing of the message.

We developed three different persuasive messages to evaluate whether they differed in their effectiveness on social persuasion, whether there were differences in emotions about COVID-19 after reading these messages, and whether emotions mediated relations between vaccine confidence and hesitancy and willingness to get vaccinated. The first text focused on protecting oneself from COVID-19 (self-interest condition), the second text focused on protecting oneself and others (self-interest + altruistic condition), and the third text focused on protecting oneself, others, and getting back to normal (self-interest + altruistic + normal). Given that level of concern about the pandemic predicts willingness to engage in preventive measures (12), we included concern about the pandemic as a covariate, and included a control condition wherein no textual/persuasive information was provided. Our research questions were as follows: (1) Are there differences in willingness to get vaccinated as a function of text condition (i.e., self-interest; self-interest + altruistic; self-interest + altruistic + let’s get back to normal) and vaccine hesitancy? (2) Are there differences in reported emotions as a function of text condition and vaccine hesitancy? (3) What is the relation between vaccine hesitancy and confidence, emotions, and willingness to get vaccinated?

Based on previous theoretical and empirical work (4, 18, 20, 43–45), we hypothesized that individuals in the self-interest + altruistic + normal persuasive text condition would report the highest willingness to get vaccinated compared to individuals in the other three conditions, with the control condition reporting the lowest level of willingness to get vaccinated (Hypothesis 1). We also predicted that individuals in the other two text conditions (self-interest, and self-interest + altruistic) would be more willing to get vaccinated than the control group, with no differences between the two text conditions (Hypothesis 2). We further predicted that individuals who were vaccine confident would be more willing to get vaccinated than those who were vaccine hesitant/resistant (Hypothesis 3).

For emotions, we hypothesized that individuals in the self-interest + altruistic + normal condition would report the highest level of joy, hope, and relief, and the lowest level of anger compared to the other three groups, with the other two text conditions reporting less anger and more joy, hope, empathy, and relief than the control condition (Hypothesis 4). We also hypothesized that vaccine hesitant individuals would report lower levels of joy, hope, and relief, but higher levels of anger about the COVID-19 vaccine compared to individuals who were vaccine confident (Hypothesis 5). We further hypothesized that vaccine confidence would positively predict joy, hope, empathy, and relief and negatively predict anger, whereas vaccine hesitancy would positively predict anger and empathy but negatively predict joy, hope, and relief (Hypothesis 6). We also predicted that anger would negatively predict willingness to get vaccinated whereas joy, hope, relief, and empathy would positively predict willingness to get vaccinated (Hypothesis 7). Finally, we hypothesized that emotions would mediate relations between vaccine confidence and hesitancy

and willingness to get vaccinated (Hypothesis 8). The hypothesized model is presented in [Figure 1](#).

Method

Participants

We conducted a power analysis using G*Power [Version 3.1; (46)]. Given previous research on social persuasion and health behaviors [e.g., Jordan et al. (11)], we expected small to medium effect sizes. With alpha set at 0.05 and power set at 0.80, power analysis revealed a required total sample size of 341. One hundred sixty-three participants were then recruited across Canada on April 12, 2021, using Amazon’s Mechanical Turk (MTurk). Another 285 participants from Canada were sampled by using a snowball sampling technique through Facebook. These two platforms were used for recruitment to ensure a more representative sample of individuals given that MTurk workers tend to be better educated, younger, and not racially diverse (47), whereas Facebook users range in age, educational level, race, and remain bipartisan in their news channels and political affiliations (48).

Of the 163 participants sampled using MTurk, five failed both attention checks and were subsequently removed. Five completed the survey in less than one minute (e.g., 11 s) and were also subsequently removed from the sample, for a sample of 153 participants from MTurk. Of the 285 participants sampled through Facebook, all but two completed the survey and passed both attention checks. The combined samples resulted in a total sample of 436 ($n = 236$ female, 155 male, 3 non-binary, 42 chose not to report). However, of the entire sample of 436, 98 reported having already received at least one dose of one of the COVID-19 vaccines available in Canada. As such, these individuals were removed from analyses since they were already vaccinated and did not need to be persuaded and another 12 were removed as they had missing data. The final analytic sample was 325. The average age was 37.81 years (range 17 to 75; $SD = 14.11$), with 78.1% reporting English as their first language, 52% reporting

receiving a bachelor’s degree or higher, and 50% reporting a personal annual income of \$65,000 CAD per year or less (14% chose not to answer). Except for Nunavut/Northwest Territories and the Yukon, all other provinces were represented.

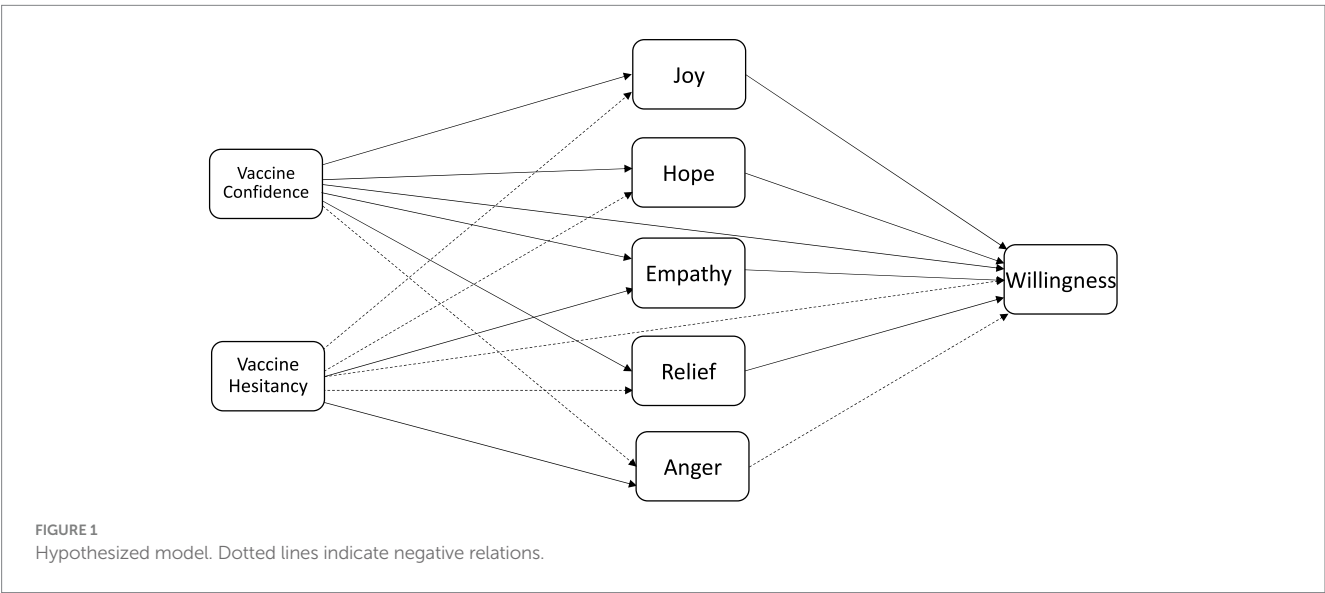
Materials

Concern about COVID-19

Seven self-report items were used to measure participants’ concern about the pandemic. Items were drawn from health-based research that assesses individuals’ perceived seriousness of an event; in this context, the negative consequences related to getting COVID (49). Previous research has shown that concern predicts the likelihood that individuals will take action to prevent illness or disease [see (50)]. Example items included, “How concerned are you at present about the coronavirus pandemic?” and “In terms of the pandemic, how concerned are you about your own physical health?” Participants rated each item on a 5-point Likert scale with anchors for each value: 1 “Not at all,” 2 “A little,” “Moderately,” “Very much,” and 5 “Extremely” concerned. Cronbach’s alpha reliability estimate was good at $\alpha = 0.73$.

Vaccine confidence and hesitancy

A sixteen-item self-report scale was used to measure participants’ confidence in vaccines and their hesitancy toward them. Items were drawn from a previously validated instrument (51). Nine items measured participants’ confidence in vaccines (e.g., “Vaccines are effective in preventing diseases”), and the remaining seven items measured participants’ hesitancy toward vaccines (e.g., “Vaccines have negative side effects that outweigh the benefits of vaccination”). Participants were instructed to rate the degree to which they agreed with each statement on vaccinations, using a rating scale from 1 “Strongly Disagree” to 5 “Strongly Agree,” with 3 “Neither Agree nor Disagree” as the middle option. Items for each subscale were summed and averaged, with higher scores reflecting more vaccine confidence for the one subscale, and more vaccine hesitancy for the other subscale. Reliability for each subscale was good; Cronbach’s alpha for



the vaccine confidence subscale was 0.86, and 0.73 for the vaccine hesitancy subscale.

Experimental texts

Three experimental texts were developed based on content from the Centers for Disease Control website on COVID-19 vaccinations.¹ Except for the personal message component, all features of the texts were identical (e.g., used persuasive language, the same credible sources, and written to be personally relevant). The first 68 words were the same across all three texts, which began by providing basic information about COVID-19 and stating how contagious COVID-19 is. The texts then described it as a serious threat and recommended that the threat should be taken seriously to prevent further spread. The texts then presented information with regards to vaccines, their safety and efficacy, and then provided encouragement to get vaccinated.

The key differences between the three texts were minor wording that focused on protecting oneself (self-interest), protecting oneself and others (self-interest + altruistic), or protecting oneself and others as well as getting back to a normal life (self-interest + altruistic + normal). For example, for the text that focused on protecting oneself, following the information on how contagious the virus is, the text stated, “This means COVID-19 is a *serious threat to you*,” whereas the other two texts stated, “This means COVID-19 is a *serious threat to you and your community*.” As another example, the text that focused on personal protection stated, “COVID-19 vaccination helps *protect you* from getting sick or severely ill with COVID-19” whereas the other two texts stated, “COVID-19 vaccination will help *protect you* from getting sick or severely ill with COVID-19 and will help *protect your loved ones* and the people around you. That is, even if you do get COVID-19 after being vaccinated, it may also prevent you from spreading it to others.” Finally, for the text that focused on getting back to normal, the text added the following, “People who have been fully vaccinated can start to do some things that they had stopped doing because of the pandemic. Countries like the UK and Israel are getting back to their normal life because everyone is doing their part and getting vaccinated. To stop this pandemic, everyone will need to get vaccinated. This is the only way we will be able to *get back to a normal life. Protect yourself and others* from COVID-19. Let’s get back to normal!” All texts then ended with “*Do not wait. Vaccinate!*” and were followed by a pamphlet that highlighted the main message (i.e., protect oneself; protect oneself and others; protect oneself and others, and let’s get back to normal). See [Appendix A](#) for the texts and pamphlets. Total word count for the texts were 172, 224, and 298, respectively, with a Flesch reading ease score of 46.3, and a Flesch–Kincaid grade level of 9.9 for all three texts.

Emotions

A self-report questionnaire consisting of five items was used to measure participants’ emotions toward COVID-19 vaccines. Each item consisted of a single word (e.g., “Happy”) and participants were asked to report the intensity of their emotional response to COVID-19 vaccines (control condition) after they read the text (text conditions). Single-item measures have demonstrated to be psychometrically sound substitutes for multi-item scales when administration time is

short [e.g., (52)]. Intensity was reported using a 5-point Likert scale using the following labels: Not at all (1), Very little (2), Moderate (3), Strong (4), and Very Strong (5). The five emotions included: joy, hope, empathy, relief, and anger.

Willingness to get a COVID-19 vaccine

A seven-item measure was developed to assess participants’ willingness to get a COVID-19 vaccine (e.g., “In light of the COVID-19 outbreak, I am willing to...”). Participants were asked to rate their willingness using a sliding rating scale that ranged from 0 “Not at all willing to do this” to 100 “Very willing to do this,” with 50 “Moderately willing to do this” as the middle marker. The first item assessed general willingness to get a COVID-19 vaccine (e.g., “Get a COVID-19 vaccine”), along with more specific options including choice of vaccine (e.g., “Get a COVID-19 vaccine if I can choose which one I get”), no choice (e.g., “Get a COVID-19 vaccine even if I cannot choose which one I get”), and then willingness to get a specific vaccine currently available in Canada (e.g., “Get the Pfizer/Moderna/AstraZeneca/Johnson and Johnson vaccine for COVID-19”). Chronbach’s alpha reliability for the seven-item scale was 0.90.

Demographic information

Participants reported their age, sex, first language spoken, highest level of education completed, current health status (ranging from poor to excellent), what health issues they have, how frequently they get the flu vaccine, current employment status, essential worker status, marital status, annual income, residence location (e.g., postal code; urban, suburban, or rural area, etc), number of parents/children/individuals living with them, political affiliation, strength of political affiliation for social issues, strength of political affiliation for economic issues, time spent per day following information about COVID-19, sources of that information (e.g., CBC, Facebook, Fox News, Radio-Canada, CNN), and religiosity (e.g., religious affiliation and strength of beliefs).

Procedure

After obtaining ethics approval from the Research Ethics Board (REB), participants were recruited through MTurk and via a snowball sampling technique through social media (Facebook). A link was provided to Qualtrics (on MTurk and Facebook, housed by our university to ensure encrypted procedures were strictly followed), which was the platform used for collecting data. Participants names were not collected to ensure anonymity and all information was stored on a secure, locked computer with double authentication measures to ensure confidentiality. Only the first author had access to the data, which was all in numerical form. Participants first consented, after which they completed the vaccine confidence and hesitancy questionnaire. Participants were then randomly assigned to one of four conditions: protect yourself “self-interest” condition; protect yourself and others “self-interest + altruistic” condition; protect yourself, others, and let’s get back to normal “self-interest + altruistic + normal” condition; or the control condition (no persuasive message).

After reading (or not in the case of the control condition), participants reported their emotions about COVID-19 vaccines followed by their willingness to get a COVID-19 vaccine. Participants then completed the demographics questionnaire after which they were

¹ <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/index.html>

paid for their time (MTurk) or were entered into a draw to win \$100 (with a chance of winning being 1 in 50). To be entered into the draw, participants recruited through Facebook were provided the first author's email and were asked to contact the first author with a randomly generated code provided at the end of the survey. Participants in the control condition spent approximately 10 min completing the survey, whereas participants in the text conditions spent approximately 12 min (self-interest) to 13 min (self-interest + altruistic, and self-interest + altruistic + normal) completing the survey and reading the texts.

Results

Preliminary data screening and analyses

Prior to conducting analyses, it was first necessary to check for normality and outliers, and whether groups differed on concern, vaccine confidence, and vaccine hesitancy. As expected, most variables were skewed due to the nature of the items, which is common in research on vaccine hesitancy and in research on emotions [see (32)]. Moreover, as expected, there were no differences between groups on concern about COVID-19, $F(3, 325) = 1.08$, $p > 0.05$, vaccine confidence, $F(3, 325) = 2.19$, $p > 0.05$, or vaccine hesitancy, $F(3, 325) = 1.23$, $p > 0.05$. Table 1 reports means and standard deviations for willingness to get vaccinated and emotions as a function of condition, and Table 2 reports correlations between all variables.

Sample characteristics for vaccine hesitancy

To assess whether our sample of vaccine hesitant/resistant individuals was consistent with previous literature (3, 13–15), we first identified whether individuals were hesitant/resistant or not. Based on

participants' score on vaccine hesitancy (i.e., an average score higher than 3, the neutral point on the scale), participants were coded as vaccine hesitant/resistant (23%) or vaccine confident (77%). Consistent with previous research, individuals who were vaccine hesitant/resistant were primarily female (62%), Catholic (25%), moderately to extremely religious (47%), but also identified mostly to the Liberal Party of Canada (46%).

Interestingly, there were no differences in vaccine hesitancy between those sampled from MTurk and those from Facebook ($\chi^2 = 2.94$, $df = 1$, $p = 0.09$) and individuals who were vaccine hesitant did not differ in their information sources for COVID-19 from those who were vaccine confident. For both groups, 22% obtained their information from CBC News (the most frequent source). Moreover, regression analyses revealed that vaccine hesitancy was not predicted by age ($p = 0.62$), health status (ranging from poor to excellent; $p = 0.72$), number of health issues ($p = 0.96$), level of concern about the pandemic ($p = 0.21$), or level of education ($p = 0.40$). However, level of religiosity was a significant positive predictor wherein stronger religious beliefs predicted more hesitancy, $\beta = -0.27$, $p < 0.001$.

Effect of persuasive messages on willingness to get vaccinated

To examine the first research question, whether groups differed on willingness to get vaccinated as a function of type of persuasive message and hesitancy, using concern as a covariate, ANCOVA results revealed a main effect of text condition, $F(3, 325) = 2.80$, $p = 0.04$, $\eta^2 = 0.03$, a main effect of hesitancy group, $F(1, 325) = 70.54$, $p < 0.001$, $\eta^2 = 0.18$, but no interaction, $F(3, 325) = 1.07$, $p > 0.05$. As hypothesized, individuals who were confident in vaccines were more willing to get vaccinated than those who were hesitant/resistant (Hypothesis 3).

Follow-up *post hoc* analyses using LSD revealed that individuals in the self-interest + altruistic + normal condition were more willing to get vaccinated compared to the control condition

TABLE 1 Means and standard deviations for willingness to get vaccinated and emotions as a function of text condition and hesitancy.

	Control ($n = 86$)	Self-interest ($n = 76$)	Self-interest + Altruistic ($n = 84$)	Personal + Altruistic + Normal ($n = 79$)
Vaccine confident				
Willingness	75.94 (23.92)	85.43 (14.88)	75.20 (25.46)	84.45 (20.80)
Joy	3.32 (1.18)	3.95 (0.97)	3.72 (1.08)	4.22 (0.89)
Hope	3.61 (1.07)	4.24 (0.82)	4.05 (0.93)	4.25 (0.84)
Empathy	2.75 (1.26)	3.13 (1.29)	3.00 (1.26)	2.84 (1.40)
Relief	3.27 (1.21)	3.93 (0.99)	3.67 (1.10)	3.87 (1.02)
Anger	1.85 (1.03)	1.50 (0.94)	1.50 (0.89)	1.65 (0.88)
Vaccine hesitant/Resistant				
Willingness	52.93 (29.09)	49.14 (28.92)	47.39 (35.22)	63.64 (25.52)
Joy	2.67 (1.24)	2.60 (0.99)	2.88 (1.50)	3.69 (1.08)
Hope	3.04 (1.16)	3.13 (1.06)	3.05 (1.43)	3.75 (1.00)
Empathy	2.70 (1.45)	2.40 (1.18)	2.94 (1.47)	2.43 (1.50)
Relief	2.62 (1.13)	2.73 (0.96)	2.94 (1.29)	3.43 (0.96)
Anger	2.29 (1.26)	2.46 (1.18)	2.29 (1.35)	2.18 (1.10)

Standard deviation is in (brackets).

TABLE 2 Zero-order correlations between variables.

	Hesitancy	Joy	Hope	Empathy	Relief	Anger	Willingness
Confidence	−0.500**	0.56**	0.567**	0.306**	0.603**	−0.277**	0.625**
Hesitancy		−0.46**	−0.427**	−0.111*	−0.469**	0.366**	−0.501**
Joy			0.70**	0.26**	0.74**	−0.45**	0.53**
Hope				0.403**	0.735**	−0.428**	0.493**
Empathy					0.277**	−0.065	0.222**
Relief						−0.406**	0.512**
Anger							−0.254**

**Significant at $p < 0.001$. *Significant at $p < 0.05$.

($p = 0.004$) and self-interest + altruistic condition ($p = 0.004$) (Hypothesis 1). However, counter to our hypothesis, there were no differences in willingness between the self-interest + altruistic + normal condition and the self-interest condition. Similarly, individuals in the self-interest condition were more willing to get vaccinated compared to individuals in the self-interest + altruistic condition ($p = 0.02$) and control condition ($p = 0.02$) (Hypothesis 2). Finally, counter to our hypothesis, individuals in the self-interest + altruistic condition did not differ on willingness compared to the control condition ($p > 0.05$).

We further explored whether vaccine type mattered, and whether choice or no choice as to which vaccine individuals received mattered with regard to messaging and willingness. Indeed, despite large differences in willingness across the various vaccines (particularly high willingness for Pfizer and Moderna, but low for Astrazeneca and Johnson and Johnson), the same patterns of results were replicated, with much higher willingness to get vaccinated (upward of 20%) when individuals were given the choice of which vaccine to receive compared to when they were not given a choice.

Effect of persuasive texts on emotions

For the second research question, whether emotions differed as a function of text condition and hesitancy, for joy, ANCOVA results revealed a significant main effect of text condition, $F(3, 325) = 7.92$, $p < 0.001$, $\eta^2 = 0.07$, a main effect of hesitancy group, $F(1, 325) = 33.23$, $p < 0.001$, $\eta^2 = 0.10$, but no interaction, $F(3, 325) = 1.63$, $p > 0.05$. As hypothesized, individuals who were vaccine confident expressed more joy in relation to the COVID-19 vaccine compared to individuals who were vaccine hesitant/resistant (Hypothesis 5). *Post hoc* follow-up analyses using LSD revealed that, as hypothesized, individuals in the self-interest + altruistic + normal condition expressed significantly more joy about the COVID-19 vaccine compared to individuals in the other three conditions (all $p < 0.01$). Individuals in the self-interest and self-interest + altruistic conditions also expressed significantly greater joy than those in the control condition (both $ps < 0.01$), and no differences were found in joy between individuals in the self-interested condition and the self-interested + altruistic condition (Hypothesis 4).

For hope, ANCOVA results revealed a significant main effect of text condition, $F(3, 325) = 4.73$, $p = 0.003$, $\eta^2 = 0.04$, a main effect of hesitancy group, $F(1, 325) = 35.67$, $p < 0.001$, $\eta^2 = 0.10$, but no interaction, $F(3, 325) = 1.27$, $p > 0.05$. As hypothesized, individuals who were vaccine hesitant/resistant were less hopeful about the

vaccine than those who were vaccine confident. *Post hoc* follow-up analyses using LSD revealed that there were no differences between the three persuasive text conditions on hope, but that individuals in all text conditions were significantly more hopeful than individuals in the control condition (all $p < 0.001$).

For empathy, ANCOVA results revealed no significant effects or interactions (all $p > 0.05$). For relief, ANCOVA results revealed a significant main effect of text condition, $F(3, 325) = 4.16$, $p = 0.007$, $\eta^2 = 0.04$, a main effect of hesitancy group, $F(1, 325) = 25.95$, $p < 0.001$, $\eta^2 = 0.08$, but no interaction, $F(3, 325) = 1.08$, $p > 0.05$. As hypothesized, individuals who were vaccine hesitant/resistant were less relieved about the vaccine than those who were vaccine confident. *Post hoc* follow-up analyses using LSD revealed that there were no differences between the three persuasive text conditions on relief, but that individuals in all text conditions were significantly more relieved than individuals in the control condition (all $p < 0.001$). Finally, for anger, ANCOVA results revealed no main effect of text condition, $F(3, 325) = 0.37$, $p > 0.05$, but a main effect of hesitancy group, $F(1, 325) = 24.63$, $p < 0.001$, $\eta^2 = 0.07$, and no interaction, $F(3, 325) = 0.76$, $p > 0.05$. As hypothesized, individuals who were vaccine hesitant/resistant were more angry about the vaccine than those who were vaccine confident.

Relations between vaccine confidence, hesitancy, emotions, and willingness to get vaccinated

To answer the last research question regarding relations between vaccine confidence, hesitancy, emotions, and willingness to get vaccinated, a path analysis using Mplus (53) was conducted (Figure 1). The model revealed an excellent fit, $\chi^2 = 28.13$, $df = 3$, $p < 0.001$, CFI = 0.96, RMSEA = 0.06 (Figure 2). Vaccine confidence negatively predicted anger ($\beta = -0.38$, $p < 0.001$) and positively predicted joy ($\beta = 0.41$, $p < 0.001$), hope ($\beta = 0.53$, $p < 0.001$), relief ($\beta = 0.32$, $p < 0.001$), $p < 0.001$, empathy ($\beta = 0.14$, $p = 0.004$) and willingness to get vaccinated ($\beta = 0.59$, $p < 0.001$). In contrast, vaccine hesitancy positively predicted anger ($\beta = 0.44$, $p < 0.001$) and empathy ($\beta = 0.14$, $p < 0.001$), but negatively predicted joy ($\beta = -0.38$, $p < 0.001$), hope ($\beta = -0.20$, $p < 0.001$), relief ($\beta = -0.13$, $p = 0.002$), and willingness to get vaccinated ($\beta = -0.60$, $p < 0.001$). Joy also positively predicted willingness to get vaccinated ($\beta = 0.28$, $p < 0.01$), as did relief ($\beta = 0.09$, $p < 0.05$), and empathy ($\beta = 0.08$, $p < 0.05$), whereas anger negatively predicted willingness to vaccinated ($\beta = -0.21$, $p < 0.001$). Mediation

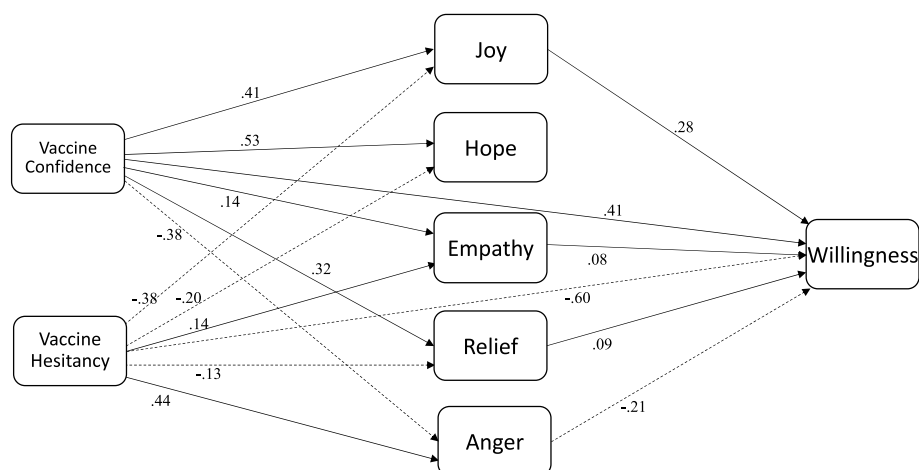


FIGURE 2
Final model.

analyses further revealed that anger ($-0.08, p < 0.001$) and relief ($0.03, p = 0.04$) mediated relations between vaccine confidence and willingness, whereas anger ($0.09, p < 0.001$) and empathy ($0.02, p = 0.04$) mediated relations between vaccine hesitancy and willingness. We discuss these results next.

Discussion

The purpose of this study was to examine the effects of three different types of persuasive messages on willingness to get vaccinated for COVID-19. We also explored the role that emotions play in social persuasion to better understand the mechanisms underlying social persuasion via text-based messages. Results revealed that consistent with hypotheses, the text that focused on getting back to normal in addition to protecting oneself and others (self-interest + altruistic + normal) was more effective in persuading individuals to get vaccinated compared to the control condition (no message) and the self-interest + altruistic condition. However, there were no differences in willingness to get vaccinated between the self-interest + altruistic + normal condition and the self-interest condition, and no differences between the control condition and the self-interest + altruistic condition.

The finding that the self-interest + altruistic condition did not affect willingness to get vaccinated is counter to recent research that found that self-interest + altruistic persuasive messages were more effective in increasing individuals' behavioral intentions like social distancing/behaviors and wearing masks compared to no persuasive message (10–12). Arguably, such social behaviors may be construed as relatively easy to engage in to protect others compared to getting vaccinated, particularly for those individuals who are vaccine hesitant/resistant. As such, a message that focuses on protecting others may not be an effective way to encourage individuals to get vaccinated. However, the persuasive message about protecting oneself was just as effective in increasing individuals' willingness to get vaccinated compared to the message that focused on getting back to normal, which also had an altruistic component to it, but only for individuals who were *not* vaccine resistant. To explain these results, we looked

deeper into the effects of each of the messages as a function of individuals' hesitancy toward vaccines.

Vaccine hesitancy and persuasion

A close examination of the effects of each type of message as a function of vaccine hesitancy group (see Table 1) shows that for vaccine hesitant individuals, the *only* message that increased willingness to get vaccinated was “Let’s get back to normal.” Given that the other two persuasive text conditions had means lower than the control condition for individuals who were vaccine hesitant, and that the “normal” condition increased willingness by over 10% compared to the control condition, we interpret this result as meaningful and important from a public messaging perspective. In the context of pandemic fatigue (2), to persuade vaccine hesitant/resistant individuals to get vaccinated may require a focus on getting life back to normal with regards to the removal of restrictions and regaining of individual freedoms.

For vaccine confident individuals, both the self-interest condition and the self-interest + altruistic + normal condition increased willingness to get vaccinated by 10% above the control condition. These results suggest that in the context of a pandemic, individuals who are confident in vaccines are willing to protect themselves but are also wanting to get life back to normal. It may be the case that individuals were more driven to prevent themselves from getting seriously sick or dying than they were for protecting others from getting sick. Alternatively, at the time that vaccines were rolling out, it was not clear whether or to what extent the COVID-19 vaccines decreased viral load or spread of the virus and, as such, the message to protect others may not have been convincing to individuals since information was rapidly changing at that time (54). Taken together, these results suggest that context matters, and that messaging needs to be tailored as a function of individuals' beliefs about vaccines and other psychological variables like choice versus no choice.

Indeed, a brief examination of the history of the anti-vaccination movement has shown that vaccine hesitancy has been around since the dawn of vaccines [see (55)]. Factors that affect vaccine hesitancy

include complacency (perceived low risk, low general knowledge and awareness), confidence (trust in vaccine safety, the system or policy makers), convenience (availability, accessibility, affordability), calculation (engagement in gathering extensive information), and collective responsibility (willingness to protect others) (56). Historically, religious beliefs (i.e., “it is not God’s will”) and mandatory programs sparked a distrust in vaccines and riots due to restrictions on personal freedoms (57, 58). Modern-era distrust of vaccines grew from concerns over vaccine safety and efficacy, particularly after the polio vaccine was released with a live, active virus that had negative repercussions for a small proportion of children who were given the vaccine (59). Today, factors like religious beliefs, cultural beliefs, and perceptions of risk and harm continue to drive vaccine hesitancy. Prior vaccine history, perceived safety of vaccines, the impacts of vaccine mandates, political affiliation, information and misinformation on the internet, and satisfaction with government decision-making on other aspects of COVID-19 prevention or strategy management also played a significant role in the uptake of COVID-19 vaccines (60).

Results from our study provide further evidence of these factors playing a role. That is, individuals with strong religious beliefs were more vaccine hesitant and were more likely to affiliate with the liberal government of Canada, which is counter to what is typically found in the US with Republicans being more vaccine hesitant (61). What is particularly noteworthy with our results is that choice mattered for individuals, regardless of whether they were vaccine confident or hesitant. Indeed, willingness to get vaccinated was 90% for individuals in the “let’s get back to normal” and “personal” conditions but dropped to 72% for those same conditions when choice of vaccine was removed. These percentages dropped to 62 and 54%, respectively, when Astrazeneca was the option, reflecting individuals’ distrust in this vaccine given news of blood clots being a risk factor. Moreover, as previously noted, for vaccine hesitant individuals, willingness was significantly higher with the message of getting back to normal than any other message, and this was particularly pronounced when they had the choice of vaccines (82% willing) versus when they did not have a choice (46% willing). Accordingly, there may have been some additive effects for vaccine hesitant individuals where the message of getting back to normal coupled with a choice of vaccine was the most powerful approach to social persuasion. To further understand the mechanisms involved in social persuasion, it is also important to consider the role of emotions.

The role of emotions in persuasion

Indeed, for all three persuasive message conditions, individuals felt more joy, hope, and relief than those in the control condition, with no differences in level of emotional intensity for the three persuasive message conditions (with the exception of joy). Moreover, no differences were found between persuasive text conditions and the control condition for anger or empathy. These results suggest that the persuasive messages had equal effects on increasing hope and relief, regardless of the type of persuasive message, and had no effect on empathy or anger. Most important, for the condition that included the message of getting back to normal, individuals expressed the greatest joy compared to individuals in the other three conditions.

As previous empirical work has demonstrated, positive emotions, like joy, can increase effortful processing of information (33) and

result in assimilation of new information into current knowledge structures (35). As such, it appears that in this context, joy played a significant role in increasing individuals’ willingness to get vaccinated, perhaps from a belief that things will get back to normal. Indeed, results from path analyses revealed that greater vaccine confidence predicted more joy, relief, hope and empathy and less anger, whereas greater vaccine hesitancy negatively predicted joy, hope, and relief, but positively predicted anger and empathy. Moreover, the more angry individuals were about the vaccine, the less willing they were to get vaccinated. However, the more joy, hope, relief, and empathy they experienced, the more willing they were to get vaccinated. These emotions also mediated relations between vaccine confidence and hesitancy wherein for confidence, joy and relief were positive mediators whereas anger was a negative mediator and, for hesitancy, relief was a negative mediator whereas empathy was a positive mediator.

These results have important implications for the effects that emotions have on processing persuasive information, particularly when the message focuses on getting life back to normal under pandemic circumstances. Drawing from the emotions literature (32), it may be the case that processing of the persuasive messages was enhanced due to an increase in joy, hope, and relief across all three conditions. These results suggest that persuasive messages that focus on getting back to normal could persuade the largest number of individuals to get vaccinated, particularly those who are vaccine hesitant/resistant. Although vaccine campaigns have targeted vaccine safety and protection of oneself (self-interest) and others (altruistic), an additional focus on getting back to a normal life may be key to achieving a high vaccine uptake. In the context of COVID-19 where, in Canada, many restrictions were put into place that limited individuals’ freedoms (particularly in the province of Quebec), a focus on regaining those freedoms via vaccination and “getting back to normal” may have been a powerful approach to social persuasion. In other contexts, this “normal” message may not have been effective if freedoms were not restricted. As such, the efficacy of this approach may not translate to other situations where freedoms are not threatened.

Implications, limitations, and future directions

Taken together, results from this study have broader vaccine education and promotion implications. Messages from trustworthy sources are important to incorporate into health promotion messaging, along with a highlight of the safety of the vaccine. Given the history of vaccine hesitancy (55), mandating vaccines is not a good choice to promote vaccine uptake. Rather, results from this study suggest that choice is critical as is a focus on freedoms rather than the removal of them. Education about the safety and efficacy of vaccines is also critical (55). But in the context of rapidly changing information about COVID-19 and vaccines, this element of vaccine safety and efficacy was nearly impossible, so freedom of choice may have been key. Results from this research also suggest that positive emotional appeals may prompt individuals to be less resistant to vaccines and foster confidence in their use.

From an information processing perspective (35), it may be the case that positive emotions foster a deeper processing of educational

information about vaccines. Future research is needed to evaluate precisely how emotions impact information processing, particularly for vaccine hesitant individuals. For example, a think-emote-aloud protocol [see (62)] may be an effective way to capture individuals' emotions and cognitive and metacognitive processes to examine their interplay during reading of persuasive messages, particularly for socio-scientific issues like vaccine hesitancy. Future research is also needed that takes into consideration other factors that affect vaccine uptake like perceived susceptibility, threat or severity of illness, and the potential role of community engagement. Moreover, our study was conducted in Canada, which, culturally, is considered a more socialist country compared to others like the U.S. What was surprising to us was the finding that "protecting others" did not have the positive effect on willingness as it has in the past in the Canadian context [see (12)]. Future work is needed to disentangle why this may have been the case and whether other cultures that are more or less collectivist or socialist would respond in similar ways to "getting back to normal."

One limitation of this study is that we did not include altruistic only or normal only message conditions to better determine what specific aspect of the messages were most effective in increasing individuals' willingness to get vaccinated. A second limitation of this study is that we did not measure actual vaccine uptake. Although vaccine intentions are a strong predictor of behavior (63), a more powerful evaluation of the effectiveness of our messages would have been to include a follow-up assessment as to whether individuals got vaccinated for COVID-19 or not. Future research should also consider interviewing individuals to better understand the effects of persuasive messages and why individuals were more willing (or not) to get vaccinated. A better understanding of the underlying mechanisms of persuasion will allow for improved persuasive messages that may more effectively combat vaccine hesitancy and resistance.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Research Ethics Review Board at McGill University. The studies were conducted in

accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. PK: Conceptualization, Methodology, Validation, Visualization, Writing – review & editing. MK: Writing – review & editing. SW: Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. Support for this research was provided by a grant to KM from the Canada Research Chair's Program (G239700).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1377973/full#supplementary-material>

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RECEIVED 27 January 2024

ACCEPTED 07 May 2024

PUBLISHED 23 May 2024

CITATION

Hijazi R, Gesser-Edelsburg A and
Mesch GS (2024) Vaccine communication
strategies among healthcare workers as a
reflection of the Israeli Ministry of Health's
communication strategies before and after
the COVID-19 pandemic.

Front. Public Health 12:1377393.

doi: 10.3389/fpubh.2024.1377393

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Vaccine communication strategies among healthcare workers as a reflection of the Israeli Ministry of Health's communication strategies before and after the COVID-19 pandemic

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Background: Healthcare workers play a central role in communicating information to the public regarding vaccines. Most of the literature has focused on healthcare workers' hesitancy and doubts about getting the flu vaccine themselves. However, few studies have dealt with how they perceive their role in communicating information regarding vaccines, especially following the COVID-19 pandemic.

Objectives: (1) To identify the communication strategies used by the Israeli Ministry of Health regarding vaccines during epidemic crises (before and after the COVID-19 pandemic); (2) To identify the communication strategies used by healthcare workers regarding vaccines before and after the COVID-19 pandemic.

Methods: A qualitative study based on in-depth interviews was conducted among healthcare workers and used a semi-structured protocol as a research tool. A total of 18 healthcare workers were sampled using purposeful and snowball sampling.

Results: Despite healthcare workers' perception that there has been a decrease in trust in the Israeli Ministry of Health among the public following the COVID-19 outbreak, they still rely on the Israeli Ministry of Health as their primary source of information and use the same communication strategies (such as fear appeals and correcting information) as of the Israeli Ministry of Health to communicate with the public, healthcare providers, and other relevant stakeholders.

Conclusion: Healthcare workers have been shaped by the professional socialization processes within the health system, leading to a predominant reliance on established communication strategies and informational channels. This reliance underscores the importance of evolving these methods to better engage with the public. To address this, there is a compelling need to innovate and adopt new communication techniques that emphasize effective dialogue and transparent interactions. By doing so, healthcare professionals can ensure that their outreach is not only informative but also responsive to the diverse needs and preferences of the community.

KEYWORDS

vaccine hesitancy, healthcare workers, COVID-19 pandemic, health communication strategies, qualitative study, Israel, parents, public trust in the healthcare system

Introduction

Health organizations during epidemics, and also when communicating information about children's routine vaccines, have adopted several communication strategies to promote vaccination and encourage the public to get vaccinated (1, 2). This study seeks to shed light on some of the strategies employed by healthcare workers before and after the COVID-19 crisis.

Myth-busting – differentiating between facts and myths – is commonly used by health organizations. According to this approach, every piece of information that comes from other sources besides the health organization itself is labeled as a “myth,” while information that originates from the health organization itself is labeled as “fact” (3). Several studies have noted the problematic use of this strategy, which was found to result in a backfire effect (4–6); the public refused to accept this information unless it was supported by scientific evidence (7–9). In addition, repeating the “myth” by the health organizations was found to make the information more familiar and more likely to be true (6). Hence, studies conducted during the COVID-19 outbreak found that health organizations continue to use the same communication strategies of myth-busting and fear appeal strategies (2, 10).

Health organizations also widely used the fear appeal strategy during previous disease outbreaks. A *fear appeal strategy* attempts to persuade the public to adopt a specific action (such as vaccination or compliance with instructions) by arousing fear. This strategy is based on emphasizing the potential danger and harm that might result if the public does not adopt the messages' recommendations (11). A comprehensive meta-analysis of fear appeal literature indicates that this strategy is ineffective (12). Moreover, fear appeal has also been associated with negative effects and responses such as risk denial, biased information processing, lower levels of self-efficacy, less attention, and a higher level of discomfort after being exposed to fear appeal messages during a vaccine promotion campaign (13, 14). Previous studies emphasized the apparent use of a fear appeal strategy by the Israeli Ministry of Health during the COVID-19 vaccination campaign (2). The use of this strategy was characterized by the language and tone politicians used to deliver information in the media (15, 16).

Health organizations have used these communication strategies and reached the public through the media, especially through channels such as social media in the last decade. However, the primary way of communicating with the public is still through healthcare workers, including nurses and physicians. Healthcare workers are considered the representatives of health organizations and as such play an essential role in public vaccination (17). This role includes communicating recommendations, providing information about vaccines, and vaccinating the public (18). Physicians and other healthcare providers are considered the most reliable source of information (19).

Parents perceive healthcare workers as a primary and trustworthy source of information about vaccination and vaccines (20) and play a central role in maintaining public trust in vaccination (21). Healthcare workers' recommendations were found to be strong drivers of vaccine acceptance among the public. Therefore, they are in a position to empower parents to make an informed decision about vaccinating their children (19).

Due to the essential role of healthcare workers in the vaccination process and as a trusted source of information for parents, as well as

influencing the parents' attitudes regarding vaccination, there is a need for a better understanding of how they communicate vaccination information. This is further supported by the fact that most of the studies in the literature on healthcare workers and vaccines have focused on vaccine hesitancy, vaccine acceptance, and vaccination intention among healthcare workers (22–24). However, few studies have dealt with how healthcare workers perceive their role in communicating information regarding vaccines to the public, especially following the COVID-19 pandemic.

This study aims to (1) Identify the communication strategies used by the Israeli Ministry of Health regarding vaccines during epidemic crises (before and after the COVID-19 pandemic); (2) Identify the communication strategies used by healthcare workers regarding vaccines before and after the COVID-19 pandemic.

Methods

Research design and procedure

This study is based on a qualitative constructivist research method (25), which enables the researchers to study the meaning of the experience as it is perceived by the research subjects. In this study, healthcare workers themselves are used as the instrument for data collection to identify the communication strategies employed by healthcare workers and health organizations (26).

The study was approved by the Faculty of Social Welfare and Health Sciences Ethics Committee for research with human subjects at the University of Haifa (approval no. 421/17). The studies were conducted in accordance with the Israeli Medical Research Involving Human Subjects Law (1996) as the local legislation, and the requirements and guidelines set by the University of Haifa Ethics Committee. Written informed consent to participate in this study was provided by the participants.

Sampling and data collection

In the first stage, the researchers performed a purposeful criterion sampling of healthcare workers such as family physicians, pediatricians, and nurses who are involved in the vaccination process with the public, including giving vaccines and communicating information regarding vaccines to the public. In the second stage, the researchers proceeded to perform snowball sampling. The study's sample included 18 healthcare workers – 9 pediatricians, 1 physician, and 8 nurses from the Mother and Child Health Clinics were interviewed (Table 1). The duration of each interview was approximately half an hour.

Research tools

In-depth interviews were conducted based on a semi-structured protocol. In the first part, the questions referred to the period before the COVID-19 outbreak in Israel. The interviewees were asked questions about how they communicate the issue of vaccines to the parents, how the Israeli Ministry of Health communicates the issue of vaccines, how they deal with uncertainty, and how they correct misinformation regarding vaccines. In addition, the

TABLE 1 Interviewees' sociodemographic characteristics (N = 18).

Variables		Frequency	Percentage (%)
Gender	Male	6	33.3
	Female	12	66.7
Age (years)	30–39	8	44.4
	40–49	5	27.8
	50–59	4	22.2
	≥60	1	5.6
Ethnicity	Jewish	6	33.3
	Arab	12	66.7
Profession	Pediatrician	9	50.0
	Physician	1	5.6
	Nurse	8	44.4
Workplace	Ministry of Health Child Centers	6	33.3
	Clalit Health Services	6	33.3
	Maccabi Health Services	1	5.6
	Leumit Health Services	3	16.7
	Meuhedet Health Services	1	5.6
	Private clinic	1	5.6
Seniority	3–9	4	22.2
	10–19	8	44.4
	20–29	2	11.1
	≥30	4	22.2

questionnaire included questions regarding the level of trust in the health system in Israel. The second part of the questionnaire aimed to examine whether the interviewees' attitudes and perceptions changed after the COVID-19 outbreak in Israel. Therefore, this part included questions about the change in the level of trust in the health system in Israel, vaccine hesitancy after the COVID-19 outbreak, and how the health organizations in Israel communicated the information about the COVID-19 virus and its vaccine to the public.

Credibility and validity

The qualitative interviews were conducted in the language preferred by the interviewee (Hebrew or Arabic) and they were audio-recorded. Then, they were transcribed verbatim, and the Arabic interviews were translated into Hebrew. The validity and reliability of this study were established based on the framework presented by Lincoln and Guba (26). These researchers suggested the term “trustworthiness” to evaluate the validity and reliability of the qualitative research. *Trustworthiness* is demonstrated through four components. The first component is credibility (comparable with internal validity) and refers to the “fit” between the participants' views and the researchers' presentation of the findings. Transferability (comparable with external validity) is the second component, which addresses the issue of generalizability of inquiry and the researchers' ability to anchor the research findings in other similar cases and other relevant theories. The third component is dependability (comparable

with reliability), which is achieved by ensuring that the research process is logical, traceable, and clearly documented. The last component is confirmability (comparable with objectivity or neutrality), which is concerned with establishing that the findings do not arise from the researchers' assumptions, prejudices, interests, and motivations, but are clearly derived from the data and allow for the acceptance of the conclusions arising from the findings (27). This study achieved these components through prolonged engagement, persistent observation, peer debriefing, and audit trials (28).

Analysis

Qualitative data were analyzed using thematic analysis (29). Specifically, we focused on text codes regarding the participants' attitudes toward vaccination, dilemmas in communicating the information regarding vaccines to the public, the public's perceived level of trust in the health system, and how participants perceive health organizations' communication methods in Israel before and after the COVID-19 outbreak. These codes were then grouped into themes and sub-themes, and following the rules for inclusion in each category, relevant texts from subsequent interviews were coded.

Results

Four main themes emerged from the analysis of the interviews (Table 2). The themes focused on the communication strategies used

TABLE 2 Themes and sub-themes.

Theme	Sub-themes
1. Trust in the Israeli Ministry of Health	1.1. Healthcare workers' trust in the Ministry of Health 1.2. The public's level of trust in the Ministry of Health before and after the COVID-19 outbreak in Israel
2. Information communication by the Israeli Ministry of Health	2.1. Fear appeals as the main strategy for communicating information 2.2. Correcting misinformation 2.3. Segmentation of the public
3. How do healthcare workers perceive the Ministry of Health's communication strategies and its ways of conveying information to the public	3.1. The controversy regarding transparency and providing complete information 3.2. Communicating uncertainty 3.3. The Ministry of Health is the most reliable source of information for healthcare workers 3.4. Healthcare workers as role models
4. How healthcare workers perceive children's vaccination and parents who are hesitant or anti-vaccination	4.1. Concerns following the recommendation to vaccinate children with the COVID-19 vaccine 4.2. How healthcare workers perceive anti-vaccination parents

by healthcare workers and the Israeli Ministry of Health before and after the COVID-19 outbreak, and on how the participants perceived these strategies. In addition, the issue of trust in the Ministry of Health also emerged as a main theme.

Trust in the Israeli Ministry of Health

Trust in the Ministry of Health emerged as a main theme in the study. The interviewees referred to (1) healthcare workers' trust in the Ministry of Health, and (2) the public's level of trust in the Ministry of Health before and after the COVID-19 outbreak in Israel.

Healthcare workers' trust in the Ministry of Health

Seven interviewees out of 18 expressed a high level of trust in the Ministry of Health. The interviewees described the Ministry of Health as a reliable and trustworthy source of health information in general and as regards vaccine information.

"I trust all the information provided by the Ministry of Health. This information is reliable and trustworthy" (Interviewee 12).

In addition, the interviewees expressed a high level of trust in the health authorities represented by the Ministry of Health and policymakers. They claimed that policymakers always make the best decisions for public health. Their decisions are based on studies and motivated by concern and responsibility for public health and not by other hidden interests. "I am confident in the policymakers and their decisions. I trust the authorities. The decisions regarding vaccines aim to promote public health and are not motivated by hidden interests" (Interviewee 7).

The public's level of trust in the Ministry of Health before and after the COVID-19 outbreak in Israel

Most interviewees referred to the change in the public's level of trust in the Ministry of Health after the COVID-19 outbreak in Israel. Fourteen out of 18 interviewees mentioned that the public's trust in the Ministry of Health was higher before the COVID-19 outbreak in Israel. However, following the COVID-19 outbreak in Israel, the public's level

of trust in the Ministry of Health decreased because of crisis management issues, particularly inconsistent instructions, inconsistent statistical reporting of the COVID-19 cases, political and economic motives, and using an intimidation-based communication strategy.

"The level of trust has decreased because of corruption and political and economic interests... The public doesn't feel their personal interest is a priority of the authorities... Instead, they see that there are all kinds of other interests and things that influence the authorities' decisions such as politics, ego, power, and economic interests" (Interviewee 10).

"After the COVID-19 outbreak, the level of trust decreased. The health authorities reported inconsistent statistics regarding the number of COVID-19 cases, in general, and serious cases, in particular. The authorities scared the public, and people understood that the number of reported patients was not accurate" (Interviewee 11).

In addition, some interviewees claimed social media was the reason for the decrease in the public's trust in the Ministry of Health after the COVID-19 outbreak. The public was exposed to anti-vaccination information and intense debate on social media regarding the COVID-19 vaccine's effectiveness and safety.

"Before the COVID-19 outbreak, the public's trust in the Ministry of Health was higher. Fewer people were exposed to what was written on social media and anti-vaccination messages. Some parents didn't know that there are parents who oppose vaccines and don't vaccinate their children" (Interviewee 14).

However, one interviewee claimed that the drop in the public's level of trust in the Ministry of Health was a temporary situation and that the level of trust has returned to what it was before the COVID-19 outbreak.

"I think the public has already forgotten what happened during the COVID-19 outbreak, and the trust has returned to its previous level. There was no real loss of trust ... It's just that at first, we received ambiguous instructions because there were constant

changes in the instructions... Almost every week, we received different instructions, and we were confused” (Interviewee 1).

Information communication by the Israeli Ministry of Health

The interviewees described the communication strategies used by the Ministry of Health. These strategies included fear appeals and correcting misinformation. In addition, they described the information delivered by the Ministry of Health as being uniform, without adapting the information to the different public groups.

Fear appeals as the main strategy for communicating information

Most interviewees (15 out of 18) claimed the Ministry of Health used and still uses fear appeal as the primary strategy to promote vaccination before and after the COVID-19 outbreak. As described by the interviewees, this strategy is based on persuasive messages that attempt to arouse fear among the public to promote routine vaccines and the COVID-19 vaccine. These messages emphasized the severity of the disease, the risk of not being vaccinated, reported statistics of infected cases and deaths, and sanctions against those who are not vaccinated and fail to comply with the health authorities’ recommendations. They described this strategy as effectively motivating the public to vaccinate and claimed that imposing sanctions – such as preventing unvaccinated children from entering kindergarten – against unvaccinated individuals is legitimate.

“The act of not letting an unvaccinated child into kindergarten is completely acceptable. I think that unvaccinated children should not be protected indirectly because other children are vaccinated” (Interviewee 8).

“The public got the vaccine because the Ministry of Health scared them and forced them to get vaccinated. The Ministry of Health described the virus as very contagious and said the disease was severe” (Interviewee 2).

Correcting misinformation

Healthcare workers and health organizations play a critical role in addressing and correcting misinformation. Thirteen interviewees described the methods by which they and the health organizations correct misinformation. For example, healthcare workers may face misinformation regarding vaccines during their appointments with parents. According to the interviewees, healthcare workers’ ways of correcting information included explaining the importance of vaccination in preventing infectious diseases to the parents, assessing the risks and benefits of vaccines, and explaining that clinical trials have been conducted to approve vaccines just like other medicines.

“I give an example of the medicines they receive. Furthermore, I explain that both these medicines and vaccines have undergone clinical trials. Moreover, I also present the statistics and how

people in the past died before vaccines were invented” (Interviewee 4).

In addition, the interviewees dealt with misinformation by referring parents to the Ministry of Health website for more information or giving them medical information leaflets provided by the Ministry of Health. Another way to deal with the misinformation suggested by the interviewees is to rely on their rich experience and say that this information needs to be corrected.

“I refer parents to the Ministry of Health website and explain that I’ve been working here for years and that they should trust me. I also try to explain more about the risks and benefits of vaccines” (Interviewee 8).

“I explain that during the 20 years that I’ve worked as a Tipat-Halav (Mother and Child Health Clinics) nurse, I’ve never seen any child who suffered from unusual symptoms or side effects such as those which you, the parent, mentioned ... I say that even if it’s true, then it occurs among a very small percentage of children” (Interviewee 2).

Two interviewees claimed that they would search for studies addressing and correcting misinformation from other sources of information besides the Ministry of Health, such as studies conducted in other countries. In addition, one interviewee also suggested referring parents to reliable information-seeking sources.

“To deal with misinformation, I search for other studies carried out in Israel and abroad, and I send these studies to the parents or even tell them where to search for reliable information” (Interviewee 7).

The interviewees also mentioned that health organizations correct misinformation by presenting the misinformation and its correction. To correct misinformation, health organizations used healthcare workers who appeared in the media or posted posts on social media mentioning fake news.

“Healthcare workers and experts appeared in the media to correct misinformation” (Interviewee 18).

“The Ministry of Health started to correct the misinformation through social media during the COVID-19 outbreak by mentioning the misinformation and labeling it as false or fake” (Interviewee 14).

Segmentation of the public

The way the Ministry of Health communicates information in general, and on the topic of vaccination in particular, emerged as a theme from the interviews. Fifteen interviewees (out of 18) described the information provided by the Ministry of Health as uniform and addressed to the broad public. This means the transmitted information is not adapted to the different groups which comprise the general public.

“I think the Ministry of Health provides everyone with the same information, but everyone deals with the information differently” (Interviewee 15).

How healthcare workers perceive the Ministry's of Health communication strategies and its ways of conveying information to the public

This main theme consisted of four sub-themes: (1) the controversy regarding transparency and providing complete information; (2) communicating uncertainty; (3) the Ministry of Health is the most reliable source of information for healthcare workers; and (4) healthcare workers as role models.

The controversy regarding transparency and providing complete information

On the one hand, four interviewees out of 18 claimed that the Ministry of Health does not provide the public with complete and transparent information. In addition, they mentioned that the Ministry of Health needs to be transparent and provide complete and accurate information to the public, so they can make informed decisions regarding their health. Moreover, some interviewees argued that not providing complete information underestimates the public's intelligence and that the health authorities perceive the public as being unable to deal with all the information and make the best decisions regarding their health.

"The Ministry of Health certainly does not provide complete information to the public. Instead, it provides the information it thinks the public should know. The Ministry of Health doesn't think the public is intelligent enough to make their own health decisions. The authorities perceive the public as lacking the ability to read, understand, and ask questions. You have a doctor, do what he tells you. Today, it is no longer like that; some patients know more about their diseases than their doctors because they have access to the information. I believe underestimating the public's intelligence is not good" (Interviewee 10).

On the other hand, six interviewees out of 18 suggested that the Ministry of Health should not provide complete information to the public. They also claimed that the public could not deal with complete information and that providing it might create confusion among the public. Therefore, the Ministry of Health should make public health decisions and provide information that promotes vaccination or motivates the public to make the decision recommended by the Ministry of Health.

"I think providing complete information is wrong because the patient should play the role of the patient, and the doctor should play the role of the doctor. The patient should not cross this border... The information should be conveyed assertively, and in a goal-oriented manner... and the goal should be to promote vaccination" (Interviewee 4).

Communicating uncertainty

Communicating uncertainty to the public was examined through nine interviewees. On the one hand, seven interviewees mentioned that the public could not handle or deal with uncertainty and that communicating uncertainty might generate confusion and "hysteria"

among the public. Therefore, health organizations should provide only specific information.

"I think the public cannot deal with uncertainty. In addition, communicating uncertainty may generate confusion. It also requires a lot of explanation and effort, which burdens the health system" (Interviewee 4).

On the other hand, two interviewees mentioned that the public wants to receive complete and transparent information, including uncertain information. Moreover, it is the public's right to receive complete information. Therefore, health organizations need to practice transparent communication.

"The public should receive all the information, including uncertainty ... there is no such thing as hiding information. The information should be transparent... I think the Ministry of Health does not communicate all the information" (Interviewee 6).

The Ministry of Health is the most reliable source of information for healthcare workers

Thirteen interviewees out of 18 mentioned that for them the only source of information regarding vaccines is the Ministry of Health. Therefore, they only share information from the Ministry of Health with parents or on social media. Moreover, some mentioned that they do not know of any other sources of information besides the Ministry of Health that are reliable and trustworthy.

"I'm not aware of any other sources besides the Ministry of Health. We get the information only from the Ministry of Health" (Interviewee 12).

"I only receive information from the Ministry of Health and share it on social networks as well" (Interviewee 13).

In addition, some interviewees mentioned that parents who ask for more information from other sources are referred to websites recommended by the Ministry of Health.

"We give parents who ask for more information a website we received in lectures for Tipat-Halav nurses. This is a website recommended by the Ministry of Health ... We refer concerned parents to this site along with those who say they prefer to postpone getting the vaccine for another month..." (Interviewee 8).

Healthcare workers as role models

Six interviewees out of 18 claimed they try to encourage hesitant and anti-vaccination parents to vaccinate their children by mentioning that they themselves, as well as their children, are vaccinated.

"In addition to explaining and talking about studies, I would tell the parents about myself, that I am vaccinated, and that my children are vaccinated. This convinced most of them to vaccinate their children" (Interviewee 15).

However, three interviewees out of 18 described the difficulty of promoting some vaccines, such as the COVID-19 vaccine, the Polio vaccine, and the Rotavirus vaccine. They said that because they consider themselves role models, it is difficult to recommend hesitant and anti-vaccination parents to vaccinate their children when they, themselves, do not vaccinate their children with these vaccines or believe that these vaccines are effective and safe.

"It was difficult for me to recommend the Corona vaccine for both adults and children. I had concerns because I know several people who suffered from side effects from the vaccine" (Interviewee 14).

"I have concerns regarding the safety of the Polio vaccine. Only two of my children were vaccinated with this vaccine. Therefore, when a hesitant parent asks me what I did, it's hard for me to tell them that I didn't vaccinate all my children because we are role models. Sometimes, I say that it doesn't matter what I did. Moreover, sometimes, I say that I did vaccinate my children ... Regarding the Rotavirus vaccine, it's hard for me to encourage hesitant parents to vaccinate their baby because I know that the baby may suffer from side effects and pain" (Interviewee 9).

How healthcare workers perceive children's vaccination and parents who are hesitant or anti-vaccination

The interviewees described their concerns and doubts regarding vaccinating children with the COVID-19 vaccine. In addition, they mentioned in this main theme how they perceive and communicate with hesitant and anti-vaccination parents.

Concerns following the recommendation to vaccinate children with the COVID-19 vaccine

The interviewees (nine out of 18) expressed concerns about the recommendation to vaccinate children with the COVID-19 vaccine. They claimed that authorities were supposed not to rush recommending vaccinating children because the COVID-19 vaccine was new. In addition to fewer severe reported cases of Corona disease among children, more information was available regarding short-term side effects, and long-term side effects were still being determined. Therefore, they were not confident about recommending the COVID-19 vaccine for children.

"Regarding the COVID-19 vaccine, my family and I were vaccinated, but regarding children's vaccinations, I would wait with that and not rush to vaccinate. Because children are not at risk, especially healthy children" (Interviewee 12).

"It was tough for me to recommend the COVID-19 vaccine because the vaccine is new and its side effects are still unknown" (Interviewee 11).

How healthcare workers perceive anti-vaccination parents

Eleven interviewees described how they perceive anti-vaccination parents. Most of them (9 out of 11) think that anti-vaccination parents

oppose vaccines because of their ideological perceptions and their opposing attitudes toward the government, or they think the vaccination process is motivated by hidden interests. In addition, anti-vaccination parents' attitudes rely on the information they receive from social media or rumors that are not evidence-based. Therefore, these healthcare workers think it is not worth trying to conduct a dialogue with these parents because they will not be convinced.

"They decide not to vaccinate without scientific proof and only because they heard that the vaccine could cause harm from their neighbors or someone who knows nothing ... their information is not scientifically based" (Interviewee 11).

"The opposition to the government is expressed by their opposition to the vaccines... At the same time, many groups with agendas publish fake news and misinformation on social media... I don't have the time or the patience to try and talk with them" (Interviewee 5).

However, three interviewees mentioned that there are anti-vaccination parents whose attitudes are based on scientific information such as studies and articles. In addition, they described these parents as highly educated.

"I was surprised to find that some anti-vaccination parents are highly educated. Some are physicians and refuse vaccines out of knowledge. For example, they cite side effects listed in the American leaflet and not in the Israeli leaflet, and they cite scientific studies and quotes from expert doctors from abroad" (Interviewee 16).

Discussion

The literature has indicated the unique and essential role of healthcare workers in mediating the public's trust in health authorities and policymakers. Previous studies have found that trust in the healthcare system is essential to public compliance with the authorities' recommendations and guidelines during epidemics (30, 31). The public's trust in the healthcare system includes trust in the health authorities, healthcare workers, and policymakers (32). Trust was also found to influence the public's acceptance of vaccines. Higher trust in the healthcare system is associated with lower barriers and higher acceptance of vaccines (33, 34). The COVID-19 outbreak has elucidated the importance of establishing trust in the health authorities among the public. Recent studies have emphasized the importance of trust in the healthcare system and its association with compliance with both the COVID-19 vaccine and the authorities' recommendations (35–40). In this study, healthcare workers reported a decrease in the public's trust in the health authorities following the COVID-19 outbreak in Israel. However, despite the decrease in the public's trust in the health authorities, the study findings show a high level of trust in the health authorities among healthcare workers during the COVID-19 outbreak in Israel.

An essential aspect related to healthcare workers' trust in this study is the fact that many perceive the health authorities as their primary and only source of credible and reliable information. Previous studies have found that although the public draws upon various sources of information, such as social media (41), healthcare workers

are still perceived as a primary and trustworthy source of information about vaccination (20). As part of the healthcare workers' role, they are required to provide information to the public, address their concerns, and answer their questions. Therefore, healthcare workers need to have up-to-date and comprehensive information (42) to serve as a reliable source for the public (43).

The same ambivalent approach represents the rest of the participants' attitudes in this study. For example, most of the participants claimed that the Ministry of Health uses a fear appeal strategy to communicate with the public. They stated that the Israeli Ministry of Health uses fear-based messages to promote vaccinations by emphasizing disease severity, risks of being unvaccinated, infection/death statistics, and sanctions for non-compliance. Participants viewed this approach and restricting kindergarten access for the unvaccinated as effective and legitimate motivators. Consistently, previous studies found that fear appeal strategy was widely employed in COVID-19 public health messages to promote preventive behaviors by highlighting illness or death risks (44, 45). However, overreliance on fear risks unintended consequences (46). While fear can motivate if applied judiciously, balancing severity, susceptibility, self-efficacy and response efficacy is complex (47). For instance, a Kenyan case study found job/income loss threats promoted hand sanitizing and masking among taxi drivers (48). In addition, previous studies found that sanction risk had no significant effect on compliance (49, 50).

Attitudes of the participants also diverged regarding transparency. Some stated that the Ministry of Health should provide complete information and communicate with transparency. On the other hand, still, other healthcare workers in this study believe the communication strategies used by the Ministry of Health are effective and think the Ministry of Health should provide the public with only partial information.

The same holds true regarding their perceptions about vaccinating children with the COVID-19 vaccine. Although they reported having concerns and doubts regarding the vaccine's safety and admitted they did not have sufficient information regarding the vaccine's side effects among children, they still communicated the importance of vaccinating children and recommended this vaccine for children. In addition, they said they believed the health authorities had successfully managed the COVID-19 crisis. Contrary to these findings, a recent study showed that Israeli health professionals expressed varied levels of trust in the authorities and a moderate level of trust in policy during the first wave of COVID-19 (51).

The findings indicate that despite health workers' reservations about a variety of issues (the use of fear appeal, child vaccinations, etc.), they still perceive the Ministry of Health as a reliable and central source of information and used the same strategies to convey information to the public during COVID-19 pandemic. These findings may be explained by the socialization of healthcare workers, which is defined as "a process in which people learn to adapt to values, skills, points of view, norms, and knowledge needed for belonging to a community, group, or organization" (52).

The inconsistent findings in this study regarding the high level of trust among healthcare workers, their perception of the public's decreased level of trust in the Ministry of Health, and their hesitant attitudes regarding giving children the COVID-19 vaccine may be explained by cognitive dissonance theory. This theory claims that inconsistency between attitudes, beliefs, and behaviors may create

cognitive dissonance and a lack of harmony accompanied by psychological stress. Therefore, people seek psychological consistency by resolving the dissonance and aligning their cognitions with their actions. Blindly trusting whatever they want to believe or avoiding contradictory information are ways to establish psychological consistency and reduce the magnitude of the dissonance (53, 54). For example, recent research found that inducing cognitive dissonance improved COVID-19 safety compliance and vaccination attempts versus controls (55). Concerning the findings of this study, cognitive dissonance may provide a useful framework for several reasons. First, it directly links the inconsistencies observed between trust in the health authorities and attitudes toward vaccination. Second, seeking consistency to resolve dissonance fits with healthcare workers' tendency to maintain trust and recommend the COVID-19 vaccine despite doubts raised. However, cognitive dissonance theory faced limitations as alternative theoretical frameworks and models were proposed to account for various dissonance-related findings (56–59). For instance, Bem (60, 61) self-perception theory and Tedeschi et al. (62) impression management theory aimed to explain dissonance effects observed in classic studies like Festinger and Carlsmith (63). Additionally, early research by Heine and Lehman (64) suggested that cultural factors may moderate experiences of dissonance. Social cognition theories and theories about motivational processes were also put forth as alternative explanatory perspectives (65, 66). Some experimental designs further challenged certain specific aspects of cognitive dissonance theory (67, 68). Therefore, other interpretations may be possible, and cognitive dissonance may not fully account for the complex factors influencing attitudes and behaviors. With these limitations in mind, cognitive dissonance theory still offers one approach for comprehending how healthcare workers reconcile their conflicting attitudes and perceptions to establish psychological consistency and reduce dissonance through vaccine recommendations and trust in authorities.

Another theory that may explain the study findings is Heider's balance theory, which reinforces the cognitive dissonance theory. This theory is based on a triadic model where a balance must exist among the three subjects involved. Therefore, the individual tends to seek modifications to maintain cognitive and emotional harmony and balance (54, 69, 70). According to this theory, healthcare workers in this study seek to maintain a balance between their trust in the science of vaccines, their trust in the Ministry of Health (which promotes vaccines), and their communication strategies and recommendations for the COVID-19 vaccine. Thus, a higher level of trust among healthcare workers in the science of vaccines leads to a higher level of trust in the Ministry of Health (which promotes vaccines), eventually resulting in behavior that reflects vaccination recommendations and adopts the same communication strategies as the Ministry of Health.

Study limitations

This is a qualitative study that does not profess to include a representative sample of healthcare workers. However, the strength of the qualitative study lies in the richness and depth of the collected data. A clear limitation is the small sample size (only 18 healthcare workers were interviewed). Consequently, the results cannot be generalized to the entire population of Israeli healthcare workers.

It is important to note, though, that thematic saturation was achieved within the analysis. In addition, the sample consisted of specific categories of healthcare workers (pediatricians, a physician, and nurses), who primarily work at child health centers that belong to the Ministry of Health and health organizations. As such, it is possible that the attitudes and perceptions shared may not fully encompass the diversity of views among Israel's broader healthcare community, which includes a more extensive array of professional roles and specializations. Therefore, future studies should include other healthcare workers besides the ones in the study sample. Further studies should also be conducted to evaluate the healthcare workers' trust in the health authorities, due to a dearth of these studies in the literature. It is important to note that this study was partly conducted before the COVID-19 outbreak and resumed after the COVID-19 vaccination campaign. Therefore, it aimed to address the change in attitudes and perceptions among healthcare workers regarding the communication of the vaccine issue. Thus, follow-up studies on healthcare workers' communication strategies should be conducted.

Conclusion

In summary, the study's findings indicate that healthcare workers have undergone professional socialization by the health system. Despite healthcare workers' perception that there has been a decrease in the public's trust in the Ministry of Health following the COVID-19 outbreak, the workers, themselves, continue to adopt the same communication strategies as the health authorities. Therefore, to increase the public's trust in both the healthcare system and in healthcare workers, multifaceted approaches and policies are recommended. Health organizations, authorities, and healthcare workers need to change their communication strategies to regain public trust. This includes transparently providing complete information, encouraging open dialogue to address public concerns and fears, and empowering healthcare workers to engage patients through dedicated discussion time and communication training. Health authorities and workers should also collaborate on unified messaging campaigns to enhance credibility, while tailoring outreach efforts to acknowledge the diversity of public perspectives across different demographic groups. It is important to note that while these recommendations are based on the findings from this study, the limited generalizability of the study should be considered.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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Ethics statement

The studies involving humans were approved by the Faculty of Social Welfare and Health Sciences Ethics Committee for research with human subjects at the University of Haifa (approval no. 421/17). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RH: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. AG-E: Conceptualization, Formal analysis, Supervision, Validation, Writing – original draft, Writing – review & editing. GM: Supervision, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

This study was part of RH PhD dissertation conducted at the School of Public Health, Faculty of Social Welfare and Health Sciences, University of Haifa, supervised by AG-E and GM.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of *Frontiers*, at the time of submission. This had no impact on the peer review process and the final decision.

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OPEN ACCESS

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RECEIVED 14 March 2024

ACCEPTED 16 May 2024

PUBLISHED 05 June 2024

CITATION

Alami A, Dave S, Uhlik C, Ebrahim M,
Krewski D and Laroche J (2024) Determinants
of influenza non-vaccination among
Canadian children: insights from a nationwide
survey.
Front. Public Health 12:1400782.
doi: 10.3389/fpubh.2024.1400782

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Determinants of influenza non-vaccination among Canadian children: insights from a nationwide survey

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Background: To identify determinants influencing Canadian parents' decision not to vaccinate their children aged 6 months to 17 years against seasonal influenza.

Methods: Data from the 2022 Childhood COVID-19 Immunization Coverage Survey, a national survey of approximately 10,500 Canadian parents/guardians and their children, was analyzed. The survey examined influenza vaccine coverage, parental perspectives on vaccines, reasons for hesitancy, and factors influencing immunization. Socio-demographic characteristics, including ethnicity, household income, working sector, educational attainment, and prevalence of chronic medical conditions among children were considered. Historical vaccine uptake and the impact of the COVID-19 pandemic on immunization decisions were also reviewed. Key determinants of non-vaccination in the 2021–2022 influenza season were analyzed using multivariable logistic regression, with a statistical significance level set at p -value < 0.05 .

Results: 70% of children aged 6 months to 17 years did not receive the seasonal influenza vaccine. Key predictors for non-vaccination included: residing in rural settings (aOR 1.35, 95% CI 1.13–1.60), parental education attainment of less than high school (aOR 2.48, 95% CI 1.24–4.97), and the absence of chronic medical conditions in children (aOR 1.60, 95% CI 1.34–1.91). Other strong predictors included lower household income; deterrence due to the COVID-19 pandemic; and parental hesitancy stemming from concerns about the vaccine's safety, effectiveness, and by beliefs that their child was not at risk of contracting the influenza or severe consequences from the infection.

Conclusion: This research underscores pivotal determinants of parental decisions not to vaccinate their children against seasonal influenza and sheds light on the impact of the COVID-19 pandemic. The results highlight the importance of addressing safety concerns and providing clear information to alleviate hesitancy.

KEYWORDS

influenza, survey, vaccine hesitancy, public health, immunization, COVID-19, Canada

Introduction

Childhood vaccination is fundamental in maintaining the health of both individuals and the broader community, especially when it comes to the seasonal influenza. This respiratory illness, though common, can lead to severe health complications, especially in young children and people over 65 years of age, as well as in those with underlying chronic health conditions (1, 2).

Children are particularly vulnerable to the seasonal influenza, with data from Canada showing they are disproportionately affected (3). Complications from influenza in children can include pneumonia, dehydration, and worsening of long-term medical problems such as heart disease or asthma, sinus problems, and ear infections (4). In rare cases, influenza complications can lead to death (4). According to the Canadian Immunization Monitoring Program Active (IMPACT) surveillance network, between 2004 and 2005 and 2012–2013 (excluding the 2009–2010 pandemic season) pediatric seasonal influenza was confirmed in 15.5% to 58.3% of hospital admissions in children 16 years of age and younger (5, 6). In the wake of the COVID-19 pandemic, the 2022–2023 seasonal influenza season in Canada marked a significant shift, resembling pre-pandemic seasonal influenza activity but with notable impact on pediatric population (7). According to the National Influenza Annual Report, Canada, 2022–2023, which draws on FluWatch data (a long-standing national surveillance system monitoring the spread of influenza and influenza-like illness in Canada), nearly half (45%; $n = 6,194/13,729$) of the reported influenza A detections occurred in the pediatric population (younger than 19 years) (7). Furthermore, when hospitalizations are broken down by type, the pediatric population accounted for 49% of hospitalizations associated with influenza B, compared to 22% for influenza A (7). Additionally, during this period, weekly pediatric influenza-associated hospital admissions persistently exceeded historical peak levels, with children aged 0–4 years being the most affected group, experiencing the highest cumulative hospitalization rate at 131 per 100,000 population (7).

Given these findings, and to mitigate the potential complications of seasonal influenza infection in children, the National Advisory Committee on Immunization (NACI) continues to recommend that the seasonal influenza vaccine should be offered annually to anyone 6 months of age and older who does not have a contraindication to the vaccine (5). Despite the availability of an effective vaccine, many parents are choosing not to vaccinate their children against the influenza (8). Gaining insights into the reasons behind these decisions is critical not only to boost vaccination rates, but also to ensure the broader community remains protected. With vaccine hesitancy frequently expressed during the recent COVID-19 pandemic, monitoring and understanding parental attitudes toward vaccination is critical to increasing seasonal influenza vaccination uptake. Parental perceptions can provide insight into expected vaccine uptake and can help shape public educational and awareness campaigns. This is particularly important given the high degree of uncertainty in estimates of seasonal influenza vaccine coverage in children. This study aims to explore factors associated with non-vaccination against the seasonal influenza in Canadian parents of children aged 6 months to 17 years old. The results of this study can provide valuable insights into parental attitudes and beliefs about influenza vaccination and inform the development of targeted interventions aimed at increasing seasonal influenza vaccination rates and protecting public health.

Methods

Data source

This study utilizes data from the 2022 Childhood COVID-19 Immunization Coverage Survey (CCICS) (9), an annual survey first implemented by the Public Health Agency of Canada in 2022. Data collection for this survey was conducted over a period extending from April 20 to July 21, 2022. The survey constitutes a nationally representative dataset for Canadian parents or guardians with children in specific age groups (0–4, 5–11, and 12–17 years). CCICS encompasses all Canadian provinces and territories and ensures a balanced representation of males and females. As a surveillance tool, CCICS provides both national and provincial/territorial-level estimates of several key factors, including seasonal influenza vaccine coverage among eligible children; knowledge, attitudes, and beliefs (KAB) of respondents toward vaccinations; and barriers and facilitators to immunization. The survey also provides information about the impact of the COVID-19 pandemic on vaccination decisions, as well as vaccination history and uptake among children and their parents or guardians. Socio-demographic data including household income, working sector, education, and citizenship status in Canada are also collected in the survey.

Study design

This cross-sectional study employed a probability-based sampling strategy, where the CCICS aimed for a sample size of 10,500 Canadian parents or guardians 18 years of age or older. To achieve a nationally representative sample, respondents were recruited from a general population sample by random digit dialing (RDD) (10), across all provinces and territories. The sampling framework allows for extrapolation to the broader Canadian population. To strengthen statistical power and ensure national representativeness, quotas were set for key sub-populations.¹ Survey sampling weights were applied to mirror the demographic composition of the Canadian population of children, based on child's sex, child's age group and province or territory of residence (based on the most recent data from the 2021 Statistics Canada census). Bootstraps were generated and applied to estimate variance. Overall, 100.3% of the target sample size was successfully achieved, ensuring that the study had adequate power.

Data collection

Data was captured using a multimodal approach, administered either online or through computer assisted telephone interviewing (CATI). CATI was specifically done in hard-to-reach populations to increase response rates (targeting parents in Atlantic and Northern provinces/territories who are often more difficult to reach online). This flexible approach facilitated comprehensive data collection across diverse demographic groups.

1 Key sub-populations for quotas included: parents with children aged 0–4, 5–11, and 12–17 years; parents from all provinces and territories; and a gender balance among children (50% males, 50% females).

Inclusion and exclusion criteria

In alignment with Health Canada's seasonal influenza vaccination authorization starting at 6 months of age, this analysis purposely excludes data on children younger than 6 months. Results are therefore based on survey responses from parents or guardians of children aged 6 months to 17 years across all Canadian provinces and territories. Missing data were not expected to pose a significant issue. A threshold for data removal was established: any variable exhibiting more than 20% missing data was excluded from the regression analysis. To assess the randomness of missing values in the dataset, we generated graphical summaries visualizing the patterns of missingness across variables: this visualization was performed for variables with more than 5% of missing data, allowing for an evaluation of whether the missing values demonstrated any discernable trends or patterns ([Supplementary material, Supplementary Figure S1](#)).

Statistical and data analysis

R Statistical Software (version 4.1.3; R Foundation for Statistical Computing, Vienna, Austria) was used for data analysis, including data filtering, analysis and wrangling, and both descriptive and inferential statistical analyses (11). Initial data exploration involved summarizing categorical dependent and independent variables using descriptive statistics. Unweighted and weighted frequencies and proportions were calculated, stratified by seasonal influenza vaccination status. Likert plots were used to summarize parental opinions on key KAB questions about vaccines: this graphical representation displayed the range of parental responses, from 'Strongly Agree' to 'Strongly Disagree,' for various belief statements about vaccine safety and effectiveness.

In line with our research objectives, we analyzed and incorporated parental hesitancy, along with its underlying reasons, to better understand determinants of children's non-vaccination against seasonal influenza. In the survey, parents were asked about their hesitancy to vaccinate their child against the influenza during the 2021–2022 season. Those who indicated hesitancy were prompted to select their specific reason(s). Given that respondents could choose multiple reasons, we categorized these into three broad categories for analytical purposes:

1. concerns about vaccine effectiveness, safety, and perceived risk which encompassed doubts about the influenza vaccine's efficacy, children's susceptibility to flu, potential vaccine side effects, concerns regarding combined influenza and COVID vaccinations, and past adverse vaccine events;
2. barriers related to access and information availability, including hesitancy due to challenges in discussing the influenza vaccine with healthcare experts, sourcing trustworthy information, and unfavorable encounters with medical practitioners; and
3. personal beliefs and other influences, such as religious or philosophical stances and fears of racism or discrimination.

From these categories, we developed a five-level classification system for analysis:

- "Not Hesitant,"
- "Hesitant: Effectiveness/Safety/Perceived Risk" (derived from the first category),

- "Hesitant: Access/Information" (from the second category),
- "Hesitant: Personal/Other Influences" (reflecting the third category),
- "Hesitant: Multiple Reasons" (for those indicating reasons across multiple categories).

This structured approach not only enriched our understanding of the multifaceted influences on vaccination hesitancy, but also was instrumental for our regression models. The five-level classification system facilitated a comprehensive exploration of the relationship between influenza vaccine hesitancy, vaccine uptake, and the specific parental reasons behind hesitancy.

A multivariable logistic regression model was employed to explore factors associated with non-vaccination of children aged 6 months to 17 years against the seasonal influenza. To account for the complexities of our survey design, we estimated standard errors, coefficients of variation, and confidence intervals using the bootstrap technique (12). As a starting point, univariate logistic regression analyses were fit to the survey data for each predictor to derive unadjusted odds ratios (ORs), with confidence interval (CI) set at 95%. Variables not achieving statistical significance at this stage were not immediately excluded; rather, as their effect could become apparent in a multivariable context after controlling for other variables, they were earmarked for potential removal in later stages.

To address multicollinearity among categorical predictors, we employed Cramer's V, guided by thresholds established by Lee et al. (13). Predictors exceeding a Cramer's V value of 0.4 were flagged for removal to mitigate the effects of a possible multicollinearity. We adopted a 'best fit' strategy for construction multivariable models. This entailed initially incorporating all relevant predictors, including those that showed statistically insignificant effects in the univariate analysis but were deemed practically significant. A stepwise backward elimination process was then conducted, guided by the Akaike Information Criterion (AIC), *p*-values, and adjustments for multiple comparisons. The final model was selected based on a combination of statistical significance, minimized AIC values and domain expertise. Adjusted odds ratios (aOR) were used to evaluate relationships between predictors and the outcome of non-vaccination among children. A likelihood ratio test was used to validate the goodness of fit of the final model (14).

An odds ratio plot was generated using ggplot2 and Finalfit packages in R (15) to visualize predictors and their respective aORs in the final model: this plot included 95% CI on the aORs to gauge the impact of each variable on the likelihood of non-vaccination in children.

Results

Sociodemographic characteristics of the survey population

A total of 10,536 individuals participated in the survey, achieving an overall response rate of 26.1%.

Of these, 10,236 respondents were included in the analysis, as responses from parents or guardians of children under 6 months of age were not included. [Table 1](#) presents the sociodemographic characteristics of the survey population, stratified by vaccination status. This table provides a comprehensive overview of the sample population across different variables, including province/territory, age of child and responding parent, sex, urban/rural setting, ethnicity, and household income.

TABLE 1 Sociodemographic characteristics of survey respondents, stratified by child seasonal influenza vaccination status.

	Overall	Vaccinated children	Unvaccinated children
Characteristic	N (%) ¹	N (%) ¹	N (%) ¹
Sample size	10,236 (100.0)	3,230 (30.0)	7,006 (70.0)
Province/Territory			
Alberta (AB)	1,240 (13.5)	463 (17.3)	777 (11.8)
British Columbia (BC)	1,342 (12.1)	444 (13.6)	898 (11.5)
Manitoba (MB)	399 (4.3)	180 (6.6)	219 (3.3)
New Brunswick (NB)	382 (1.9)	139 (2.2)	243 (1.7)
Newfoundland and Labrador (NL)	389 (1.2)	168 (1.7)	221 (0.9)
Nova Scotia (NS)	408 (2.3)	159 (3.0)	249 (2.0)
Ontario (ON)	3,019 (37.9)	932 (39.3)	2,087 (37.4)
Prince Edward Island (PE)	386 (0.4)	165 (0.6)	221 (0.3)
Quebec (QC)	1,945 (22.2)	251 (9.5)	1,694 (27.6)
Saskatchewan (SK)	404 (3.8)	175 (5.5)	229 (3.1)
Territories	322 (0.4)	154 (0.7)	168 (0.3)
Child age			
6 months – 4 years	2,551 (25.1)	1,047 (33.4)	1,504 (21.5)
5–11 years	3,724 (40.4)	1,166 (39.1)	2,558 (40.9)
12–17 years	3,961 (34.6)	1,017 (27.6)	2,944 (37.6)
Age of responding parent			
18–29	201 (1.7)	50 (0.9)	151 (2.0)
30–39	2,968 (30.0)	1,039 (33.0)	1,929 (28.7)
40–49	4,932 (49.2)	1,511 (47.9)	3,421 (49.8)
50+	2,025 (19.1)	612 (18.1)	1,413 (19.6)
Child sex at birth			
Male	5,306 (51.0)	1,656 (50.2)	3,650 (51.3)
Female	4,930 (49.0)	1,574 (49.8)	3,356 (48.7)
Sex of responding parent			
Male	3,990 (39.2)	1,209 (37.5)	2,781 (39.9)
Female	6,191 (60.8)	2,015 (62.5)	4,176 (60.1)
Urban/rural setting			
Urban	8,415 (86.1)	2,743 (89.7)	5,672 (84.5)
Rural	1,737 (13.9)	475 (10.3)	1,262 (15.5)
Ethnicity of responding parent			
Black	267 (2.9)	38 (1.3)	229 (3.6)
East/Southeast Asian	457 (4.4)	176 (5.5)	281 (3.9)
South Asian descent	304 (3.5)	94 (3.4)	210 (3.5)
Latin American	153 (1.7)	44 (1.4)	109 (1.8)
Middle Eastern and North African	222 (2.5)	54 (1.9)	168 (2.7)
Indigenous	158 (0.9)	52 (0.9)	106 (0.9)
White European descent	7,825 (79.1)	2,572 (80.8)	5,253 (78.3)
Other/Mixed parent ethnicity	476 (5.1)	138 (4.8)	338 (5.3)
Education of responding parent			
Less than high school	134 (1.1)	25 (0.4)	109 (1.4)
High school or equivalent	808 (7.3)	212 (6.1)	596 (7.9)
Postsecondary below Bachelor's	3,247 (31.5)	766 (22.1)	2,481 (35.6)
Bachelor's or above	5,926 (60.0)	2,209 (71.3)	3,717 (55.1)

(Continued)

TABLE 1 (Continued)

	Overall	Vaccinated children	Unvaccinated children
Status of residency in Canada			
Canadian by birth	8,111 (78.5)	2,684 (82.1)	5,427 (76.9)
Canadian by naturalization	1,578 (17.0)	405 (14.1)	1,173 (18.3)
Permanent resident/landed immigrant	447 (4.1)	122 (3.5)	325 (4.4)
Refugee claimant/Asylum seekers	9 (0.1)	4 (0.1)	5 (0.1)
Temporary resident	36 (0.2)	9 (0.2)	27 (0.3)
Working sector of responding parent			
High-risk sector ²	3,970 (39.4)	1,326 (40.4)	2,644 (38.9)
Not high-risk sector	5,969 (60.6)	1,859 (59.6)	4,110 (61.1)
Total household income (\$)			
Under 40,000	650 (6.7)	136 (4.5)	514 (7.6)
40,000-59,999	721 (7.3)	153 (4.5)	568 (8.5)
60,000-79,999	870 (8.9)	222 (6.6)	648 (9.9)
80,000-99,999	1,152 (11.9)	324 (10.1)	828 (12.7)
100,000-149,999	2,502 (27.0)	776 (25.5)	1,726 (27.7)
150,000 and above	3,522 (38.2)	1,414 (48.8)	2,108 (33.5)
Prevalence of chronic conditions among children			
With chronic condition ³	1,285 (12.4)	473 (14.7)	812 (11.4)
Without chronic condition	8,835 (87.6)	2,729 (85.3)	6,106 (88.6)
Prevalence of disabilities among children			
With disability ⁴	675 (6.5)	197 (6.0)	478 (6.7)
Without disability	9,477 (93.5)	3,011 (94.0)	6,466 (93.3)

¹Percent weighted by: region, child's age group, and child's sex at birth.

²High-Risk Working Sector: This category includes individuals currently employed or volunteering in sectors with elevated exposure risks. These sectors encompass healthcare, laboratory services, childcare, educational institutions, occupations with animal exposure, emergency services, and other critical roles such as staff in correctional facilities, crew on ships or aircraft, military personnel, humanitarian relief workers, and providers of essential community services.

³Chronic Medical Condition: This refers to health conditions as outlined in the Canadian Immunization Guide and include sickle cell anemia or thalassemia major, neurological or neurodevelopmental disorders, asthma and other chronic respiratory diseases, chronic conditions affecting the liver, heart, or kidneys, diabetes, obesity, Down Syndrome, immune suppression (due to chemotherapy, radiotherapy, steroid use, HIV, organ transplants), cancer, and other significant medical conditions.

⁴Disability: This is defined as a person who has a long-term or recurring impairment (such as vision, hearing, mobility, flexibility, dexterity, pain, learning, developmental, memory or mental health-related) which limits their daily activities inside or outside the home (such as at school, work, or in the community in general).

Thirty percent (30.0%, $N=3,230$) of children younger than 18 years were vaccinated against seasonal influenza. A majority of the responding parents/guardians were female (60.8%) and of White European descent (79.1%). Nearly two thirds of the parents (60.0%) had a bachelor's degree or higher, with 39.4% reporting being employed in high-risk sectors (including health care or laboratory workers, those working in child care or schools, those exposed to animals or their materials, and emergency services workers). Children ranged in age from 6 months to 4 years (25.1%), 5 to 11 years (40.4%), and 12 and 17 years (34.6%). A small minority of children had chronic medical conditions (12.4%) and disabilities (6.5%).

Pre-Pandemic and current seasonal influenza vaccination patterns among parents and children

Prior to the COVID-19 pandemic, 42.7% of parents indicated that they typically received an seasonal influenza vaccine either every influenza season or most seasons. However, for the 2021–2022

influenza season, two-thirds (66.9%) of parents opted out of receiving the vaccine, while only one-third (33.1%) reported getting vaccinated (Table 2). When asked about their child's seasonal influenza vaccination status prior to the COVID-19 pandemic, 38.4% of parents indicated vaccinating their child every or most influenza seasons, 18.5% reported having their children vaccinated sometimes, and 43.1% reported never vaccinating their child against the flu. A great majority of parents (93.3%) reported that their child had received all recommended routine vaccinations, with a further 4.2% receiving partial vaccinations, and 2.4% remaining unvaccinated.

Concerning the likelihood of having their child vaccinated against seasonal influenza in the upcoming season, approximately half (50.3%) of parents signaled strong intent (either 'definitely will' or 'probably will') to have their children vaccinated; 22.9% of parents expressed a moderate likelihood of avoiding vaccination, saying they 'probably will not', while 18.9% expressed strong views against vaccination, responding with 'definitely will not'.

The most common motivation for parents vaccinating their child was self and household protection from seasonal influenza (85.0%), followed by desire to prevent the spread of seasonal influenza in the

TABLE 2 Parental and child seasonal influenza vaccination history, future intentions, and reasons for vaccination.

Vaccination history and reasons for vaccination	N (%) ¹
Responding parent frequency of receiving an influenza vaccine prior to COVID-19	
Every influenza (flu) season	2,475 (23.2)
Most influenza (flu) seasons	2,006 (19.5)
Some influenza (flu) seasons (including once only)	2,818 (27.8)
Never	2,894 (29.5)
Responding parent influenza vaccination during the 2021–2022 influenza season	
Yes, vaccinated	3,928 (37.1)
No, did not get the vaccine	6,263 (62.9)
Uptake of recommended routine child vaccination	
Complete	8,786 (93.3)
Partial	384 (4.2)
None	219 (2.4)
Child frequency of receiving a influenza vaccine prior to the COVID-19 pandemic	
Every influenza (flu) season	2,330 (24.3)
Most influenza (flu) seasons	1,354 (14.1)
Some influenza (flu) seasons (including once only)	1,783 (18.5)
Never	3,831 (43.1)
How likely is it that you will get your child vaccinated against the influenza (flu) in the next influenza (flu) season?	
Definitely will	2,871 (26.7)
Probably will	2,455 (23.6)
Probably will not	2,264 (22.9)
Definitely will not	1,836 (18.9)
Do not know	780 (7.9)
Reasons for child to receive a influenza (flu) vaccine	
To protect themselves and/or household members from the influenza (flu)	2,688 (84.5)
Based on public health recommendations	1,507 (46.1)
To prevent the spread of the flu in my community	1,594 (49.2)
The influenza (flu) vaccine was recommended by a health care professional	928 (27.7)
The influenza (flu) vaccine is available and free	1,343 (40.5)
Increased concerns about flu because of the COVID-19 pandemic	914 (27.9)
My child receives it every year	1,578 (48.9)
Other	49 (1.6)

¹Percent weighted by: region, child's age group, and child's sex at birth.

²Multiple response options could be selected by respondents.

community (49.0%), and the fact that the child receives the vaccine annually (48.0%).²

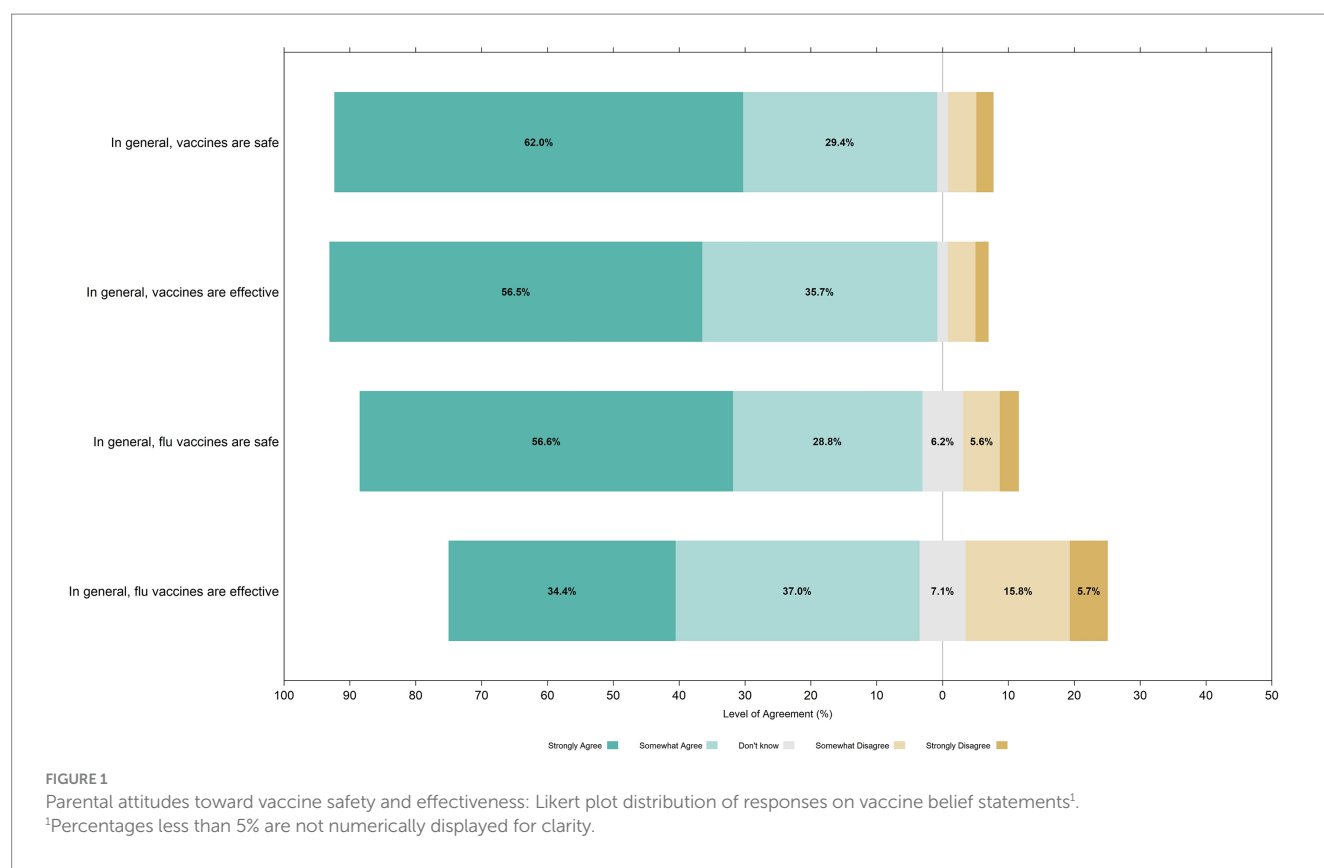
Parental attitudes, influences, and barriers to seasonal influenza vaccination

A substantial majority of parents expressed favorable opinions regarding general vaccine safety and effectiveness. Specifically, 91.4%

of parents either strongly or somewhat agreed that vaccines are generally safe, and 92.2% concurred on their effectiveness. Confidence levels in seasonal influenza vaccines varied somewhat: 85.4% of parents believed the influenza vaccine to be safe, and 71.4% attested to its effectiveness. A Likert plot displaying the range of responses on the various belief statements is provided in [Figure 1](#), illustrating the distribution of opinions among survey respondents.

Approximately 24% of parents expressed hesitancy in vaccinating their child against seasonal influenza. The primary reason underlying this hesitancy was the belief that their child was not at risk of contracting influenza or developing severe symptoms, a view held by nearly half (47.2%) of these hesitant parents. Additional reservations were grounded in concerns about the influenza vaccine's effectiveness (35%) and apprehensions regarding its safety or potential side effects (29.4%). These

² As participants could select multiple options, percentages do not add to 100%.



specific reasons for hesitancy are further detailed in Table 3. While the COVID-19 pandemic might have impacted seasonal influenza vaccination decisions for the 2021–2022 season, a notable majority (79.7%) of parents reported that the pandemic did not influence their choice. While the pandemic served as a motivator for 10.6% of parents, nearly an identical percentage found it to be a deterrent for vaccinating their child against the influenza. When examining the barriers that might have prevented parents from vaccinating children against seasonal influenza, the vast majority (81%) reported no obstacles to vaccination. Among the remaining parents who did face challenges, the barriers were diverse. Difficulty in securing time off from work or school was the most common obstacle, cited by 34% of these parents, followed by their child's fear of needles (24%). Financial concerns were relatively rare, with only 3% citing the cost of the vaccine as a barrier. Other obstacles included limited access to transportation in remote areas (2%), language barriers (0.5%), and concerns about racism or discrimination (0.9%).

Determinants of non-vaccination

As detailed in Table 4, the multivariable logistic regression models incorporated variables that were identified as predictors for non-vaccination against seasonal influenza in children. Independent predictors of non-vaccination included the child being in the older age group (12–17 years) compared to younger children (less than 12 years of age), residence in rural locales rather than urban settings (aOR: 1.35, 95% CI: 1.13–1.60, $p < 0.001$), and parental educational attainment below the level of a Bachelor's degree compared to those with a Bachelor's degree or above. Ethnicity of the parent was also

found to be a predictor of non-vaccination, but its impact was not uniform across all groups, with children of Black parents significantly more likely to be non-vaccinated compared to children of White European descent (aOR: 2.91, 95% CI: 1.82, 4.67, $p < 0.001$). Children in lower household income tiers were associated with a significantly higher odds of non-vaccination compared to the highest income bracket (>\$150,000): under \$40,000 (aOR: 1.80, 95% CI: 1.35–2.41, $p < 0.001$) and \$40,000–\$59,999 (aOR: 2.07, 95% CI: 1.58–2.72, $p < 0.001$). Additionally, parents who perceived the COVID-19 pandemic as a deterrent to seasonal influenza vaccination were considerably more likely to refrain from vaccinating their child (aOR: 9.59, 95% CI: 6.04, 15.23, $p < 0.001$). Reasons given by respondents for their reluctance to vaccinate their children were strong predictors of non-vaccination. For example, parental hesitancy due to concerns about seasonal influenza vaccine effectiveness, safety, and perceived risk of infection were associated with a significant high odds of non-vaccination compared to non-hesitant parents (aOR: 18.78, 95% CI: 13.03, 27.08, $p < 0.001$). Figure 2 provides a visual representation of the multivariable logistic regression model's findings, which display the aORs and their 95% confidence intervals for each predictor of seasonal influenza non-vaccine.

Discussion

Using data from a nationally representative sample of Canadian parents/guardians with children under 18 years of age, this study explores factors influencing parental decisions to vaccinate children against seasonal influenza. Notably, during the 2021–2022 influenza

TABLE 3 Knowledge, attitudinal and behavioral factors affecting parental hesitancy toward child seasonal influenza vaccination.

Factor	N (%) ¹
Parental opinion on safety of vaccines	
Strongly agree	6,379 (62.0)
Somewhat agree	2,961 (29.4)
Don't know	166 (1.8)
Somewhat disagree	418 (4.3)
Strongly disagree	255 (2.5)
Parental opinion on effectiveness of vaccines	
Strongly agree	5,875 (56.5)
Somewhat agree	3,551 (35.7)
Don't know	166 (1.7)
Somewhat disagree	404 (4.2)
Strongly disagree	197 (1.9)
Parental opinion on safety of flu vaccines	
Strongly agree	5,882 (56.6)
Somewhat agree	2,903 (28.8)
Don't know	595 (6.2)
Somewhat disagree	536 (5.6)
Strongly disagree	267 (2.8)
Parental opinion on effectiveness of flu vaccines	
Strongly agree	3,654 (34.4)
Somewhat agree	3,809 (37.0)
Don't know	687 (7.1)
Somewhat disagree	1,496 (15.8)
Strongly disagree	545 (5.7)
Responding parent hesitancy² in vaccinating child against flu	
Hesitant	2,236 (23.7)
Not hesitant	7,514 (76.3)
Impact of COVID-19 pandemic on parental decision to vaccinate their children against flu	
More likely	1059 (10.6)
Less likely	954 (9.7)
No impact	7976 (79.7)
Reasons why parents were hesitant to vaccinate their children against the flu³	
My child is not at risk of getting the flu or at risk of severe infection	950 (42.8)
I wanted to first discuss the flu vaccine with my child's health care practitioner	94 (3.9)
I was concerned about the effectiveness of the flu vaccine	773 (35.0)
I had concerns about the safety of the flu vaccine and/or side effects	660 (29.4)
My child had a bad experience with previous vaccines	141 (6.2)
I did not know where to get reliable information	54 (2.1)
Religious or philosophical reasons	107 (4.8)
My child had a bad experience with healthcare providers	27 (1.1)
Concerns about racism or discrimination	15 (0.7)
Never get flu vaccine/not necessary	101 (4.3)
Concerns about combining the COVID-19 & flu vaccines /COVID-19 vaccine was enough	69 (2.9)
Other	268 (11.4)

(Continued)

TABLE 3 (Continued)

Factor	N (%) ¹
Obstacles that prevented parents from vaccinating their children against the flu³	
No obstacles	1,571 (80.9)
Difficulty to book time off work/school for a vaccine appointment	431 (34.1)
Living in a remote area (limited transportation)	26 (2.0)
No reliable internet access	#
Cost of the vaccine	32 (2.7)
Language barrier	8 (0.5)
Concerns about racism or discrimination	11 (0.9)
My child fears needles	320 (24.3)
Other	578 (44.1)

¹High sampling variability or small sample size.

²Percent weighted by region, child's age group, and child's sex at birth.

³Vaccine hesitancy refers to a delay in acceptance or refusal of vaccines despite availability.

⁴Multiple response options could be selected by respondents.

season, a substantial majority of 70% of the children within this age bracket remained unvaccinated. The survey data indicated that prior to the COVID-19 pandemic, only 24% of children received the influenza vaccine every influenza season, with 43% of parents surveyed reporting their child had never received the vaccine. Interestingly, in light of the potential impact of the pandemic on Canadians' view on vaccination, 80% of parents or guardians indicated that the pandemic did not alter seasonal influenza vaccination decisions for their children.

The great majority (81%) of parents or guardians whose children remained unvaccinated reported encountering no barriers to the seasonal influenza vaccination process. At the same time, about a quarter (24%) of parents or guardians expressed hesitancy toward the vaccination of their children against seasonal influenza. This hesitancy stemmed predominantly from a perceived lack of risk associated with the disease and reservations about the vaccine's efficacy and safety, suggesting that both the threat from seasonal influenza infection and the advantages of vaccination are underestimated. The diminished perception of risk correlates directly with reduced vaccine uptake, a pattern consistent with findings from broader international research (8, 16).

In the present study, sociodemographic factors were strongly correlated with vaccination decisions. Specifically, our analysis demonstrated a decreasing likelihood of non-vaccination with decreasing age, a finding that aligns with previous research exploring determinants of seasonal influenza vaccination in children prior to the onset of the COVID-19 pandemic (17, 18). This pattern is particularly important given that younger children with seasonal influenza often manifest symptomatic infections at higher rates, require antibiotic treatments, and on occasions experience severe complications (19, 20).

While there is some evidence that sex may play a role in seasonal influenza vaccine coverage among children (21–23), we did not find significant differences in seasonal influenza vaccine uptake between male and female children. However, disparities emerged when examining the influence of parental ethnicity on vaccination patterns. Notably, children of Black parents exhibited an almost three-fold increase in the likelihood of non-vaccination relative to those of White European descent. Such disparities highlight the possibility of varied barriers to vaccination across different ethnic groups, a theme supported by prior studies (24–26).

Geographic differences also had a substantial influence on vaccination coverage. Children residing in urban settings typically exhibit a higher likelihood of receiving the seasonal influenza vaccine, which may be largely attributed to greater accessibility to health services (27). In the present study, children from rural areas were 35% more likely to be unvaccinated compared to their urban peers. This trend corroborates earlier findings of lower seasonal influenza vaccination coverage observed among children living in rural settings, irrespective of factors like the child's age, maternal educational background, family income, or the number of children in the same household (27). Educational attainment of parents emerged as an important determinant of vaccination choices. Previous research suggests that parents with lower educational attainment generally have reduced literacy rates, potentially affecting their understanding of the risks associated with seasonal influenza on their children (28–31). Similarly, our analysis revealed that parents with lower levels of education are more likely to have non-vaccinated children compared to those with a university degree. Additionally, the COVID-19 pandemic emerged as a determinant of parental decisions on vaccinating their children: although the majority of respondents indicated that the pandemic did not influence their decision regarding seasonal influenza vaccination for their child, those who felt deterred by the pandemic exhibited markedly increased odds of having their child unvaccinated. This observation aligns with recent research, which identified changes in risk perception due to COVID-19 as a significant factor influencing caregivers' intentions to vaccinate their children against seasonal influenza (32).

The findings from this analysis underscore the complexity and multifaceted nature of parental hesitancy toward vaccinating their children against seasonal influenza. Concerns related to seasonal influenza vaccine effectiveness, safety, and perception of seriousness of the seasonal influenza infection emerged as a strong predictor of child non-vaccination. Despite the availability of various resources in Canada to inform families about the importance of influenza vaccination in children, such as the Canadian Immunization Guide by the Public Health Agency of Canada (33), influenza prevention infographics and factsheets by Immunize Canada (34), and detailed efficacy data from the NACI in its Canadian Immunization Guide Chapter on Influenza and Statement on Seasonal Influenza Vaccine (35), parental concerns about the effectiveness of the vaccine in children persist. This observation aligns

TABLE 4 Multivariable logistic regression analysis: identifying key predictors of seasonal influenza non-vaccination in children.

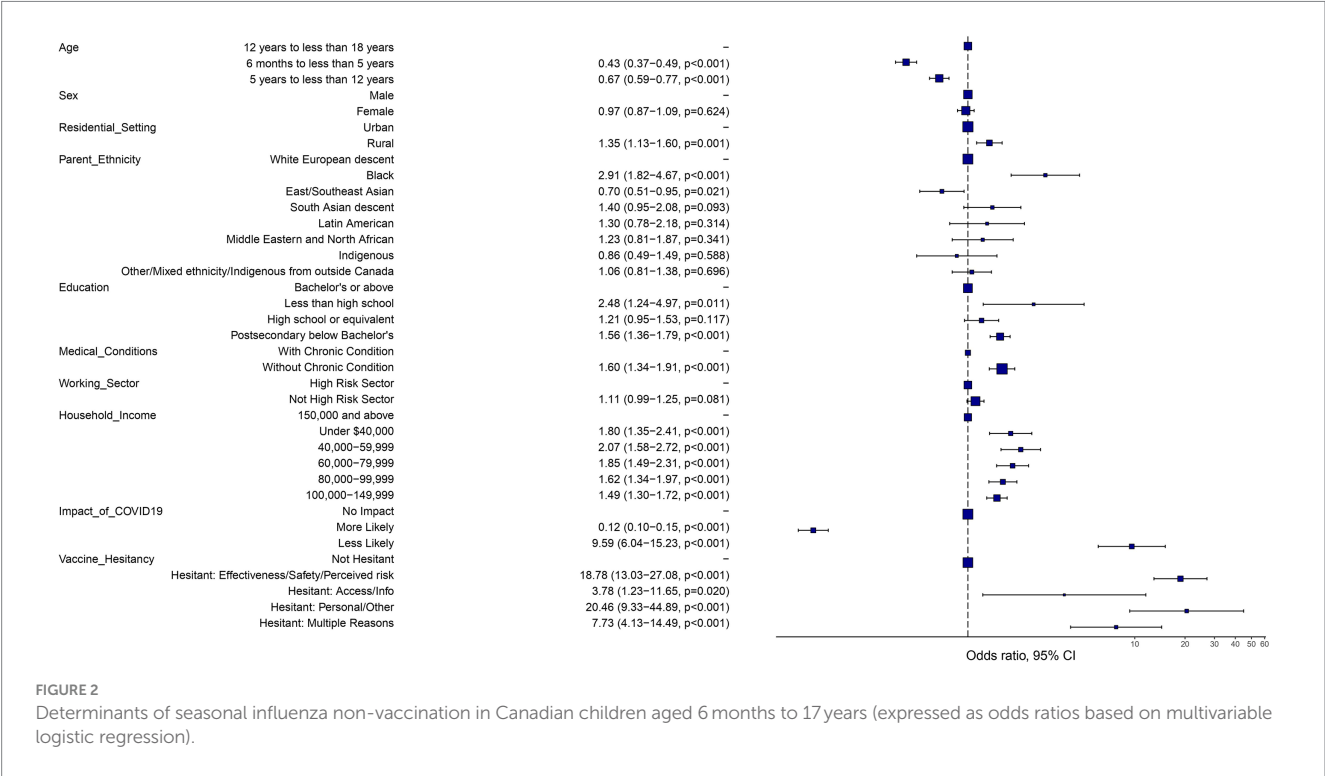
Characteristic	Adjusted Odds Ratio		
	aOR ¹	95% CI ²	p-value
Child age			<0.001
12 years to less than 18 years	—	—	
6 months to less than 5 years	0.43	0.37, 0.49	<0.001
5 years to less than 12 years	0.67	0.59, 0.77	<0.001
Child Sex			0.624
Male	—	—	
Female	0.97	0.87, 1.09	0.624
Urban/Rural setting			<0.001
Urban	—	—	
Rural	1.35	1.13, 1.60	<0.001
Ethnicity of responding parent			<0.001
White European descent	—	—	
Black	2.91	1.82, 4.67	<0.001
East/Southeast Asian	0.70	0.51, 0.95	0.021
South Asian descent	1.40	0.95, 2.08	0.093
Latin American	1.30	0.78, 2.18	0.314
Middle Eastern and North African	1.23	0.81, 1.87	0.341
Indigenous	0.86	0.49, 1.49	0.588
Other/mixed ethnicity/Indigenous from outside Canada	1.06	0.81, 1.38	0.696
Education of responding parent			<0.001
Bachelor's or above	—	—	
Less than high school	2.48	1.24, 4.97	0.011
High school or equivalent	1.21	0.95, 1.53	0.117
Postsecondary below Bachelor's	1.56	1.36, 1.79	<0.001
Existing medical condition of child			<0.001
With chronic condition	—	—	
Without chronic condition	1.60	1.34, 1.91	<0.001
Working sector of responding parent			0.081
High risk sector	—	—	
Not high risk Sector	1.11	0.99, 1.25	0.081
Total household income (\$)			<0.001
150,000 and above	—	—	
Under 40,000	1.80	1.35, 2.41	<0.001
40,000–59,999	2.07	1.58, 2.72	<0.001
60,000–79,999	1.85	1.49, 2.31	<0.001
80,000–99,999	1.62	1.34, 1.97	<0.001
100,000–149,999	1.49	1.30, 1.72	<0.001
Impact of COVID-19 pandemic on parental decision to vaccinate children against influenza			<0.001
No impact	—	—	
More likely	0.12	0.10, 0.15	<0.001
Less likely	9.59	6.04, 15.23	<0.001
Reasons for parental hesitancy to vaccinate child against influenza			<0.001
Not hesitant	—	—	
Hesitant: effectiveness/safety/perceived risk	18.78	13.03, 27.08	<0.001

(Continued)

TABLE 4 (Continued)

Characteristic	Adjusted Odds Ratio		
	aOR ¹	95% CI ²	p-value
Hesitant: access/info	3.78	1.23, 11.65	0.020
Hesitant: personal/other	20.46	9.33, 44.89	<0.001
Hesitant: multiple reasons	7.73	4.13, 14.49	<0.001

¹aOR = adjusted odds ratio.
²CI = confidence interval.



with other studies, which have also highlighted that parents' comprehension of influenza's severity and the potential safety and adverse effects of the vaccine play a pivotal role in the seasonal influenza vaccine uptake and decisions to vaccinate their children (28, 36–38). Such findings resonate with earlier studies that spotlight the influence of prior vaccination behaviors on current decisions (39), weaving a narrative of the complex interplay between historical experiences and present-day vaccination decisions (40–42).

It is evident that many parents' decisions to vaccinate or not are anchored in their perceptions of risk, often shaped by incorrect or incomplete information (43, 44), including concerns that the vaccine might induce influenza or unfounded fears about potential side effects (45). In this study, parents expressing hesitancy due to concerns about the vaccine's effectiveness, safety, or their perception of risk had significantly higher odds of not vaccinating their children than parents who were not hesitant. Likewise, parents who cited multiple reasons for their hesitancy, access or information-related hesitancy concerns, and those who expressed personal or other reasons for hesitancy were also strongly associated with non-vaccination. This underscores the need of accurate information dissemination, clear public health messages about the potential seriousness of influenza infection in children, and addressing parental concerns about the safety and efficacy of the seasonal influenza vaccine to enhance immunization rates among children. In light of these

challenges, short-term interventions can play a pivotal role in improving vaccine coverage. Implementing face-to-face communication interventions allows for direct engagement with parents, effectively conveying the importance of influenza vaccination. Furthermore, expanding digital platforms can facilitate the dissemination of accessible, science-backed information, empowering parents to make informed decisions. Additionally, launching targeted educational campaigns directed at parents and caregivers can highlight the benefits of influenza vaccination, emphasizing its role in preventing severe illness, reducing hospitalizations, and safeguarding vulnerable populations. By employing these strategies, we can enhance immunization rates among children, contributing to the broader goal of public health protection.

Strengths of our study include the large sample size; a detailed examination of sociodemographic factors, parental and child vaccine uptake history; and questions on parental knowledge, attitudes, and beliefs, including the impact of COVID-19 pandemic. To our knowledge, this study is the first to assess children's seasonal influenza vaccination in Canada during the COVID-19 pandemic, and utilizing a nationally representative sample. We also acknowledge specific limitations of the study. As protocol called for surveying just one adult (parent/guardian) and one child from each family, the vaccination status of other siblings within the family was not examined. With an overall response rate of 26.1%, there remains the possibility of

non-response bias. However, different strategies were employed to minimize the potential risk of this bias, including utilizing local phone number outpulsing and offering the survey in Canada's two official languages. Although reliance on self-reported data introduces the possibility of recall bias, the likelihood of such bias is presumably low since respondents were reflecting on vaccinations within the last six months.

Conclusion

This survey underscores the complexity of parental decisions regarding vaccinating their children against seasonal influenza. Key determinants influencing non-vaccination decisions included lower household income, lower parental educational attainment, the influence of the COVID-19 pandemic as a deterrent, and various facets of vaccine hesitancy. These findings offer valuable insights for policymakers and public health professionals, emphasizing the need for tailored strategies to overcome barriers, especially in lower-income families. By addressing parental concerns, including safety apprehensions and misconceptions about seasonal influenza vaccination, and implementing informed, targeted public health initiatives, these strategies can effectively alleviate hesitancy and enhance vaccination uptake, thereby contributing to better overall public health outcomes.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Detailed results, tables, and the methodological report can be accessed through the Library and Archives Canada website. Survey results can be accessed at: <https://www.canada.ca/en/public-health/services/immunization-vaccines/vaccination-coverage/childhood-covid-19-immunization-coverage-survey-2022-results.html>. Requests to access the dataset should be directed to: ccics-ecvec@phac-aspc.gc.ca.

Ethics statement

The studies involving humans were approved by the Health Canada and the Public Health Agency of Canada Research Ethics Board. Participants provided their informed consent to participate in the survey. The survey was also approved by the Privacy Management Division of the Public Health Agency of Canada. The studies were conducted in accordance with the local legislation and institutional

requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AA: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. SD: Conceptualization, Validation, Writing – review & editing. CU: Conceptualization, Validation, Writing – review & editing. ME: Conceptualization, Supervision, Writing – review & editing. DK: Conceptualization, Methodology, Supervision, Writing – review & editing. JL: Conceptualization, Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This study was supported by funding from the Public Health Agency of Canada.

Conflict of interest

DK reports serving on the Chief Science Advisor for Canada's Expert Panel on COVID-19 from 2020–2023.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1400782/full#supplementary-material>

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RECEIVED 16 April 2024

ACCEPTED 06 June 2024

PUBLISHED 25 June 2024

CITATION

Ramphul R, Zamorano AS, Upadhyay S,
Desai M and Bauer C (2024) Spatiotemporal
analysis of HPV vaccination and associated
neighborhood-level disparities in Texas—an
ecological study.

Front. Public Health 12:1418526.

doi: 10.3389/fpubh.2024.1418526

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Spatiotemporal analysis of HPV vaccination and associated neighborhood-level disparities in Texas—an ecological study

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Background: HPV is responsible for most cervical, oropharyngeal, anal, vaginal, and vulvar cancers. The HPV vaccine has decreased cervical cancer incidence, but only 49% of Texas adolescents have initiated the vaccine. Texas shows great variation in HPV vaccination rates. We used geospatial analysis to identify areas with high and low vaccination rates and explored differences in neighborhood characteristics.

Methods: Using Anselin's Local Moran's I statistic, we conducted an ecological analysis of hot and cold spots of adolescent HPV vaccination coverage in Texas from 2017 to 2021. Next, we utilized a Mann–Whitney U test to compare neighborhood characteristics of vaccination coverage in hot spots versus cold spots, leveraging data from the Child Opportunity Index (COI) and American Community Survey.

Results: In Texas, there are 64 persistent vaccination coverage hotspots and 55 persistent vaccination coverage cold spots. The persistent vaccination coverage hot spots are characterized by ZIP codes with lower COI scores, higher percentages of Hispanic residents, higher poverty rates, and smaller populations per square mile compared to vaccine coverage cold spots. We found a more pronounced spatial clustering pattern for male adolescent vaccine coverage than we did for female adolescent vaccine coverage.

Conclusion: In Texas, HPV vaccination coverage rates differ depending on the community's income level, with lower-income areas achieving higher success rates. Notably, there are also gender-based discrepancies in vaccination coverage rates, particularly among male adolescents. This knowledge can aid advocates in customizing their outreach initiatives to address these disparities.

KEYWORDS

spatial analysis, HPV vaccination, vaccination disparities, cancer prevention, minority health, HPV, geospatial analysis, health care disparities

Introduction

Human papillomavirus (HPV) accounts for over 99% of cervical cancers and most oropharyngeal, anal, vaginal, and vulvar cancer (1, 2). More than 90% of HPV-associated cancers are preventable through HPV vaccination (3), which is recommended as a routine vaccination for children as early as age 9, with catch-up recommended up to age 26 for those not previously vaccinated and up to age 45 using shared clinical decision-making (4). Since the introduction of the HPV vaccine in 2006, there has already been a significant decline in nationwide cervical cancer incidence, especially in the 15–20-year age group, suggesting the positive impact of vaccination (5). However, the United States falls well behind its Healthy People 2020 target of 80% vaccinated adolescents, with only 54.5% completing the series (6, 7).

As of 2017, only 49% of adolescents in Texas had initiated the HPV vaccine series, and the state ranks 47 out of 50 in vaccination rates nationwide (8). Vaccination rates across the state are not geographically uniform, with some rural counties outperforming the major cities and the rest of the states (8, 9). While previous studies have demonstrated this regional variation, they have been limited to analyses of large state regions, which makes further analysis of associated sociodemographic factors incomplete.

Geospatial analyses of HPV vaccination have been crucial to identify disparities and target areas for intervention. A systematic review of area-level variation in HPV vaccination uptake revealed significant differences influenced by socioeconomic factors, healthcare access, and educational attainment (10). For example, regions with higher poverty rates and lower access to healthcare services often exhibit lower vaccination rates. Conversely, areas with robust public health infrastructures and targeted education campaigns tend to achieve higher vaccination coverage. These findings emphasize the need for localized public health strategies considering these sociodemographic factors. By understanding the specific characteristics and barriers in different regions, public health initiatives can be better tailored to improve HPV vaccination rates effectively (10, 11). Such detailed geospatial and sociodemographic analyses can help bridge the gaps in HPV vaccination coverage, ensuring more uniform protection against HPV-associated cancers across diverse communities.

Significant barriers to HPV vaccination exist, including lack of knowledge of the vaccine or the associated cancers, lack of access to immunization (involving geographic, financial, and public policy factors), lack of provider recommendation, and parental hesitations about accepting the vaccine for children/adolescents due to the association with a sexually transmitted infection (12). We aim to geospatially model areas of Texas with persistently high or low levels of HPV vaccination coverage to better understand the associated area-level characteristics and identify areas where increased vaccination efforts may be pursued.

Methods

Study population

Data were obtained through the Texas Department of State Health Services Immunization Information System (ImmTrac2) Registry (13) on the percentage of registrants aged 9+ who received at least one dose

of the HPV vaccine, categorized by ZIP code, for each year from 2017 to 2021. It also provided separate percentage estimates of male and female registrants aged 9+ who received at least one dose by ZIP for each year from 2017–2021. ImmTrac2 is a state-wide opt-in vaccine registry and includes information provided by healthcare providers, pharmacies, public health clinics, Medicaid claims administrators, and the Texas Department of State Health Services Vital Statistics Unit. While it contains information for both children and adults, most children are entered into the system at birth, while adults over 18 must consent to participate or continue participation. Additionally, vaccinations given to children must be reported by law (13). As a result, the ImmTrac2 registry is predominantly valuable as a database for vaccinations of childhood and adolescence. ImmTrac2 opt-in immunization registry requires parental consent to store children's vaccination records. While Texas law mandates healthcare providers to report all immunizations given to children under 18 to ImmTrac2, including these records in the registry relies on obtaining parental or guardian consent. If consent is provided, the vaccination information is stored; otherwise, it is not, although the provider still meets the legal reporting requirement. The exact percentage of childhood vaccinations reported to ImmTrac2 varies based on consent rates, but mandatory reporting ensures a high overall reporting rate despite the lack of precise figures (13). In 2020, 80% of Texas children under 6 years old had at least two immunizations recorded in ImmTrac2 (14), indicating ImmTrac2's robust coverage of pediatric populations.

Data in this study was publicly available and received an exemption from Institutional Review Board (IRB) approval.

Mapping and statistical analysis

We utilized Anselin's Local Moran's I statistic, pioneered by Luc Anselin in the "Local Indicators of Spatial Association—LISA," to identify statistically significant clusters of ZIP codes with high/low estimated rates of HPV vaccination coverage each year from 2017 to 2021 (15). Using the Environmental Science Research Institute's ArcGIS Pro Version 2.2.0 software, we ran the Cluster and Outlier Analysis Tool, which implements the Local Moran's I statistic by first determining a "neighborhood" around each ZIP code in the dataset (16). While several strategies exist to determine the "neighborhood" around each ZIP code, we used the Queen Contiguity Method. In this method, all ZIP codes that touch a ZIP code are considered its "neighborhood" and are included in its computations (17). The Queen Contiguity Method has been successfully used in several studies to identify health outcomes and service clusters (17).

After determining the neighborhoods around each ZIP code, the Cluster and Outlier Analysis Tool calculates a Local Moran's I score for each ZIP code, where a positive value for "I" indicates that a ZIP code has a neighboring ZIP code with similarly high or low vaccination rates compared to the rest of the study area (16). These ZIP codes are part of clusters. After calculating a Local Moran's I for each ZIP code in the data set, statistical significance is tested by running a Monte Carlo simulation. The values in the "neighborhoods" around each ZIP in the study area are randomly rearranged 9,999 times. A Local Moran's I score is calculated each time, creating a random reference distribution of Local Moran's I to compare with the observed Local Moran's I. A pseudo-*p*-value is then calculated by determining the proportion of Local Moran's I statistics generated

from random permutations that display more clustering than the original data. If the proportion is less than 0.05, the ZIP code is demarcated as a statistically significant vaccination coverage hot or cold spot (16). Persistent vaccination coverage in hot and cold spots were defined as ZIP codes that consistently exhibited statistically significant high or low vaccination coverage rates over five consecutive years, respectively.

Finally, we utilized a Mann–Whitney U test to explore statistical differences in neighborhood characteristics between ZIP codes that were persistent vaccination coverage hot or cold spots for all registrants aged 9+ and then by male and female registrants. Median percentages of neighborhood characteristics (e.g., % Black, % below the federal poverty level, etc.) were chosen as the measure of the center instead of the mean because it is less affected by extreme values and skewed distributions. This provides a more accurate representation of the central tendency in our dataset, where variables like income and population density exhibit significant skewness. Statistical analyses were performed in SPSS version 28.01.1.

Neighborhood evaluation metrics

The Child Opportunity Index (COI) and the U.S. Census Bureau's American Community Survey (ACS) were used to describe neighborhood characteristics (18, 19). The COI is a validated composite index to measure neighborhood resources and conditions. It consists of 29 social determinants of health (SDOH) indicators of neighborhood-based opportunities, including high-quality schools, green space, healthy food, toxin-free environments, and socioeconomic resources (18). COI indicators are assigned individual z-scores and summed to an overall z-score using indicator-specific weights that signify how strongly each indicator predicts children's health and economic outcomes. We used the most recent version of this data, which was from 2015. The COI indicators are divided into three subdomains: Education, Health and Environment, and Social and Economic. ZIP codes are scored as a very low opportunity, low opportunity, moderate opportunity, high opportunity, or very high opportunity within each domain (18).

The ACS is the U.S. Census Bureau's largest household survey and provides ZIP code level estimates of poverty levels, racial/ethnic diversity, insurance coverage, and population density (19). We used the most recently published data (2016–2020), which gives an average estimate of the characteristics over the 60-month period. Finally, we condensed ZIP code level Rural–Urban Commuting Area (RUCA) codes (20) into four categories (urban-focused, large rural city, small rural town, and isolated small rural town) as discussed by the Rural Health Research Center.

Results

The average percent of registrants (aged 9+) by ZIP code in Texas's ImmTrac2 database who received at least one dose of the HPV vaccine remained relatively similar from 2017 to 2021, though trended slightly downward over the 5 years (Figure 1). The average percentage ranged between 21 and 23%. Average vaccination rates by ZIP over this five-year period were higher for female adolescents than male adolescents,

which aligns with trend data from the CDC's National Immunization Surveys (11).

Among the 1,800+ ZIP codes in Texas, we identified 64 ZIP codes that were statistically significant hot spots of HPV vaccination coverage 5 years in a row and 55 ZIP codes that were cold spots of vaccination coverage 5 years in a row. As illustrated in Figures 2, 3, the persistent vaccination coverage hot spots were primarily near the southern Gulf coast, the northwestern portion of the state, and close to El Paso. Cold spots were primarily located in the central portion of the state, the panhandle, and in parts of major urban areas like Houston and Dallas. However, on closer inspection of the major cities of Dallas and Houston, there are significant differences in these densely populated areas, with the cold spots in the urban and suburban wealthier areas and the hot spots in southeast Dallas and northeast Houston, which are typically lower income. The remainder of the ZIP codes in the state were not part of statistically significant clusters 5 years in a row or were outliers.

When evaluating differences in HPV vaccination by reported gender, we found 55 hot spot ZIP codes and 38 cold spot ZIP codes among male adolescents alone. These were in areas similar to overall hot/cold spots. However, among female adolescents alone, we identified just 11 hot spot ZIP codes of HPV vaccination and 13 cold spot ZIP codes. These were also located in areas like overall hot/cold spots (figures by gender not shown).

Demographic analysis of persistent hot spot and cold spot ZIPs

We found that persistent hot spot ZIP codes of HPV vaccination coverage had significantly lower overall COI scores, indicating lower opportunity areas than persistent cold spot ZIP codes (overall median score 2 vs. 4, $p < 0.001$, Table 1). As seen in Figure 2, Temporal changes in both vaccination hot spots and cold spots were identified. Over time, hot spots on the bottom part of the southern Gulf Coast expanded, whereas the northwestern portion has decreased. Cold spots, especially in the panhandle, expanded over time. Overall, spatial patterns were quite similar. This difference persisted in each subdomain (Education, Health, Environment, and Social and Economic) and when each was broken out by gender (Table 1).

As shown in Table 2, using American Community Survey (ACS) data, persistent hot spot ZIPs had a higher median percentage of the population below the federal poverty level (17.40% vs. 7.14%, $p < 0.001$). Persistent hot spots also had higher rates of resident children who are either uninsured (2.87% vs. 1.92%, $p < 0.001$) or on public insurance (11.75% vs. 2.91%, $p < 0.001$) than persistent cold spots. Cold spot ZIPs had statistically higher percentages of children on private insurance plans (12.3% vs. 8.6%) ($p = 0.001$). There were significantly higher rates of Hispanic residents in hot spot ZIPs compared to cold spot ZIPs (53.32% vs. 20.65%, $p < 0.001$) and lower percentages of Asian residents (0.89% vs. 8.28%, $p < 0.001$). Persistent hot spot ZIPs did have a statistically higher rate of Caucasian residents than persistent cold spots, but this did not persist when broken out by gender. There was no difference in the percentage of Black residents overall or by gender between hot and cold spots. Hot spot ZIPs had lower median populations per square mile (29.00 vs. 2287.80, $p < 0.001$). Still, there was no difference in rural/urban designation by RUCA code, with the majority being urban-focused.

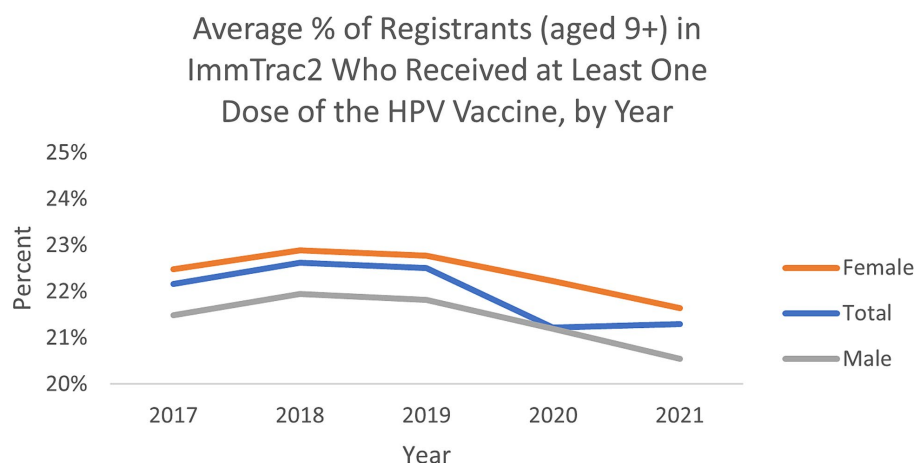


FIGURE 1

Average percent of registrants (aged 9+) by ZIP in ImmTrac2, who received at least one dose of the HPV vaccine in Texas.

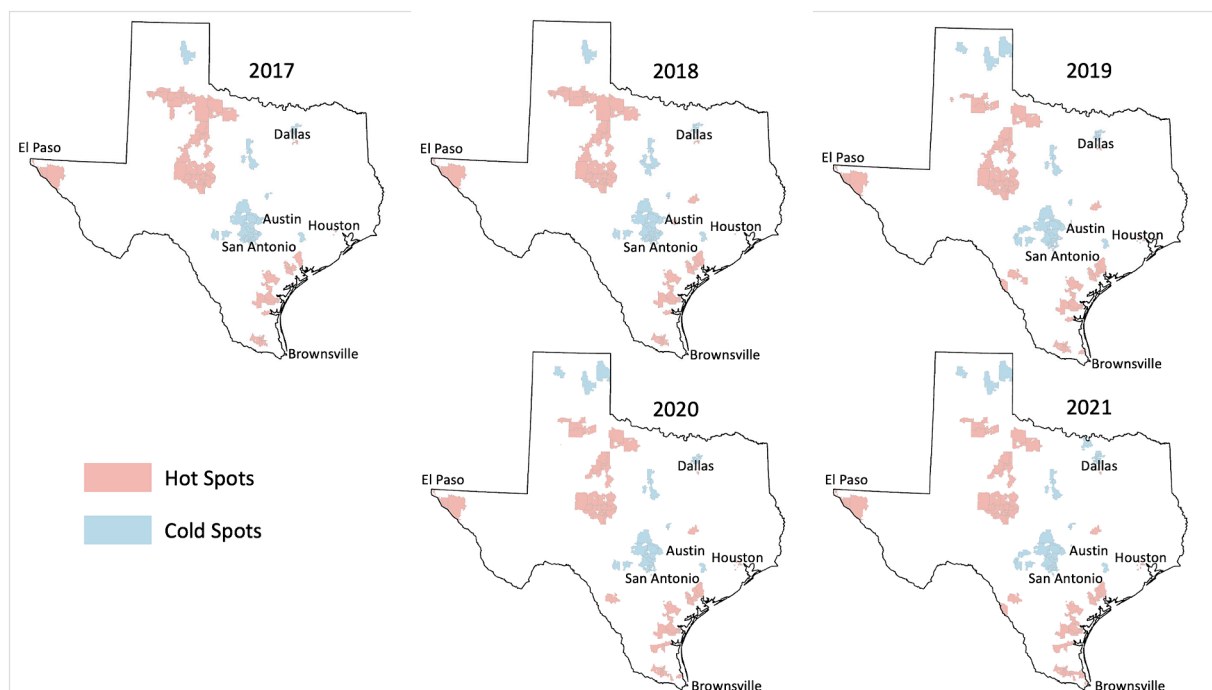


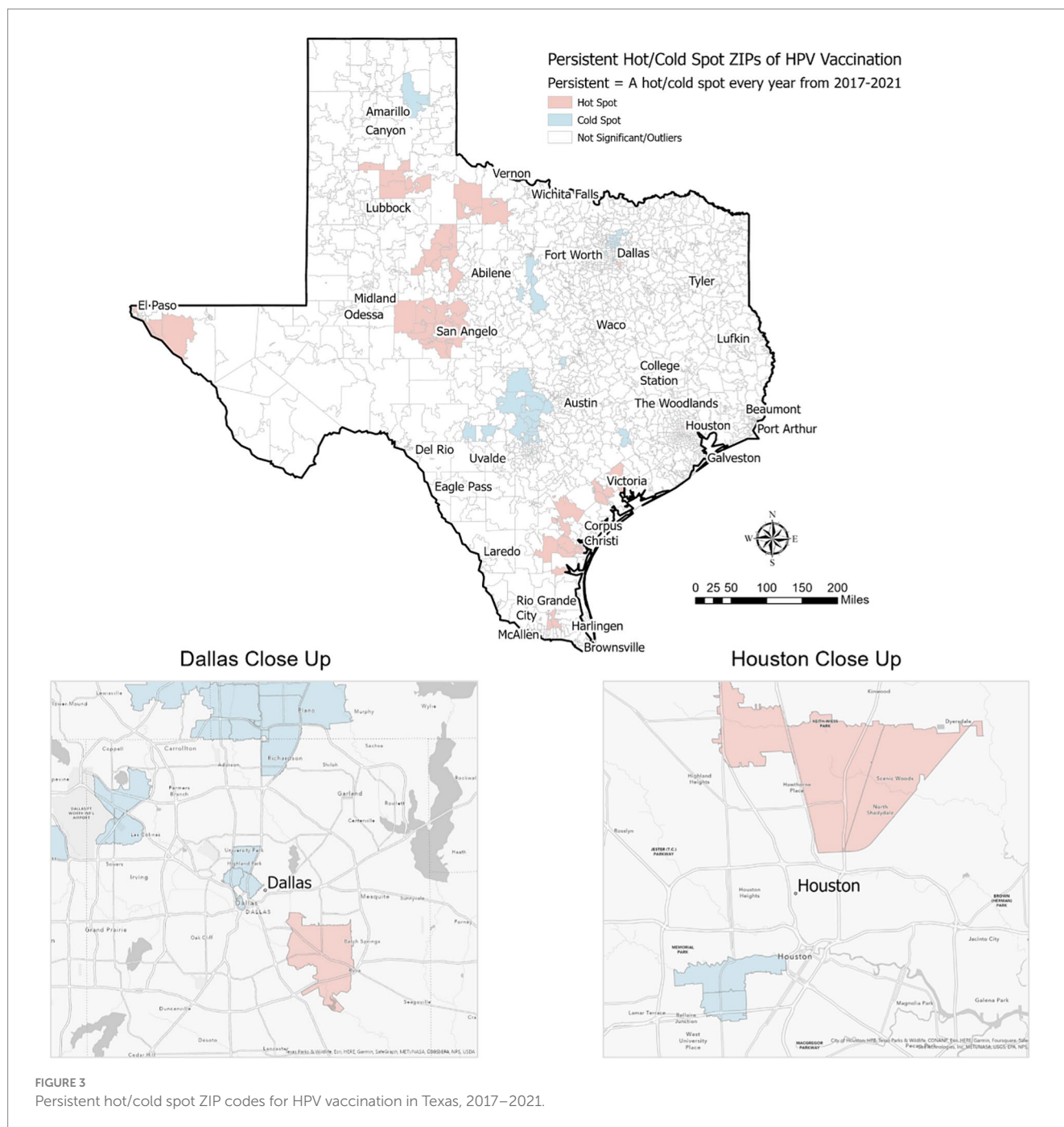
FIGURE 2

HPV vaccination hot and cold spots in Texas.

Discussion

This study found significant geographic, gender, and socioeconomic disparities between persistent hot spots and persistent cold spots of HPV vaccination coverage in Texas. Persistent hot spots are more likely to be disadvantaged neighborhoods, with lower Child Opportunity Index scores and subdomain scores, higher poverty rates, lower median household incomes, and greater percentages of children on public insurance or uninsured. They are also generally less densely populated than persistent cold spots and have higher percentages of Hispanic residents. Persistent cold spots of HPV vaccination, on the

other hand, have significantly higher rates of Asian residents and are more densely populated. This finding aligns with studies documenting a “reverse disparity” in HPV vaccination, with higher rates among certain racial minorities and those receiving public insurance (21). It has been hypothesized, for example, that the El Paso region of Texas has such a high vaccination rate due to the perceived increased risk of HPV-related cancers in the community, leading to greater voluntary vaccination uptake (22). There also may be more robust provider recommendations and vaccine outreach in areas perceived as at higher risk of HPV-related cancers. Our study affirms this reverse disparity among much of Texas but suggests that some underrepresented



minority populations, notably communities of Asian residents in urban locations, may benefit from further analysis.

Comparing our results with studies from other states, we observe both similarities and differences. In New York, higher HPV vaccination rates have been reported among Hispanic and Black adolescents, aligning with our findings in Texas (23). However, these states did not exhibit the same extent of reverse disparity for male adolescents, suggesting that local cultural, socioeconomic, and policy factors might influence these patterns (23, 24). For instance, the study “Improving HPV Vaccination Rates in a Racially and Ethnically Diverse Pediatric Population” highlighted successful interventions that increased vaccination rates in a diverse population yet did not report significant gender disparities like those found in Texas (24).

These differences underscore the importance of considering local context and tailored interventions when addressing HPV vaccination disparities across different regions.

Several studies have observed a reverse disparity in HPV vaccination rates among Hispanic communities, similar to trends seen in cervical cancer screening. For instance, research has shown that Hispanic adolescents have higher HPV vaccination rates compared to their non-Hispanic white counterparts, likely due to targeted public health initiatives and community outreach programs (25). Similarly, in many states, Hispanic women constitute a significant proportion of the clients served by the National Breast and Cervical Cancer Early Detection Program (NBCCEDP), indicating effective outreach and utilization of services within this community (24). Studies have also

reported higher cervical cancer screening rates among Hispanic women, attributed to culturally tailored interventions and community health programs that address language barriers and provide patient navigation (26). These findings underscore the importance of culturally sensitive healthcare interventions in improving preventive health measures in Hispanic communities. However, addressing

disparities in follow-up care and treatment remains critical to ensure comprehensive care for these populations.

Regarding characteristics of persistent hot spot ZIP codes of HPV vaccination coverage, such as higher rates of children on Medicaid insurance and lower rates on private insurance plans, this may be representative of the general socioeconomic makeup of the

TABLE 1 Child opportunity index score analysis of persistent hot and cold spot ZIPs of HPV vaccination.

Child opportunity index domains [†]	Persistent hot spots	Persistent cold spots	<i>p</i> -value*
Child opportunity index score, overall (median score)	2.0	4.0	<0.001
Males aged 9+	2.0	4.0	<0.001
Females aged 9+	3.0	5.0	0.003
Education domain (median score)	2.0	5.0	<0.001
Males aged 9+	2.0	3.5	<0.001
Females aged 9+	3.0	5.0	0.009
Health and environment domain (median score)	2.0	4.0	<0.001
Males aged 9+	2.0	4.0	<0.001
Females aged 9+	3.0	5.0	<0.001
Social and economic domain (median score)	2.0	4.0	<0.001
Males aged 9+	2.0	4.0	<0.001
Females aged 9+	3.0	5.0	0.026

[†]1, very low opportunity; 2, low opportunity; 3, moderate opportunity; 5, high opportunity; 6, very high opportunity. *Mann–Whitney U Test Significance Level (0.05). Bold text indicate statistically significant values.

TABLE 2 Demographic and socioeconomic characteristics of persistent hot spots and cold spots.

ZIP code level characteristics		Persistent hot spots	Persistent cold spots	<i>p</i> -value*
Income	Population below the federal poverty level (percentage, median)	17.4	7.1	<0.001
	Males aged 9+	17.6	9.5	<0.001
	Females aged 9+	12.2	8.4	0.007
	Median household income (USD, median)	47,751	83,486.0	<0.001
	Males aged 9+	46,880	71,999.5	<0.001
	Females aged 9+	58,795	85,942	<0.001
Race/Ethnicity (percentage, median)	Caucasian	87.8	73.3	0.025
	Males aged 9+	84.98	79.8	0.566
	Females aged 9+	88.3	73.3	0.459
	African American	3.2	7.9	0.223
	Males aged 9+	4.6	5.1	0.842
	Females aged 9+	4.3	7.9	0.649
	Hispanic	53.3	20.7	<0.001
	Males aged 9+	67.4	20.96	<0.001
	Females aged 9+	38.98	22.3	0.041
	Asian	0.89	8.3	<0.001
	Males aged 9+	0.9	4.1	0.007
	Females aged 9+	0.7	8.6	0.035

(Continued)

TABLE 2 (Continued)

ZIP code level characteristics		Persistent hot spots	Persistent cold spots	p-value*
Insurance coverage of children (percentage, median)	Medicaid	11.8	2.9	<0.001
	Males aged 9+	13.3	3.5	<0.001
	Females aged 9+	8.2	2.8	<0.001
	Private	8.2	12.3	0.001
	Males aged 9+	7.9	9.9	0.029
	Females aged 9+	11.1	13.5	0.277
	Uninsured	2.9	1.9	<0.001
	Males aged 9+	3.1	1.9	0.009
	Females aged 9+	3.02	1.9	0.150
Population density	Population per square mile (median)	29.0	2287.80	<0.001
	Males aged 9+	41.5	168.9	0.012
	Females aged 9+	5.5	199.04	0.004
	RUCA codes (median result) [‡]	Urban-focused	Urban-focused	0.445
	Males aged 9+	Urban-focused	Urban-focused	0.124
	Females aged 9+	Urban-focused	Urban-focused	0.649

*Mann–Whitney U Test Significance Level (0.05). [‡]Categorized into four domains: Urban-focused, Large rural city, Small rural town, and Isolated rural. Bold text indicate statistically significant values.

communities (i.e., lower median household income). However, this may also be due to vaccination benefits among federally sponsored insurance, notably the Vaccines for Children program, which provides the HPV vaccine at no cost to those who meet eligibility criteria (Medicaid or uninsured). The reflection on how private insurance may deter vaccination warrants a deeper discussion. Private insurance plans often have higher co-pays and deductibles compared to public insurance, which can discourage families from completing the HPV vaccination series. Studies have shown that individuals with public insurance or who are uninsured are more likely to receive vaccinations through public health programs, which often cover the full cost of vaccines (27). This financial barrier associated with private insurance plans may contribute to lower vaccination rates among insured individuals, highlighting the need for policy interventions to reduce out-of-pocket vaccination costs. More research is needed to understand the barriers to HPV vaccination among all populations, but coverage for all people, regardless of insurance status, should be prioritized.

Importantly, our study highlights differences in adolescent HPV vaccination coverage hot spots among male adolescents versus female adolescents. There were many more hot and cold spots of HPV vaccination coverage among male adolescents, indicating more clusters of areas with high HPV vaccination coverage rates and low vaccination coverage rates. This suggests that across the state, HPV vaccinations are more widespread among female adolescents compared to male adolescents. Increasing vaccination strategies specifically targeting male adolescents, therefore, may be warranted.

Our study does have some limitations. Primarily, our data is from the ImmTrac2 system, an opt-in program that may not entirely represent the population. Additionally, the use of the ACS and COI data as population-based metrics may not be representative of the individuals receiving the vaccines. We were unable to obtain more specific demographic information on participants, which limits the analysis to an ecological approach (8). Finally, there is a notable discrepancy between our reported adolescent HPV vaccination coverage rates (21–23%)

and those reported in the Nehme article of (30–40%) (8), which cited higher rates for Texas. This is because the Nehme article used data from the National Immunization Survey-Teen (NIS-Teen). NIS-Teen is a random digit dialing telephone survey of households in the U.S. plus provider-reported vaccination histories of teens whose parents participate in the phone survey and consent to having their teen’s vaccination providers contacted. While NIS-Teen data offers comprehensive and representative vaccination coverage estimates, it relies on sample-based estimates. Conversely, ImmTrac2 provides detailed and timely immunization records, beneficial for monitoring and program evaluation, but its opt-in nature leads to underrepresentation and variable participation, as it requires parental consent for minors, resulting in incomplete data. Nonetheless, ImmTrac2 maintains robust coverage of vaccines given to pediatric populations (14).

To our knowledge, this is the first spatiotemporal analysis of HPV vaccination coverage in Texas. Modeling statistical hot spots of HPV vaccination and identifying ZIP codes that model as hot/cold spots 5 years in a row presents a thorough approach to understating HPV vaccination geographically in Texas. Few studies on HPV vaccinations utilize high spatial resolution data, like ZIP codes, which allow for integrating neighborhood-level data like the Child Opportunity Index and key American Community Survey variables. These data sources allow a better understanding of neighborhood context, which may affect vaccination behaviors. Understanding the spatiotemporal dynamics of HPV vaccination rates in a vast state like Texas can enable advocates to tailor messaging and outreach more effectively to promote vaccine uptake.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://www.dshs.texas.gov/immunizations/>

what-we-do/programs; https://data.diversitydatakids.org/dataset/coi30-2010-tracts-child-opportunity-index-3-0-database--2010-census-tracts?_ga=2.105088003.1687438952.1713278005-6079392.1713278005

Author contributions

RR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Resources, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing. AZ: Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. SU: Project administration, Writing – original draft, Writing – review & editing. MD: Data curation, Investigation, Methodology, Writing – review & editing. CB: Formal analysis, Funding acquisition, Methodology, Resources, Validation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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Acknowledgments

The Joint Center on Geospatial Analysis and Health, A Collaboration of The University of Texas Health Science Center at Houston School of Public Health and The University of Texas MD Anderson Cancer Center, made possible by UTHealth Academic Excellence Endowment and donors to the University of Texas MD Anderson Cancer Center's Annual Fund.

Conflict of interest

The authors declare that the research was conducted without any commercial or financial relationships that could potentially create a conflict of interest.

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RECEIVED 29 December 2023

ACCEPTED 21 June 2024

PUBLISHED 03 July 2024

CITATION

Assefa A, Kiros T, Erkihun M, Abebaw A, Berhan A and Almaw A (2024) Determinants of pneumococcal vaccination dropout among children aged 12–23 months in Ethiopia: a secondary analysis from the 2019 mini demographic and health survey. *Front. Public Health* 12:1362900. doi: 10.3389/fpubh.2024.1362900

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Determinants of pneumococcal vaccination dropout among children aged 12–23 months in Ethiopia: a secondary analysis from the 2019 mini demographic and health survey

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Background: Vaccination is a cost-effective public health program that helps reduce significant morbidity and mortality in children under the age of five. Worldwide, the number of vaccine-preventable causes of child death has significantly decreased since the Expanded Program of Immunization (EPI) was introduced. However, for a variety of reasons, 23 million children did not have adequate access to vaccines in 2020. Therefore, this study aimed to evaluate the determinants of pneumonia conjugate vaccine (PCV) dropout among children aged 12–23 months in Ethiopia.

Methods: The study analyzed cross-sectional data obtained from the 2019 mini Ethiopian demographic and health survey. Multilevel binary logistic regression analysis was utilized, and the best fit model was chosen using the Akaike Information Criteria. The study comprised a weighted sample of 989 children aged 12 to 23 months. The study presented the Adjusted Odds Ratio (AOR) along with a 95% Confidence Interval (CI) to identify the significant factors influencing PCV dropout.

Results: The PCV dropout rate was reported at 20.2% in this study. In the multilevel analysis, possession of a health card (AOR = 0.076, 95% CI: 0.019, 0.04), vaccination for PCV 2 (AOR = 0.002, 95% CI: 0.023, 0.263), and region 7 (AOR = 6.98, 95% CI: 10.1, 48.31) were significantly associated with children's PCV dropout.

Conclusion: Having a health card, having received the PCV 2 vaccinations, and region were significant predictors of PCV dropout. Consequently, health education on immunization for all mothers and region-specific, customized public health interventions are needed to reduce the vaccination dropout rate.

KEYWORDS

vaccine, children, dropout, women, demographic and health survey

Introduction

Pneumonia is an acute lower respiratory tract infection that damages the alveolar air space and lung tissue. For children under the age of five, pneumonia is the greatest cause of illness and mortality (1). Over 900,000 children died from pneumonia worldwide in 2016, making up around 16% of the 5.6 million deaths of children under five (2). With 50% of the global death rate for children under five caused by pneumonia, Sub-Saharan African nations carried the lion's share of the burden. In sub-Saharan African nations, pneumonia is the leading cause of death, accounting for about 172 deaths per 1,000 live births (3, 4). In Ethiopia, pneumonia is the number one cause of death in the postnatal period as well as the primary cause of morbidity and mortality in children under the age of five. Each year, more than 40,000 children under the age of five die from pneumonia, which accounts for 20% of all causes of death (5, 6).

Pneumonia, which causes significant morbidity and mortality in children under the age of five, is among the diseases that can be prevented by vaccination. Vaccination is a cost-effective public health program that helps reduce these rates. Worldwide, the number of vaccine-preventable causes of child death has significantly decreased since the Expanded Program of Immunization (EPI) was introduced in 1974 with the goal of boosting routine immunization coverage (7). Around 2 to 3 million children a year are saved through vaccination (8). By the end of 2021, the pneumococcal vaccine had been launched in 154 member states, and global third-dose coverage was anticipated at 51% (9). In November 2011, Ethiopia added the 10-valent pneumococcal conjugate vaccine (PCV 10) to its childhood immunization schedule with the help of Gavi, the Vaccine Alliance. In accordance with the national vaccination program's three-dose schedule, children receive the shot at 6, 10, and 14 weeks of age (10).

In accordance with World Health Organization (WHO) recommendations, children are deemed fully immunized when they have received the following vaccinations by the age of 12 months: BCG for tuberculosis, three doses of DPT-Hep B-Hib (diphtheria, pertussis, and tetanus), pneumonia-conjugate vaccine (PCV) and polio, two doses of Rota virus, and a measles shot (11). In 2011, the national immunization program added the three doses of PCV to the vaccination schedule (12).

According to Ethiopia's routine vaccination schedule, infants should begin receiving vaccinations at birth and finish them before turning 1 year old. This includes receiving a single dose of the Bacillus Calmette-Guerin (BCG) vaccine at birth or as soon as possible, as well as the first dose of the oral polio vaccine (OPV). Three doses of the OPV, Pentavalent, Rota1, Rota 2, and pneumonia vaccines are given at intervals of 4 weeks duration at the 6th, 10th, and 14th weeks, respectively, and finally, the measles vaccine is given at the age of 9 months (13) (Table 1). 90% national coverage and 80% district coverage goals were set by the Global Vaccine Action Plan and the EPI for the year 2020 (14).

Even though immunization rates had increased, in 2020, some 23 million children still lacked sufficient access to the shot (15–17). By the end of 2020, 83% fewer children worldwide have received their childhood vaccinations than there were in 2019 (18). Around 60% of these children

TABLE 1 Routine immunization schedule in Ethiopia.

Vaccine	Disease	Age
BCG	Tuberculosis	At birth
Pentavalent	Diphtheria, Pertussis, Tetanus, H. influenza type b, Hepatitis B	6, 10, 14 weeks
OPV	Polio	At Birth, 6, 10, 14 weeks
Measles	Measles	9 Months
Pneumonia-conjugate Vaccine (PCV)	Pneumonia	6, 10, 14 weeks
Rotarix (rotavirus vaccine)	Rotavirus	6, 10 weeks
Tetanus (TT) immunization for women in child bearing age	Tetanus	1st contact pregnancy; +1 month, +6 months; +1-year, +1 year

resided in low-and middle-income nations (19). According to data from an Ethiopian demographic health survey, 39% of children aged between 12 and 23 months in 2016 received all required vaccinations. Because of this, the country's immunization rates are often below the threshold needed to create herd immunity and stop the spread of eight EPI-targeted diseases (20). Numerous studies have shown that factors such as home birth, residence, mother's knowledge of immunization, home visits by health workers, distance to medical facilities, misunderstandings about the benefits of immunization, and lack of knowledge about vaccine contraindications were predictors for child immunization (21–23).

Full immunization coverage in Ethiopia remained extremely low, at 33.3%, for all age-appropriate immunizations, including three doses of PCV, despite the government's reform initiatives. In addition, there is a notable variation in immunization coverage across various parts of the country (24). Several studies have examined the numerous factors that may contribute to childhood immunization dropouts (25). To our knowledge, few studies have been done on the rates of measles and polio coverage, but there have not been any studies on PCV coverage or dropout rates using survey data from Ethiopia. Therefore, this study sought to evaluate the determinants of the PCV dropout rate in Ethiopia using the 2019 mini-DHS data.

Methods and materials

Data source and study subjects

The 2019 Ethiopian mini demographic and health survey (EMDHS) data served as the data source for the analysis. It is the second EMDHS and the fifth DHS implemented in Ethiopia. The survey was conducted by the Ethiopian Public Health Institute (EPHI) in collaboration with the Central Statistical Agency (CSA), the Federal Ministry of Health (FMOH), financial and technical support from development partners, and technical assistance from the Inner City Fund (ICF). The survey was conducted from March 21, 2019 to June 28, 2019, based on a nationally representative sample that provided estimates at the national and regional levels and for urban and rural areas.

Two administrative cities (Addis Ababa and Dire Dawa) and all nine regions of Ethiopia (Tigray, Afar, Amhara, Benishangul-Gumuz,

Abbreviations: ANC, Antenatal care; AIC, Akaike information criteria; AOR, Adjusted odds ratio; EA, Enumeration area; EMDHS, Ethiopian mini demographic and health survey; EPI, Expanded program of immunization; PCV, Pneumonia conjugate vaccine; TT, Tetanus toxoid; WHO, World Health Organization; GHS, Global Health Survey.

Gambela, Harari, Oromia, Somalia, and the Southern Nations, Nationalities, and People's Region, or SNNP), were included in the nationally representative sample (26). The two administrative cities and the nine regions were grouped into three categories in our analysis: city administrations (Addis Ababa and Dire Dawa), developed regions (Tigray, Amhara, Oromia, and SNNP), and emerging regions (Afar, Benishangul-Gumuz, Gambela, Harari, and Somalia). 8,855 reproductive-age women (ages 15 to 49) from a nationally representative sample of 8,663 households were interviewed for the survey. All census enumeration areas (EAs) established for the 2019 Ethiopia Population and Housing Census (EPHC), which was carried out by the CSA, served as the sampling frame for the 2019 EMDHS. All 149,093 EAs developed for the 2019 EPHC are included in the census frame.

The 2019 EMDHS sample was stratified and selected in two stages. 21 sampling strata were produced by stratifying each region into urban and rural areas. EA samples were chosen in two stages, independently, for each stratum. In the first stage, a total of 305 EAs (93 in urban areas and 212 in rural areas) were selected with probability proportional to EA size and with independent selection in each sampling stratum. A household listing operation was carried out in all selected EAs, and the resulting lists of households served as a sampling frame for the selection of households in the second stage.

In the second stage of selection, a fixed number of 30 households per cluster were selected with an equal probability of systematic selection from the newly created household listing. All women age 15–49 who were either permanent residents of the selected households or visitors who slept in the household the night before the survey were eligible to be interviewed. The study included children between the ages of 12 and 23 months who did have complete data on their age and outcome variable. Those children with missing data in the DHS dataset were excluded, and the final analysis comprised a sample of 989 children aged 12 to 23 months.

The 2019 EMDHS was used to extract pertinent data regarding vaccinations for children aged 12 to 23 months. This was completed after registering and submitting the study's proposal via the website to obtain ICF international approval for access to and use of the dataset. After receiving authorization via email, the dataset was downloaded from the <http://www.DHSprogram.com> website.

Outcome variable

PCV dropout for children between the ages of 12 and 23 months was the study's outcome variable. Vaccination dropout refers to a child who has received the first dose of a vaccination according to recommendation but has missed the next dose (the third dose). A child who received the first dose of the PCV vaccination and not the last (third) was classified as "dropping out of PCV" and labeled "yes," while a child who received the first and last doses was classified as "no." The dropout rate was calculated by subtracting the frequency of PCV 1 status from PCV 3 status and dividing it by 100.

Independent variables

Based on various works of literature, the potential variables associated with childhood immunization dropout were divided into two categories: individual-and community-level variables. The variables at the individual level include the mother's age, mother's

educational status, marital status, wealth index, number of antenatal care (ANC) visits, place of delivery, presence of a health card, child sex, birth order, number of children ever born, and vaccination received for PCV2. Community level variables were urban–rural status, region, and aggregated variables created from individual level variables including community wealth index, community women's education, and community place of residence. Since the EMDHS data were not normally distributed, aggregated community variables were classified as low or high using the median value (27, 28).

Statistical analysis

IBM SPSS statistical software version 25 was used for the analysis. Weighting was utilized to correct for the sample's non-proportional distribution among the various regions and their rural and urban areas. Thus, it is ensured that the survey results are representative at the national and regional levels. The variables were described using percentages and frequencies, and tables and a figure were used to display the data.

Women and children were nested within a cluster in the DHS data; these clusters may have shared characteristics. The conventional logistic regression model's assumptions of equal variance and independence of observations are broken by the hierarchical structure of the data. Consequently, the clustering effect was taken into consideration by fitting a multilevel logistic regression model (both random and fixed effects). The community-and individual-level variables associated with PCV dropout were found using the two-level mixed-effects logistic regression model. In this study, four successive models were fitted. The first model is called the null model, and it does not contain any variables, whereas Model I has only individual level variables. Only community level variables are used to build Model II, and both individual and community level variables are combined to create Model III, a mixed model.

A two-level mixed model with individuals nested within communities was fitted. In order to model the log odds of children receiving a full immunization (29):

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + u_{0j}$$

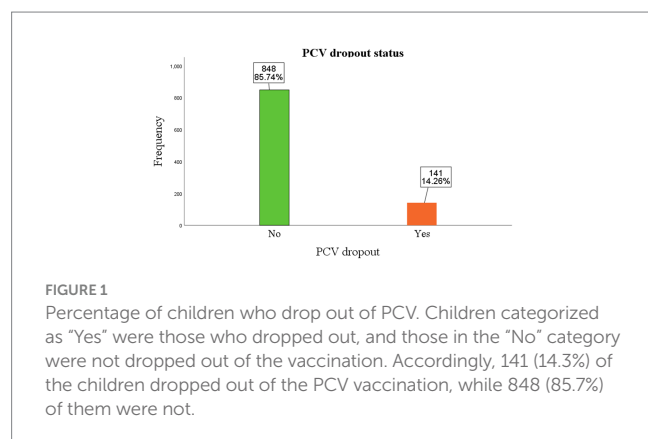
Where γ_{00} represents the intercept—that is, the probability of immunization in the absence of explanatory variables—and Y_{ij} represents the full immunization status of the i^{th} child in the j^{th} cluster. The regression coefficient of the individual level variable, X_p , is denoted by the term γ_{p0} , while the regression coefficient of the community level variable, Z_q , is represented by γ_{0q} . The explanatory variables at the individual and community levels are X_p and Z_q , respectively. The community level error is denoted by the term u_{0j} , where the subscripts i and j stand for the individual level and cluster number, respectively.

The best fit model was determined by calculating the model's lowest Akaike Information Criteria (AIC), and the best-fitting model was determined to be the mixed model (30). This model demonstrated that both individual and community level variables account for 49.3% of the total variance in the odds of children dropping out of PCV vaccination. For the multivariable multilevel analysis, variables from the bivariable multilevel analysis with a p value <0.2 were considered. A p -value of 0.05 was established as the cut point for statistical significance. The measures of association between the odds of PCV

TABLE 2 Estimates of the random effects of community and individual level factors on children's PCV dropout rate in Ethiopia in 2019.

Estimates	Null model	Model I	Model II	Model III
AIC	4888.73	1314.25	4015.85	1011.01
PCV (%)	Reference	46.6	41.3	49.3
ICC (%)	43	28.7	30.7	27.7
Community level variance	2.482*	1.326	1.458	1.259*

**p* value < 0.001, PCV = proportional change in variance.



dropout and the various explanatory variables were expressed as Adjusted Odds Ratios (AOR) with their 95% CIs (Table 2).

By calculating the Intra-class Correlation Coefficient (ICC), the null model was fitted in order to estimate the clustering effect and support the use of multilevel analysis. The formula below was used to determine ICC—the percentage of variability explained by the upper level (community) (30). $ICC = \frac{VA}{VA + \pi^2 / 3}$, where VA is community level

variance and $\frac{\pi^2}{3}$ is individual level variance, equals 3.29. Consequently, community differences account for roughly 43% of the overall variation in the odds of children experiencing PCV dropout. ICC = 0.05 is often regarded as a conventional threshold to indicate more substantial evidence of clustering (31). In the null model, the clustering effect-related variance was 43; in models I, II, and III, it was 28.7, 30.7, and 27.7, the lowest in the mixed model. The proportional Change in Variance (PCV) was computed with respect to the null model in order to investigate the relative contributions of individual and community level variables in explaining children's PCV dropout. Proportional

Change in Variance (PCV) = $\frac{V_0 - V_i}{V_0}$, where variance in the null model is represented by V_0 , and variance in the subsequent models is represented by V_i (30). Model III exhibits the highest proportional change in variance, indicating that the combination of individual and community level variables accounts for a larger portion of the variation in children's PCV dropout rate than either one does on its own.

Ethical considerations

The 2019 EMDHS was conducted by the Ethiopian Public Health Institute (EPHI) in collaboration with the Federal Ministry of Health

(FMOH), financial and technical support from development partners, and technical assistance from the Inner-City Fund (ICF). Before every interview during the survey's implementation, participants were asked to provide their informed consent. The project proposal's concept note and title were submitted via the DHS website in order to register and obtain authorization to use the EDHS data. The EDHS data set was not disclosed to a third party without first requiring registration, and the accessed data was only used for this study.

Results

Dropout rate

The dropout rate of PCV was reported at 20.2% in Ethiopia. In this study, 14.3% of the children were dropped out of PCV, compared to the majority of the children (85.7%) who were not (displayed in Figure 1).

Individual level characteristics of the study subjects

A total of 989 children aged 12–23 months were included in the analysis. More than half of the respondents (52.9%) were in the age group between 25 and 34 years. 499 (50.5%) of the children were male. Majority (36.9%) of the children were found in 2–3 birth order, while 20.3, 20.3, and 19.8% of them were found in 1, 3–4, and 6–15 birth order, respectively. The majority (94%) of the respondents were married. The majority of mothers (48.1%) do not have a formal education. The households with the lowest wealth index comprised 46.1% of the mothers. 53.6% of the respondents, or more than half, have had four ANC visits. Children's health cards were possessed by 72.2% of the mothers. Of the children in the study, males made up nearly half (50.5%). More than half (53.3%) of the children were born at home. In this study, 70.5 and 64.8% of children received the PCV 1 and PCV 2 vaccinations, respectively. On the other hand, 43.8% of children drop out of the PCV 3 vaccination (Table 3).

Community level characteristics of the study subjects

The majority of respondents (43.1%) came from developed regions (Amhara, Oromia, SNNPR, and Tigray), whereas the remaining 42.6 and 14.4% came from emerging regions and city administrations, respectively. Rural residents made up 73.2% of the respondents. More than two-thirds (67.4%) of mothers came from communities with a high percentage of poverty. The majority (57.1%) of the mothers were from communities with a high proportion of deliveries at home. About seven out of 10 (69.2%) of the participants came from areas where the percentage of uneducated women was high (Table 4).

Significant predictors of PCV dropout

In our study, the presence of a health card and PCV 2 vaccination status were significant individual level factors that affected children's PCV dropout rates, whereas region was a statistically significant

TABLE 3 Individual level characteristics of children 12–23 months of age in Ethiopia, 2019 (n = 989).

Characteristics	Frequency (n)	Percent (%)
Sex of child		
Female	490	49.5
Male	499	50.5
Birth order		
1	227	23.0
2–3	365	36.9
4–5	201	20.3
6–15	196	19.8
Mother's age		
15–24	292	29.5
25–34	523	52.9
35–49	174	17.6
Marital status		
Married	930	94.0
Not married	59	6.0
Wealth index		
Poor	456	46.1
Middle	133	13.4
Rich	400	40.4
Educational level		
No education	476	48.1
Primary	341	34.5
Secondary and higher	172	17.4
Number of ANC visit		
0	138	28.9
1–4	256	53.6
5–20	84	17.6
Place of delivery		
Home	256	53.3
Health facility	224	46.7
Health card		
Yes	714	72.2
No	275	27.8
Received PCV 1		
Yes	697	70.5
No	292	29.5
Received PCV 2		
Yes	641	64.8
No	348	35.2
Received PCV 3		
Yes	556	56.2
No	433	43.8

(Continued)

TABLE 3 (Continued)

Characteristics	Frequency (n)	Percent (%)
Child live with		
Respondent	978	98.9
Elsewhere	11	1.1
Total of children ever born		
1–3	589	59.6
4–6	272	27.5
7+	128	12.9

community level factor. Children of respondents who have a health card were 92.4% (AOR = 0.076, 95% CI: 0.019, 0.04) less likely to drop out of PCV than those who have no health card. Likewise, children who received PCV 2 were 99.8% (AOR = 0.002, 95% CI: 0.023, 0.263) less likely to drop out of PCV vaccination than those who did not received it. Respondents from emerging regions were 7 (AOR = 6.98, 95% CI: 10.1, 48.31) times more likely to drop out of PCV vaccination than city administrations (Table 5).

Discussion

Dropout rates are frequently used as a gauge of how well immunization programs are working, and low dropout rates signify good access to and use of immunization services (32). This study aimed to concurrently uncover the community-level and individual-level factors influencing children's PCV dropout rate in Ethiopia. Thus, the individual level factors influencing PCV dropout were having a health card and receiving a PCV 2 vaccination. One community-level factor influencing children's PCV dropout rate was region.

The PCV dropout rate was found to be 20.2% in the current study. Therefore, intervention is necessary as a dropout rate in the EPI program of more than 10%, reported by the WHO and the Global Health Survey (GHS), calls for action (33). There are a number of speculations as to why vaccination dropout rates are higher, including forgotten dose reminders, lack of vaccines, rejection because a card is misplaced, absence of counseling, caretakers' fear of vaccine side effects, absence of postpartum care visits, and financial difficulties with transportation (11, 34). It has been demonstrated that strategically placing sticker reminders with suggested vaccination return dates throughout the home can lower the dropout rate (35).

This study demonstrated a significant association between children's PCV dropout and the possession of a health card. A health card is a vaccination record that the parents of the children (mothers), own. It lists all of the vaccines that the child has received and the dates of those shots. It also includes details such as the child's age and the vaccine schedule's lot number for each dose of a vaccine. In addition, the vaccination card can serve as a forecast, informing parents of when their child should see the vaccination provider again to finish a series of shots or begin a new one (36). Children of mothers who possess a health card have a lower rate of PCV dropout compared to children of mothers who do not own a health card. Parallel to our findings,

TABLE 4 Community level characteristics of children 12–23 months of age in Ethiopia, 2019 (*n* = 989).

Variables	Frequency (N)	Percentage (%)
Urban–rural status		
Urban	265	26.8
Rural	724	73.2
Region		
Emerging regions	426	43.1
Developed regions	421	42.6
City administrations	142	14.4
Community women education		
Low	684	69.2
High	305	30.8
Community wealth index		
Low	322	32.6
High	667	67.4
Community place of delivery		
Low	424	42.9
High	565	57.1

several studies from Ethiopia (28, 37), Ghana (38), Gambia (25), Nigeria (39), and East China (40) showed that a health card is a significant determinant factor for children’s vaccination status. This might be because mothers will find it simple to remember their child’s appointment if they own a health card, and health providers will find it easy to inform and monitor the status of vaccinations. Identifying and counseling mothers who have vaccination cards may also be a simple task for health extension workers during house-to-house visits (25, 41).

One community-level factor that was significantly associated with the PCV dropout rate of children was region. The odds of PCV dropout were higher in children of respondents who reside in emerging regions as compared to those who live in city administrations. In line with what we found, a number of studies showed that region has a significant association with children’s vaccination status (25, 27, 28, 42, 43). This could be because most respondents from emerging regions are from remote, hard-to-reach areas, and mothers there are less aware of the advantages of receiving all recommended vaccinations, EPI sessions, and health services. As opposed to this, respondents living in city administrations may have greater access to media outlets like radio, television, and newspapers, which raises their likelihood of being aware of vaccinations. Moreover, the availability of health services, including the immunization program, varies by region, which could be another explanation for this variation (27, 42, 44).

Vaccination against PCV 2 was also significantly associated with children’s PCV dropout. The odds of PCV dropout were lower among children who received PCV 2 vaccination. This could be because, in the aftermath of PCV 2, mothers may have been confident enough to proceed with the vaccination due to adequate information. Furthermore, improved immunization campaigns may have made mothers aware of the advantages of receiving all doses.

TABLE 5 Individual and community level factors associated with PCV dropout of children 12–23 months of age in Ethiopia, 2019 (*n* = 989).

Variables	Vaccination status frequency (%)		AOR (95% CI)
	Yes	No	
Health card			
Yes	104 (14.6)	610 (85.4)	0.076 (0.019, 0.309)***
No	37 (13.5)	238 (86.5)	1
Residence			
Urban	27 (10.2)	238 (89.8)	0.22 (0.003,3.796)
Rural	114 (15.7)	610 (84.3)	1
Sex of child			
Male	72 (14.4)	427 (85.6)	1
Female	69 (14.1)	421 (85.9)	0.45 (0.203, 2.301)
ANC visit			
Yes	29 (21.0)	109 (79.0)	0.18 (0.608, 14.208)
No	52 (15.2)	290 (84.8)	1
Wealth			
Poor	74 (16.2)	382 (83.8)	1
Middle	18 (13.5)	115 (86.5)	0.44 (0.62, 3.376)
Rich	49 (12.3)	351 (87.8)	0.69 (0.327, 5.461)
Received PCV 2			
Yes	85 (13.3)	556 (86.7)	0.002 (0.023, 0.263)**
No	56 (16.1)	292 (83.9)	1
Regions			
Emerging regions	60 (14.1)	366 (85.9)	1
Developed regions	62 (14.7)	359 (85.3)	4.06 (1.54, 10.71)
City administrations	19 (13.4)	123 (86.6)	6.98 (10.1, 48.31)*

p* < 0.05, *p* < 0.02, ****p* < 0.001.

Limitations

The study has limitations in addition to its merits. Causal and temporal inferences cannot be made because the study used a cross-sectional study design. The men’s variable and TT vaccination for women were missing in the 2019 mini EDHS data and not included in the analysis.

Conclusion

In this study, the PCV dropout rate was reported to be 20.2% among children aged 12–23 in Ethiopia. Moreover, having a health card and having received the PCV 2 vaccination were individual level significant predictors of PCV dropout, and one community-level factor that was significantly associated with PCV dropout was region. Consequently, health education on immunization for all mothers and region-specific, customized public health interventions are needed to reduce the PCV

vaccination dropout rate. Furthermore, since children are more likely to miss their vaccinations if their mothers do not have a health card, it is critical to counsel or raise mothers' awareness of the importance of a health card. An Android system that automatically reminds health providers and mothers, if appropriate, is also helpful to minimize vaccination dropout, even though it requires further research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

AAs: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. TK: Formal analysis, Software, Writing – review & editing. ME: Formal analysis, Writing – review & editing. AAb: Formal analysis, Writing – review & editing. AB: Formal

analysis, Writing – review & editing. AAl: Formal analysis, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

We are grateful to the Federal Ministry of Health (FMoH), the Ethiopian Public Health Institute (EPHI), and the Central Statistical Agency (CSA) for data collection and survey implementation. We also express our gratitude to the DHS program for promptly fulfilling our request for data access.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 14 December 2023

ACCEPTED 11 June 2024

PUBLISHED 08 July 2024

CITATION

Suragh TA, Adzrago D, Allicock MA,
Yeh PG and Cuccaro P (2024) Exploring the
relationship between vaccine hesitancy and
mothers' perspectives on COVID-19 vaccines
for children ages 5–11 years during the
omicron predominant period 2021–2022: a
qualitative study.
Front. Public Health 12:1355452.
doi: 10.3389/fpubh.2024.1355452

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Exploring the relationship between vaccine hesitancy and mothers' perspectives on COVID-19 vaccines for children ages 5–11 years during the omicron predominant period 2021–2022: a qualitative study

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Background: The United States Food and Drug Administration authorized COVID-19 vaccines for children ages 5–11 years in October 2021 during the Omicron predominant period. Parental vaccine hesitancy was prevalent during this time, resulting in low childhood COVID-19 vaccine uptake. Most studies exploring factors influencing parental vaccine hesitancy have focused on racial and ethnic minorities and lower socioeconomic populations; however, there is little knowledge of the drive drivers of vaccine hesitancy among White parents with higher education and socioeconomic statuses.

Methods: We conducted semi-structured interviews with a sample of 15 White mothers of children ages 5–11 years in Atlanta, GA, between October–December 2021. Thematic analysis was performed using NVivo 12.

Results: Mothers were college-educated, homeowners, and fully vaccinated against COVID-19. Key findings included decreased pediatrician's recommendations for COVID-19 vaccines, reliance on information from specialized doctors and scientists, distrust in public health authorities, high risk-perception of COVID-19 vaccines, and low risk-perception of COVID-19 disease. Factors related to vaccine acceptance were altruism and practicality.

Conclusion: This study adds to the sparse literature on reasons for vaccine hesitancy among White mothers of children ages 5–11 years with higher educational and socioeconomic status. Improving vaccine uptake among this group is critical for protecting the health of their children and other vulnerable populations. Tailored vaccine messaging and intervention are warranted to address their unique attitudes, beliefs, and behaviors. An enhanced understanding of the factors influencing subpopulations of parents can help vaccine policymakers and healthcare providers improve efforts to reduce vaccine hesitancy, particularly for new vaccines.

KEYWORDS

COVID-19, childhood vaccination, vaccine hesitancy, vaccine refusal, qualitative

1 Introduction

The coronavirus disease (COVID-19) pandemic has highlighted the implications of vaccine hesitancy on low vaccine uptake and acceptance (1). It has demonstrated vaccine hesitancy's threat to individual and population-level protection against highly infectious diseases (1, 2). Vaccine hesitancy – the delay or refusal of a vaccine despite its availability – is associated with low COVID-19 vaccine uptake among children (3–5). COVID-19 has resulted in negative health outcomes in children, including multisystem inflammatory syndrome (MIS-C). This has resulted in hospitalizations and deaths in children ages 5–11 years (6, 7). Nearly 15.6 million children in the United States (U.S.) have tested positive for COVID-19 (7), with the highest number of cases occurring during the Omicron predominant period 2021–2022. The FDA authorized the Pfizer-BioNTech COVID-19 vaccine for emergency use in children ages 5–11 years on October 29, 2021 (8). COVID-19 vaccination is the most effective way to reduce children's COVID-19 morbidity and mortality, yet vaccination coverage remains suboptimal, with White children having some of the lowest vaccination rates (45%) compared to Asian and Hispanic Children (75 and 49%, respectively) (9). Geographic differences in vaccination coverage also exist, with eight of the 10 states having the lowest vaccination coverage in the South (10).

Vaccine hesitancy may explain the vaccination coverage disparities among children ages 5–11 years. Vaccine hesitancy strongly influences parents' decisions to vaccinate their children and is a complex notion varying across vaccine types, times, and settings (3). The World Health Organization's (WHO) Increasing Vaccination Model (IVM) proposes that vaccine uptake is based on people's thoughts and feelings, such as perceived risks and benefits, and social processes, like social norms and information (11). In addition to these factors, practical issues such as vaccine cost and availability result in vaccine acceptance, delay, or refusal (11). Vaccine hesitancy is influenced by multiple interrelated factors, and some individuals may accept some vaccines and refuse or delay others (12).

Reasons for parental COVID-19 vaccine hesitancy included the vaccine's novelty and lack of confidence in its safety and efficacy (13–18). For example, parents described that the vaccines were developed too quickly and were not well studied leading to concerns about unknown vaccine risks and potential side effects, such as myocarditis and fertility issues (14, 19, 20). The changing vaccine recommendations, including the need for boosters and vaccine dosage in children, also created confusion and doubt among parents regarding the necessity of childhood vaccinations (14–17, 21, 22). Studies found that vaccine-hesitant parents tended to have less knowledge of vaccines, leading to less confidence in the vaccine's efficacy (19). Beliefs that COVID-19 was more severe in children with pre-existing conditions and adults led to vaccine hesitancy among parents who felt their children were healthy and did not feel compelled to protect the community at large (14–16). Distrust of government and public health officials also contributed to conspiracy theories and misinformation about the COVID-19 vaccine (13, 14, 17–20). This misinformation spread quickly through social media, where some parents seek vaccine information (18–20). These beliefs were persistent even among parents fully vaccinated against COVID-19 (13, 23).

Vaccine hesitancy is also largely influenced by demographics such as race, income, and educational level (24, 25). A common belief is that vaccine-hesitant individuals are of lower income and educational

status and occur mostly among racial and ethnic minorities (13, 25, 26). However, vaccine hesitancy is prevalent among White individuals and those with higher educational levels and socioeconomic status (24, 27). This may be due to the environments in which they live and work, which might limit their exposure to large groups of people (e.g., crowded schools and houses) and influence their perceptions of disease severity. A Kaiser Family Foundation poll found that parents who are Black or Hispanic are less likely to feel their child is “very safe” from COVID-19 at school than White parents (33% vs. 52%) (28).

Many studies examining parental perceptions of childhood COVID-19 vaccines have been quantitative (13, 16, 21–23), with few qualitative studies (14, 15, 29). Qualitative research allows the gathering of rich data and exploration of thoughts and feelings that enable researchers to gain insight into decision-making processes and help explain human behavior, including a mother's decision to vaccinate their child against COVID-19 (30). To our knowledge, this was one of the few qualitative studies to explore maternal perceptions of COVID-19 vaccines for children ages 5–11 immediately after the FDA introduced the vaccine. Lastly, most of the literature has focused on drivers of vaccine hesitancy among racial and ethnic minorities and those with lower socioeconomic status (31–33). Limited information exists on factors influencing COVID-19 hesitancy among White, higher-income, and educated parents. It is critical to increase vaccine uptake among this subpopulation to protect their children and other vulnerable groups and increase vaccine uptake.

The objective of the study was to understand the beliefs, attitudes, and behaviors of White mothers of high socioeconomic status and education levels regarding COVID-19 vaccination among children ages 5–11 years. Findings can have clinical and policy implications, such as better strategies to target different subpopulations of parents with unique vaccine hesitancy concerns and needs.

2 Methods

2.1 Participants

We conducted semi-structured interviews with 15 mothers from October to December 2021. We used purposive sampling to recruit mothers. The sample was recruited primarily from one childcare service/company that connects families with in-home care in Atlanta, GA, and the rest of the sample was obtained through snowball sampling. The lead author emailed the childcare service describing the study and asked if the information could be passed to mothers. After each interview was completed, the lead author asked the participant to share information about the study with other mothers who might be interested. Mothers were eligible to participate if they had a child ages 5–11 years, lived in Atlanta, GA, and spoke English.

2.2 Data collection

We used semi-structured interviews to create dialog while allowing for emergent ideas (34, 35). We developed a semi-structured interview guide based on a literature review and consultation with experts in qualitative research and vaccine hesitancy, including faculty at the University of Texas Health Science Center at Houston (UTHealth Houston). Interview questions were not tied to a particular theory or

framework to allow researchers to gather rich, complex data without being constrained by theoretical constructs. Mothers were asked broad, open-ended questions about their perceptions of routine and COVID-19 childhood vaccines. Questions centered around their views of COVID-19 vaccines and how this compared to routine childhood vaccines, trusted sources of COVID-19 vaccine information, perceptions of COVID-19 disease, and factors that would influence their decision to vaccinate their child against COVID-19. Verbal consent was received before the interviews. Interviews lasted 45–60 min and were audio and video recorded using Zoom (Zoom Video Communications Inc., 2016). Interviews were professionally transcribed verbatim, and transcripts were independently coded by a primary (TS) and secondary (DA) reviewer. A third reviewer resolved disagreements of codes (PC).

2.3 Data analysis

Thematic analysis was performed and included deductive and inductive approaches using NVivo 12 software (released in March 2020) (36). Utilizing Braun and Clarke's thematic content analytic approach, the researchers (TS & PC) first conducted multiple transcript readings that were discussed among the research team to develop a codebook that aligned with the research question and study objective (37, 38). Emergent themes were discussed among the researchers and used in revising the codebook. Analysis continued with the refinement of codes until saturation was met and no new codes or themes emerged (39). All study procedures were approved by the Committee for the Protection of Human Subjects (the institutional review board) at UTHealth Houston (HSC-SPH-11-0577).

3 Results

3.1 Sample

In total, 15 mothers with children ages 5–11 years completed individual interviews. Participants were White, college-educated homeowners and the majority reported receiving two doses of COVID-19 vaccines for themselves. Participants' ages ranged from 36 to 47 years (Table 1). Pseudonyms were used to describe the participants to protect the identity of the participants and because the sample was demographically similar (40). The majority of mothers were hesitant about COVID-19 vaccines, and their hesitancy was driven by the unfamiliarity and novelty of the vaccine, balancing the risks and benefits of the vaccine, distrust in government, science, and public health authorities, decreased trust in pediatricians and increased trust in medical specialists. Mothers who were accepting of COVID-19 vaccines had a greater fear of adverse effects of COVID-19 disease than the vaccine and wanted to return to normalcy with children in school and protect the greater community. The following themes emerged in relation to COVID-19 vaccine hesitancy and vaccine acceptance:

3.2 Vaccine hesitancy is influenced by the unfamiliarity and novelty of the vaccine

Mothers described their unwillingness to vaccinate their children based on their level of familiarity and novelty surrounding COVID-19

TABLE 1 Demographic characteristics of mothers of children ages 5–11 years ($N = 15$).*

Demographics	<i>N</i> (%)	%
Age (years)		
29–39	10	67
40–49	5	33
Education		
Bachelor's degree	5	33
Graduate degree	10	67
Number of children		
1–2	11	73
3–4	4	27

*Mothers were all White, owned their homes and were vaccinated against COVID-19.

vaccines. Routine vaccines for known illnesses such as influenza were viewed differently from emergent diseases like COVID-19. For routine childhood vaccines like the Rotavirus vaccine, mothers described confidence in the vaccines' safety and efficacy due to the length of time the vaccines had been around and having been vaccinated themselves as a child. This familiarity resulted in mothers' confidence and acceptance of routine vaccines as recommended by their pediatricians. Conversely, uncertainty and fear led to the nonacceptance of childhood COVID-19 vaccines. Mothers expressed the vaccine's novelty, fast development, and unknown long-term side effects as reasons for low confidence in the vaccine. Paradoxically, mothers who were vaccinated against COVID-19 unwilling to vaccinate their children, and hesitant to follow their pediatrician's recommendations as they normally would before the COVID-19 vaccine. Lauren expressed her views on routine and COVID-19 vaccines,

... I pretty much just followed the standard doctor's guidelines. So, whenever...we had a doctor's appointment when they were little kids.... I always consented to them to get the vaccines. I never delayed...the vaccines that we have done in the past have been around for such a long time, and so there's a lot of, you know, evidence that they are not harmful. And with...these [COVID-19] vaccines, they have come out so quickly, gotten through the approval process so quickly (Lauren, mother of 2 children).

The fast approval and quick manufacturing of COVID-19 vaccines made mothers wonder if the vaccine risks outweighed the benefits.

3.3 Balancing the risks and benefits of childhood COVID-19 vaccination

Some reasons underlying mothers' hesitancy towards COVID-19 vaccines were due to unknown and potential long-term side effects, particularly their novelty and the short manufacturing times for these vaccines. Maria expressed concerns about possible side effects,

I think it's probably effective and safe. Because I feel like people, millions of people, hopefully, would not be taking it if it wasn't. I guess because it's so new, we do not know what any of the

long-term side effects are. Like, is my son going to have fertility issues later? Is it going to affect his sperm? (Maria, mother of 2 children).

These concerns outweighed any perceived benefit to vaccination. The belief that vaccinating children would protect them and the community did not motivate mothers toward vaccination. Rachel expressed her ambivalence about COVID-19 vaccines,

I think it is one of the hardest decisions that I've ever had to make for my kids... we are not set on which way we'll go right now... you just do not want to do anything to harm your kids.... And this, I'm not convinced we are doing it for the kids yet and that makes me really nervous, and I do not want to make a bad decision for them...because it could affect them for the rest of their life. And there's just so much unknown (Rachel, mother of 2 children).

A sentiment expressed by mothers was that their children were not at risk for severe complications from COVID-19 because they were healthy and unexposed to large groups. Some mothers described having pods of 4–5 children that studied and played together when schools were closed and not having to be around many people. Olivia shared her reasons for waiting to vaccinate,

My children, luckily, do not have any problems other than being preemies. They are not obese. There are no tobacco users in our life. We're very thankful not to have any of those sorts of risk factors. We also live in Atlanta, where we do not ride public transportation on a regular basis...we are not exposed to big crowds, that kind of thing. It might be different if I was taking a subway in New York City every day and come in contact with a lot of people, but, my plan is to wait at least two years... (Olivia, mother of 2 children).

3.4 Vaccine hesitancy influenced by distrust science

Vaccine hesitancy was influenced by distrust in government and public health officials and increased trust in medical and infectious disease specialists.

Mothers who were hesitant about childhood COVID-19 vaccines described their lack of confidence and trust in the scientific information disseminated to the public by the government, vaccine manufacturers, and public health officials. They were skeptical about the vaccine's safety and efficacy due to the perceived lack of rigor in the scientific studies. Mothers did not think there was enough evidence to justify childhood COVID-19 vaccination and were not convinced vaccination was the decision for their children. Their ability to interpret scientific information independently influenced their trust and confidence in science.

Sarah expressed her doubts,

...this experience has dramatically changed my perspective on our medical institutions and the amount of trust I have in them in a major way... The sample size with kids for the Pfizer testing was... roughly, like, a little under 2,200. That, to me, is not a large enough

sample with a large enough time period for me to sign my kid up... (Sarah, mother of 3 children).

The changing and conflicting messaging by the public health authorities during the COVID-19 pandemic contributed to mothers' uncertainty about the vaccine. Messages, like the length of time children needed to wait to be vaccinated after having COVID-19, the spacing of COVID-19 and other childhood vaccines, and face mask guidelines led to mothers' doubting the accuracy of information channeled through traditional sources, including their pediatricians. Despite having established relationships with their pediatricians, mothers now felt them to be less trustworthy and knowledgeable of the efficacy and safety of childhood COVID-19 vaccines. Ashley stated,

"...our doctor has been sending out emails every week about how safe the vaccine is. And I mean that's great, but. And like how safe masking is for kids, but I just do not really, um, it's just not to my taste. So, probably not her doctor...there are some news outlets that I find to be credible..." (Ashley, mother of 4 children).

Alternatively, mothers relied on information from specialty doctors like cardiologists and infectious disease specialists. Unlike pediatricians, whom they felt would recommend the vaccine regardless of potential safety concerns, mothers felt specialists provided more honest and independent reviews of childhood COVID-19 vaccines. For example, mothers felt more comfortable speaking to cardiologists regarding the potential risk of heart inflammation (e.g., myocarditis and pericarditis) following COVID-19 vaccination. This reliance on specialists was facilitated by the proximity and access to these professionals, who were their neighbors, friends, and family members. Maria expressed her reasons for increased reliance on specialist doctors, "...I love their pediatrician, and we have a really good relationship with him...I feel like the epidemiologist is closer to this specific focus...I know my doctor is not in the lab testing vaccines...he's not on the front lines." (Maria, mother of 2 children). This shifting trust in science influenced mothers' perception of the severity of COVID-19 in children and the risks associated with the COVID-19 vaccine. Mothers did not mention reliance on specialists for routine vaccines, and it appears this shift in perception was related to the novelty and unfamiliarity of the COVID-19 vaccine as well as based on their trusted sources of vaccine information.

3.5 Vaccine hesitancy influenced by trust in source of COVID-19 vaccination information

A key driver of vaccine hesitancy among mothers was their level of trust in the sources of information promoting childhood COVID-19 vaccination. If mothers did not trust the information or agenda of institutions and authorities, they were less confident that the vaccine was the best decision for their children. Sources deemed trustworthy included scientific websites and organizations (e.g., the Mayo Clinic), news, podcasts, cardiologists, epidemiologists, family, and friends. While mothers mentioned viewing information on social media platforms like Facebook, they did not consider these platforms trustworthy or their primary source for vaccine information. They

described the extent to which they would actively seek out information and make their conclusions about the vaccine (e.g., searching for adverse events following COVID-19 vaccination on publicly available government databases) instead of passively accepting information. Sarah described how she searched for credible information,

... I read the New York Times every morning, and I read the AJC [The Atlanta Journal-Constitution] every morning...I also, you know, Google things. And when I Google things, I try to click websites that I recognize and that are things like John Hopkins, Mayo Clinic...things that seem like they would not get away with misinformation... (Sarah, mother of 2 children).

Mothers were also keenly aware that politics heavily influenced the dissemination of COVID-19 vaccine information. They described the differing opinions regarding childhood COVID-19 vaccines' safety and necessity based on conservative versus liberal sources of information. The politicization of the COVID-19 pandemic led mothers to question the true motivations behind campaigns promoting childhood COVID-19 vaccinations and whether vaccines were being used for political gain rather than to protect their children's health. This perception contributed to mothers' reluctance to vaccinate as they refused to put their children at risk for unknown side effects due to political pressure, creating doubt about the veracity of the scientific information being used to promote the vaccine for children. Rachel expressed her concerns,

...I do not trust the politics, and some of [the] encouragement to give it to them [children] is to protect adults who refused to get it themselves. And that's not fair. I do not want to do something to my kids that the studies have not been fully done on to protect adults, who are old enough to decide for themselves and have the free choice to do it or not, and it's their fault if they do not. I cannot help that in my opinion. And I'm not gonna punish my kids because they [adults] do not [get vaccinated] (Rachel, mother of 2 children).

3.6 Vaccine acceptance influenced by fear of COVID-19 disease and wanting to return to normalcy

The belief that COVID-19 vaccines could protect children and the community resonated with some mothers and affected their decision to vaccinate their children. Mothers who already vaccinated their children against COVID-19, or intended to, believed the benefits of vaccination outweighed the potential long-term risks of COVID-19 disease. Katherine expressed her concerns,

...I'm really nervous about the long-term effects of my son getting COVID because...Like, what if it causes some lung issues and he's not able to play soccer like he does...we kind of know right now from the trials that there's not going to be these really long long-term effects from the COVID vaccine, whereas I do not feel like we know that for actual COVID-19 infection...I do not think the COVID vaccine is going to make my son suffer, but I do feel like

COVID, potentially, in the long run, could make him suffer..." (Katherine, mother of 1 child).

A minority of mothers accepted the vaccine for reasons like fewer missed school days and the ability to travel. They described older family members as more at risk for severe complications of COVID-19, and vaccinating their children was a way to allow them to spend time with others safely. For these women, altruism and practical reasons outweighed the perceived risks associated with the vaccine.

Allison expressed her considerations,

... besides the health, there's also the logistics. Like I feel like I work in a hospital, and they are at risk, and so I wanted them protected. There's also, at the schools, I know that there will be different requirements for quarantining if there's exposures, and if they have vaccines, then they will not have to quarantine, so there will not be missed school...and all of that was really important to me. I do not want my kids learning virtually anymore, ever, if possible... (Allison, mother of 2 children).

Regarding the logistics of traveling, Lauren stated,

...we have some international travel coming up, so...we said, "Okay. Well, maybe we should go ahead and get the kids vaccinated...And it's honestly less for the fact that you know, we think it'll prevent them from contracting [COVID-19 infection] or their symptoms, but more from the fact of, you know, we do not want any disruptions to the travel, to be quite honest..." (Lauren, mother of 2 children).

4 Discussion

Our study identified key factors related to vaccine hesitancy and acceptance of childhood COVID-19 vaccines among White, mothers of children ages 5–11 years from higher educational and socioeconomic backgrounds. Mothers who were vaccine-hesitant expressed unfamiliarity and fear of unknown adverse effects of COVID-19 vaccines, decreased trust in pediatricians' recommendations, and distrust in science and public health authorities. Mothers who were vaccine-acceptant expressed sentiments including trust in the science and public health authorities, fear of COVID-19, and aspects of altruism such as wanting to protect their children, family, and community. Reasons for practicality and wanting to return to normalcy were also noted for accepting childhood COVID-19 vaccines.

Our findings reinforce the notion that vaccine hesitancy is a complex phenomenon and vaccine decision-making is influenced by many contextual factors (3, 11, 12). Individuals cannot be grouped exclusively as "hesitant" or "acceptant." Mothers in our study were hesitant to vaccinate their children with COVID-19 vaccines yet accepted routine childhood vaccines like polio and influenza. Mothers' familiarity with routine vaccines, such as having taken these vaccines as children and understanding their safety profiles, influenced their decisions to vaccinate their children. This finding aligns with research that found parents accepting some but not all vaccines and mothers vaccinated against COVID-19, yet still hesitant for their children (12, 13, 23). The novelty of COVID-19 vaccines routine vaccines made

mothers feel less confident in the vaccines' safety and efficacy (13–18). Similar to other studies, most of the mothers in our study were fully vaccinated against COVID-19 but were still concerned about the vaccine's safety in their children, for example, citing long-term fertility issues (13, 14).

Our findings align with other vaccine trends that have shown demographic factors, including White, affluent, educated parents who are least likely to vaccinate their child against the human papillomavirus (HPV) and are a major group within the anti-vaccine movement (41–43). Despite this subpopulation having fewer potential barriers to vaccination (e.g., financial instability and lower education), their decision-making is influenced by their research, weighing the benefits and risks of vaccination, and personal beliefs values, and attitudes (44–46). In our study, mothers accessed, reviewed, and interpreted publicly available government datasets on adverse events following childhood COVID-19 vaccination to help them understand the vaccine's safety and side effects. For example, mothers who believed the sample sizes of the clinical trials were small may feel more confident in their decision to vaccinate their child if they received detailed information on how to interpret sample size calculations and vaccine efficacy (45). This misunderstanding of COVID-19 scientific information being disseminated by the government and public health officials led to distrust in these entities and is a common theme in the literature. It is essential for policymakers to increase efforts to develop tailored materials that offer more transparent vaccine safety information for a subgroup of parents who are well-informed and access resources that most parents might not know exist (e.g., publicly available government surveillance databases). For example, vaccine messaging can include more technical information, such as how to interpret scientific data from clinical trials and government vaccine surveillance systems (44–46). These efforts can increase vaccine confidence and trust among parents.

Studies have found pediatric healthcare providers to be the most trusted sources of vaccine information and facilitators of childhood vaccine uptake (14, 21, 22, 44). We found contrasting evidence as mothers in our study expressed decreased trust in their pediatricians and increased reliance on medical specialists like cardiologists and epidemiologists for COVID-19 vaccine information. During the H1N1 pandemic, individuals also lost trust in the government and health authorities, decreasing their willingness to get vaccinated (47). Parental vaccine hesitancy is influenced by many factors, such as vaccine type and how it was introduced (e.g., during a pandemic or mass vaccination campaign) (44–46). It is essential to strengthen long-standing relationships between pediatricians and parents, especially during a pandemic, when parents may be more concerned and less trusting of scientific information. Policymakers can consider how to develop tools to encourage collaborative provider-parent communication. Creating an environment where parents feel confident in the information received as opposed to feeling pressured to vaccinate their child against their will or despite their concerns can be beneficial among subgroups of parents like those in our study (45, 48).

The politicization of COVID-19 vaccines influenced mothers' hesitancy towards vaccinating their children against COVID-19. Mothers expressed distrust in the true motivations of public health authorities recommending childhood COVID-19 vaccination. The belief that politicians misused COVID-19 vaccine information for their political gains aligned with research that suggested public

confidence in COVID-19 vaccines was affected by how the government handled the COVID-19 pandemic (49). A poll by the Kaiser Family Foundation found political affiliation to be a stronger predictor of whether someone is vaccinated than demographic factors, such as education, race, and age (50). Considering how social, contextual and political factors may influence vaccine attitudes and beliefs, highlights the importance of public health officials leveraging multiple communication channels to address parental concerns (51).

Mothers in our study mentioned podcasts and medical websites as trusted sources of information. Podcasts were preferred because they offered differing views of childhood vaccination, and mothers appreciated the neutrality of discussions. This neutrality countered the partisan bias typically found in traditionally conservative and liberal news. Interestingly, social media was not regarded as a source of vaccine information but rather just a place to socialize, contrasting the mounting evidence that misinformation on social media influences vaccine decision-making (18, 20, 52). For mothers similar to our sample, it may be more effective to disseminate public health messaging regarding childhood COVID-19 vaccination through outlets not related to social media.

Our findings also highlighted the nuances in parental and child COVID-19 vaccination status. While other studies found parents vaccinated or intended to vaccinate against COVID-19 also intended to vaccinate their children (13, 16), our study yielded different findings. The majority of mothers in our study were all vaccinated against COVID-19 and accepted the risks of vaccination for themselves. Yet some were still hesitant and unwilling to put their children at similar risk. Children ages 5–11 years are different than older age groups, such as adolescents who may have some autonomy around vaccine decision-making (15). Therefore, mothers of young children may feel an even greater responsibility for their child's health.

Similar to other studies, parental motivations for vaccinating their child against COVID-19 included a desire to protect the broader community, return to normalcy, and mitigate the negative social and emotional consequences of COVID-19, such as educational losses due to missed school (14, 16). Mothers expressed getting their children vaccinated so they could travel internationally, and it would appear that the familial and logistical benefits of vaccination would outweigh any perceived risks associated with the vaccine. Mothers in our sample were highly affluent and may have different motivations for wanting their child vaccinated than less affluent mothers. Also, policymakers may want to emphasize the importance of school-based interventions and immunization policies that can encourage vaccine uptake in children (53).

Vaccine hesitancy can be conceptualized as linear stages of hesitancy and non-hesitancy based on the Increasing Vaccination Model and the Precaution Adoption Process Model (11, 54, 55). Some mothers in our study would fall within the stages of undecided (i.e., considered but not yet decided) and refuse (i.e., considered and decided to refuse). A notable difference with our findings is that the process may not be linear. For example, some mothers immediately refused childhood COVID-19 vaccines without first being undecided. This behavior highlights the complexities of understanding vaccine hesitancy. There is a public health need to shift mothers from undecided to decided, and understanding the perspectives of mothers who may have fewer financial barriers and access to more resources,

such as those who are highly educated, can help in tailoring policy-driven interventions. For mothers who accepted COVID-19 vaccines, according to the model above, some would still be classified as “decided but not yet highly educated” due to delays in getting their child vaccinated. These mothers described technical barriers like being put on a waitlist to see their doctor. Despite the variety of places where COVID-19 vaccination is available, it is possible that mothers feel more comfortable vaccinating their children in a pediatrician’s office or a school setting. This preference may inform policy decisions related to vaccine distribution and understanding how these barriers may be reduced to facilitate faster vaccination for willing parents.

4.1 Strengths and limitations

Our qualitative approach allowed for a deeper exploration of White mothers of higher educational and socioeconomic statuses’ perspectives, producing rich data that offer more context than quantitative survey data. While studies have highlighted influencers of vaccine hesitancy among minority populations, very few have focused on higher socioeconomic populations. We found mothers with higher educational and financial status hesitant to vaccinate their children ages 5–11 years against COVID-19. This finding suggests that parents of various backgrounds have different beliefs and values, and future public health efforts should consider this when promoting vaccine uptake. These differences are especially critical during the early months of a vaccine’s rollout during a pandemic when many lives are at risk (47, 56, 57). Our qualitative study is one of the few studies that occurred when the FDA authorized the Pfizer-BioNTech COVID-19 vaccine for emergency use in children ages 5–11 years and represented early views and perceptions. Additionally, COVID-19 vaccine uptake in children ages 5–11 years remains suboptimal, with White children having the third lowest vaccination coverage. These findings may help explain why White parents of higher educational and socioeconomic status might still be hesitant.

Limitations of our study include that our sample was purposively recruited from one setting, a childcare service, and represents one geographic location, Atlanta, GA. The sample comprised of White, highly educated, higher-income mothers from the South. Their perspectives are not generalizable to other mothers. We focused on mothers because they tend to be primary healthcare decision-makers for children, including vaccinations (41); however, not having the perspectives of fathers or other caregivers limits the conclusions we can draw from our findings. Our study took place at the beginning of the vaccine rollout for children ages 5–11 years, and it is possible that mothers’ perceptions changed over time.

4.2 Future recommendations

Our study demonstrates the need to develop tailored public health interventions, vaccine policies, and clear and transparent communication strategies to address the unique needs and concerns of subgroups of parents. Understanding how demographic factors, such as race, income, and education, may influence vaccine hesitancy may inform different strategies to shift attitudes and beliefs toward accepting childhood COVID-19 vaccines. Mothers in our study were informed about childhood COVID-19 vaccines by researching

scientific websites, reading clinical trial information, talking to medical specialists who were their friends and families, and reviewing data from government surveillance databases. Developing an intervention that could connect mothers with medical and infectious disease specialists and scientists may be beneficial in addressing their concerns and countering misinformation. These interventions could potentially assist mothers with interpreting scientific information accurately, including understanding the limitations of surveillance systems. Mothers in our study did not rely on social media as trusted sources of information, and therefore, we recommend promoting vaccine information and engaging with parents through their preferred communication channels, such as podcasts. Future research is warranted to study vaccine hesitancy perspectives of other parents with higher education and socioeconomic statuses and from different geographical regions to see if similar patterns exist.

5 Conclusion

Vaccine hesitancy may influence a mother’s decision to delay or refuse to vaccinate their child against COVID-19 and may be influenced by demographic factors such as race, income, and educational attainment. Our study highlighted the unique vaccine concerns and needs of White mothers with higher educational and socioeconomic status an understudied group. Most studies have focused on the driver of parental vaccine hesitancy among racial and ethnic minorities and those with lower socioeconomic status. Mothers in our study conducted their own research and reached out to members of their social network who were medical specialists such as cardiologists. They preferred discussing vaccine safety information, such as the potential long-term effects, with these specialists rather than their pediatricians and primary care providers. This is concerning, given that previous studies have found that recommendations from pediatricians are the most impactful on vaccine receipt (54). It suggests the need for more tailored vaccine communication strategies and interventions, such as connecting these parents with scientists, epidemiologists, and medical specialists who can answer their questions and help them understand the risk–benefit ratio of COVID-19 vaccines. Our sample did not rely on social media for vaccine information, and policymakers may need to increase their presence on alternative platforms, such as podcasts, to counter misinformation. Vaccine-hesitant parents are a heterogeneous group, and understanding the beliefs, attitudes, and behaviors of subpopulations of parents is critical in reducing vaccine hesitancy and increasing COVID-19 vaccine uptake. Findings from our study revealed initial perceptions of childhood COVID-19 vaccines for children ages 5–11 years and can inform vaccination policies and health promotion guidelines surrounding the introduction of novel vaccines for emerging diseases.

Data availability statement

The datasets presented in this article are not readily available because it consists of audio and video recordings of interviews with participants. We want to protect the confidentiality and privacy of the participants. Upon request we may be able to provide summaries.

Requests to access the datasets should be directed to TS, tiffany.suragh@uth.tmc.edu.

Ethics statement

The studies involving humans were approved by the Institutional review board at UTHealth Houston (HSC-SPH-11-0577). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. DA: Formal analysis, Writing – review & editing. PY: Writing – review & editing. MA: Conceptualization, Formal analysis, Supervision, Writing – review & editing. PC: Conceptualization, Formal analysis, Methodology, Resources, Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. TS was supported through a predoctoral fellowship, the UTHealth School of Public Health-NCI Cancer Control Research Training Program

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(National Cancer Institute/T32CA057712, MPI: P. D. Mullen, M. E. Fernandez, S. W. Vernon).

Acknowledgments

We would like to acknowledge the participants of the study who were open to sharing their perspectives during the COVID-19 pandemic and Sherly McCurdy from the University of Texas Health Science Center at Houston (UTHealth) School of Public Health, Department of Health Promotion and Behavioral Sciences, for her guidance.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 25 March 2024

ACCEPTED 21 June 2024

PUBLISHED 10 July 2024

CITATION

Shumba CS, Kiraithe P, Kambo I and
Shaibu S (2024) Community Health
Volunteers' experiences of implementing
COVID-19 vaccine education and promotion
in Kenya: a qualitative descriptive study.
Front. Public Health 12:1406959.
doi: 10.3389/fpubh.2024.1406959

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Community Health Volunteers' experiences of implementing COVID-19 vaccine education and promotion in Kenya: a qualitative descriptive study

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Background: Vaccination was a key measure in the COVID-19 pandemic response, though much work was needed to promote vaccine uptake and acceptance. In Kenya, Community Health Volunteers (CHVs) played a key role in vaccine education and promotion. We conducted this study to explore CHVs' experiences of implementing COVID-19 vaccine education and promotion during the pandemic to increase COVID-19 vaccine uptake in two areas of Kenya.

Methods: In a qualitative descriptive study, we conducted 30 structured in-depth interviews with 20 CHVs and 10 Community Health Assistants from rural Kilifi County and Kangemi, an urban informal settlement of Nairobi County in Kenya between April 2022 and July 2022.

Findings: Thematic analysis generated five key themes in relation to CHVs' experiences of implementing COVID-19 vaccine education and promotion: Five key themes emerged regarding CHVs' experiences of implementing COVID-19 vaccine education and promotion: (1) vaccine preferences influenced acceptance, (2) the fear of side effects was a barrier, (3) misinformation was widespread (4) lack of trust in government and politicization of vaccines was a barrier, and (5) CHVs' efforts were a facilitator to increased uptake.

Conclusion: Extensive community outreach from CHVs contributed to the high uptake of primary vaccines and boosters during the COVID-19 pandemic. CHVs acting as role models by receiving vaccinations first was particularly important in influencing communities to accept vaccinations. Findings provide evidence for prioritizing CHVs in the planning and implementation of future vaccination initiatives in Kenya and other countries.

KEYWORDS

Community Health Volunteers, COVID-19 vaccination, vaccine uptake, pandemic, Kenya

Introduction

COVID-19 is a disease caused by the SARS-CoV-2 coronavirus and since December 2019 when the first case was recorded in Wuhan, China, there have been over 760 million cases and 6.9 million deaths globally (1, 2). Since the beginning of the pandemic, Kenya registered, 344,094 confirmed cases and 5,689 deaths (3). In 2020 and 2021, there was a global focus on the development and deployment of vaccines to reduce COVID-19-related illness and mortality (4). There was a rapid development of COVID-19 vaccines to provide protection against severe illness and death, with more than 13 billion vaccine doses administered worldwide by June 2023 (1). The roll-out of the main types of COVID-19 vaccines in Kenya, namely Pfizer, Johnson and Johnson, Moderna, AstraZeneca and Sinopharm, commenced in March 2021, with the goal of attaining 100% vaccination coverage by December 2022 (5). However, by March 2023, a total of 23,359,310 COVID-19 vaccine doses had been administered in the country, with 14,317,039 people receiving at least one dose, and only 26.63% of the population having received at least one dose thereby falling short of the target (6). The poor vaccine coverage was largely attributed to vaccine inequity issues as countries in Africa did not have timely access to COVID-19 vaccines, had limited capacity for regional vaccine manufacturing thereby relying on foreign production, coupled with challenges in distribution and utilization of the vaccines once they were accessible (7, 8).

Vaccination was a vital measure for reducing virus transmission and minimizing public health impact, however, to be effective, the immunization program required high uptake and acceptance rates. While the success of vaccine deployment hinged on a wide range of factors, last-mile delivery and roll-out were particularly important. Community Health Workers (CHWs) were critical in introducing vaccines to local communities, given their understanding of these communities and their extensive knowledge of other vaccination drives (4). From the outset of the vaccination roll-out, it was evident that a lot of work would be required from CHWs to boost trust, acceptance, and uptake. CHWs have been defined previously as lay health workers who have some basic training to promote health in their communities and often are not salaried (9). Strengthening community health systems that include several cadres of community health workers, has become a pertinent area of focus in supporting achievement of universal health coverage in sub-Saharan Africa (9). There are ongoing efforts to formally standardize their training and professionalize and remunerate them (10). The roles of CHWs differ across contexts but typically will involve preventive and promotive services, community drug distribution, diagnosis of some illnesses, referrals, and health and vital statistics reporting (9). CHWs are trusted by their communities and often the first line of contact with the health system, acting as a link between their communities and health facilities. In Kenya, CHWs who are referred to as Community Health Volunteers (CHVs) receive basic training but are not considered healthcare professionals although they are engrained into Kenya's health system with a guiding national framework (11, 12). The CHVs are drawn from the local communities, play a crucial role in increasing access to health services among marginalized population, and are supervised by Community Health Assistants (12, 13). Due to their established

roles mobilizing communities to promote child health and immunization, there was an expectation/a default position that CHVs would also play a major role in promoting uptake of COVID-19 vaccines in Kenya (12).

In Kenya, Community Health Volunteers (CHVs) played a key role in COVID-19 vaccine outreach and as part of the frontline health workforce, they promoted uptake through community engagement and mobilization, but their perspectives are underrepresented in the literature on their experiences and contributions to the pandemic response. There is evidence on how the knowledge, attitudes, and perceptions of CHWs regarding COVID-19 vaccination influenced vaccine hesitancy (12, 14, 15). However, less is known about the experiences of CHWs in conducting COVID-19 vaccination outreach in their communities. The capacity to implement effective risk communication and community engagement strategies including vaccine education and promotion in a pandemic context hinge on a strong comprehension of the critical strategies deployed by CHVs in their communities, barriers, and enablers, but this is understudied. Understanding these experiences is crucial for improving vaccination uptake and addressing vaccine hesitancy among communities. We conducted this study to explore CHVs' experiences of implementing COVID-19 vaccine education and promotion during the pandemic to increase COVID-19 vaccine uptake in two areas of Kenya.

Methods

Study design and setting

This was a qualitative descriptive study conducted between April 2022 and July 2022 in two areas of Kenya. In this paper, we focus on the specific experiences of CHVs providing COVID-19 vaccine education and promotion to increase vaccination uptake. This study was undertaken as part of a broader study aimed investigating the roles of CHVs during the COVID-19 pandemic in rural and urban Kenya. The qualitative descriptive design was chosen because it enabled examination of how the CHVs experienced promoting COVID-19 vaccine uptake in their communities in Kenya, an important topic sparsely documented in the literature on COVID-19 responses thereby contributing to the body of knowledge (16). Further, this design was preferred to provide the foundational understanding and set the basis for future studies among CHVs and their communities on COVID-19 vaccination. The qualitative descriptive design is a distinctive component of qualitative research that is in itself valuable especially when direct descriptions of phenomena including who, what and where are desired by the researcher (17).

We chose two distinct geographical settings to capture the diversity of experiences in an urban and rural context and compare. The first, Kilifi County, in particular Kaloleni and Rabai Sub-Counties are rural areas with an estimated population of 352,175 of whom 70% live below the poverty line (18). They are some of the poorest areas in the country and heavily reliant on subsistence agriculture and tourism, with limited health infrastructure and long distances to primary health care facilities (13). The second area, Kangemi, is a low-income informal settlement in the western part of Nairobi County, the capital of Kenya, with an estimated population of 100,000 (19, 20).

Sampling and recruitment

We purposively recruited a total of 30 participants comprising 20 CHVs and 10 Community Health Assistants (CHAs), with 10 and five (5) from each county, respectively. A total of 30 participants was sufficient to achieve saturation, whereby no new themes emerged on the phenomenon of the CHVs experiences in promoting COVID-19 vaccine uptake (21). Community Health Assistants supervise CHVs within community health units, which each comprise an average of 1,000 households and 5,000 people within a geographically defined area. Each unit is aligned to an administrative sub-location with 10 CHVs and specified health facilities (22). The CHAs were included as participants in the study in addition to CHVs, given their supervisory role of 10 CHVs, their understanding of the roles of multiple CHVs and how these evolved during the pandemic period. Their perspectives were critical to aiding understanding of how the experiences were shaped among several CHVs, thereby complementing the study's objective.

Data collection and interview process

We held entry meetings with county leadership teams and approached CHAs in participating counties who then introduced us to the CHVs in their respective areas. We informed the CHAs and CHVs about the study, emphasized confidentiality and voluntary participation, as well as risks and benefits of study. We asked those who were willing to participate to contact the study team to arrange a phone interview. We developed structured in-depth interview guides in English and translated them to Kiswahili. The interviews were all telephonically conducted by PK, a trained and experienced Research Assistant and the recordings and transcripts were checked by SS and CS, ensuring consistency in data collection. We pilot-tested the interview guides with two participants to identify and remedy any problems. The interviews lasted about an hour and were concluded with a summary and debrief of the issues discussed. Key questions were: What were the communities' attitudes toward the COVID-19 vaccines? What are some of the reasons why community members accepted to be vaccinated? What are some of the reasons community members gave for refusing to be vaccinated? How was the vaccine uptake in your area? What do you think were the factors that influenced the vaccination coverage rate that you attained in your community? Were there any specific challenges you faced as a CHV while promoting COVID-19 vaccine uptake?

Data management and analysis

All interviews were audio-recorded and transcribed from Kiswahili into English and back translated. Transcripts were checked against the audio recordings for quality checks and de-identified prior to uploading to a secure database at the Aga Khan University, School of Nursing and Midwifery. We imported and analyzed the data with NVIVO-12 software and utilized a thematic inductive approach (23), which involved development of a coding framework with themes and categories. We employed data source triangulation, by examining the data from both CHVs and CHAs and checking for concurrence or divergence of the information, enhancing our understanding of

CHVs' experiences in promoting COVID-19 vaccine uptake (24). Transcripts were coded independently by PK and CS and reviewed by SS. Where there was lack of agreement on the coding, CS and SS re-examined the transcripts and reached consensus through discussion. The study team also held a final in-depth discussion and review of key themes to ensure agreement on the codebook.

Ethics

We obtained ethical approval from both the Aga Khan University Kenya's Institutional Scientific and Ethics Review Committee [Ref: 2020/IERC-89(v3)] and the National Commission for Science Technology and Innovation (EOP/NMS/HS/088). We also sought and obtained permission to conduct the study from county governments, local leaders, and gatekeepers. Further, we obtained voluntary informed consent from all CHAs and CHVs who participated in the study. Participant privacy and confidentiality were assured during data collection as no specific identifiers were recorded and all transcripts were de-identified granting anonymity, assigned codes and could not be linked back to the participants (25). None of the analysis and study reports included any identifying information on individual participants. Further, the data was stored in a secure password protected database accessed only by the research team.

Results

Characteristics of CHVs and CHAs

Our study had a wide range of participants ages 20–70 years, with 65% between 20–40 years. Half (50%) of the participants had completed primary and secondary level education while the rest had post-secondary education. Most (65%) had 6–20 years' experience as CHVs while the rest had 1–5 years' experience. Household coverage for CHVs ranged from 25–100 households, with most (60%) covering 76–100 households as part of their duties. Our analysis indicated that CHAs and CHVs from the two regions played a crucial role in promoting vaccine uptake and acceptance during the COVID-19 pandemic. Five key themes emerged regarding CHVs' experiences of implementing COVID-19 vaccine education and promotion: (1) vaccine preferences influenced acceptance, (2) the fear of side effects was a barrier, (3) misinformation was widespread (4) lack of trust in government and politicization of vaccines was a barrier, and (5) CHVs' efforts were a facilitator to increased uptake. Data are presented under each theme and sub-theme (Table 1) with supporting de-identified quotes from CHVs and CHAs.

Theme 1: vaccine preferences influenced acceptance

In the narratives of the CHVs, as COVID vaccines became available in the country and they provided vaccine education and promotion, it was apparent that preferences had already been formed. Participants described how Moderna (mRNA vaccine) was preferred over AstraZeneca, mostly attributed to concerns surrounding safety, effectiveness, side effects and individual suitability of vaccines. This

TABLE 1 Identified themes and sub-themes.

Themes	Sub-themes
1. Vaccine preferences influenced acceptance	1.1 Preference for the Moderna vaccine 1.2 Preference linked to side effects 1.3 Uncertainty of suitability of vaccines for individuals
2. Fear of side effects was a barrier	2.1 Lost time from work/income loss 2.2 Reported side effects 2.3 Delayed acceptance to ascertain vaccine impact on others
3. Misinformation was widespread	3.1 Vaccine a cause of infertility 3.2 Interference with well-being and death 3.3 Non-existence of COVID-19
4. Lack of trust in government hindered uptake	4.1 Rumors of voting through the COVID-19 vaccine 4.2 Government accused of selling citizens
5. CHVs' efforts were a facilitator to increased uptake	5.1 CHVs prioritized for vaccination 5.2 CHVs increased vaccination uptake

theme came up consistently in the informal settlements of Kangemi, in comparison to rural Kilifi where this did not emerge as a concern.

Sub-theme 1.1: preference for the Moderna vaccine

As COVID-19 vaccines became available, many expressed uneasiness and confusion. CHVs reported that there was a strong preference for the Moderna vaccine over AstraZeneca. Some people thought the AstraZeneca vaccine would be harmful, influenced by false information and rumors regarding safety. For instance, one rumor circulated that the AstraZeneca vaccine was causing people to die. Despite such rumors, CHVs worked hard to convince their communities to take up the AstraZeneca vaccine due to Moderna stockouts.

Respondents indicated a strong preference for the Moderna vaccine which they believed was safe and effective compared to other accessible alternatives. However, some people made decisions based on vaccine accessibility, consenting to receive the AstraZeneca vaccine for their second dose when Moderna was unavailable.

At first, people were saying if you were vaccinated with AstraZeneca you will die... most, people had fear in those types of names... One could say if you are injected this one you die, this one you get drowsy... They had different opinions, according to the types of vaccines they were using. Kangemi CHV 01 Script

... I know about the households I am in charge of. ... It reached a point, and it was said that Moderna has finished and not available... I went to inquire from the facility, and I was told that for ones that took Moderna for the first dose, since Moderna was out of stock, let them take AstraZeneca for the second dose, and that's what I did. Kangemi CHV 09 Script

Sub-theme 1.2: preference linked to side effects

Vaccine preferences were also linked to perceived side effects of specific vaccines and the severity of these effects. For instance, one CHV reported that the Johnson and Johnson vaccine was believed to cause insomnia. Communities held several incorrect beliefs about vaccines' adverse effects which were often based on rumors. Conversely, there was a preference for vaccines with perceived lesser or more manageable side effects.

It is just a myths and misconception thing, the myths that they were discussing. You find people where they meet saying, you know, I was vaccinated with Johnson and Johnson, it is bad and you cannot fall asleep. You find another one saying I was vaccinated with the Moderna. Moderna makes one go to sleep. Kangemi CHV 04 Script

Sub-theme 1.3: uncertainty of suitability of vaccines for individuals

It was reported that many community members wanted assurance on the suitability of specific vaccines for them as individuals. Findings suggested that people sought individualized information and counseling to make knowledgeable decisions about vaccination. However, it was generally not possible to provide such advice. Variables such as age, allergies, pre-existing health conditions, and other personal traits affected vaccine acceptability.

ask you when you are here, when getting injected, which one is good for me to be injected with. What is suitable for me? And which one isn't suitable for me. You see ... the community wants to get first-hand information from me. They want to know which one is good, and which one is better. Kangemi CHV 01 Script

Theme 2: fear of side effects was a barrier

The fear of side effects was cited as a major hindrance to uptake of the COVID-19 vaccines in both Kilifi and Kangemi. CHVs reported community members' concerns on potential loss of income while nursing vaccine side effects. Reports of side effects experienced by those who got vaccine shots fuelled the reluctance. Additionally, in both Kilifi and Kangemi, community members were reported at the outset to take a cautious approach. They wanted to see how those who took the vaccine shots were impacted health wise before committing to receiving them. Over time the confidence to take the vaccines increased as the communities did not hear of severe adverse events.

Sub-theme 2.1: lost time from work/income loss

One of the biggest fears expressed was that vaccination side effects would cause people to lose time from work and consequently, income. Such anxieties were especially apparent among breadwinners.

CHV: *This is because they were saying they are being injected but tomorrow we are not going to be able to go to work. Kangemi CHV 02 Script*

Interviewer: *What were they saying?*

CHV: *That the injection has a lot of side effects in the body when injected.*

Interviewer: *Like which one?*

CHV: *That the hand was becoming numb ... Kangemi CHV 02 Script*

So, when you are injected, you can stay even a week without doing any work. Kangemi CHV 02 Script

Some refused because they were the breadwinners. Kangemi CHV 02 Script

Another one could say he was vaccinated, and he experienced dizziness. Kangemi CHV 10 Script

Sub-theme 2.2: reported side effects

There were also concerns about reported vaccine side effects. In one instance, a woman's menstrual cycle was delayed following vaccination.

Someone would tell you I was injected, for example, I remember there was a woman who was injected, and her menses delayed... Kangemi CHV 10 Script

Sub-theme 2.3: delayed acceptance to ascertain vaccine impact on others

Some respondents reported waiting to see how the vaccines affected others before accepting vaccination themselves. This hesitation can be explained by worries about potential adverse effects. Those initially skeptical about the vaccine became less so as more of the community members received vaccinations and shared their experiences.

They wanted others to be vaccinated first. Kangemi CHV 10 Script

...but when now many people were getting vaccinated other people gained confidence. Now that the bad things that were to happen to them did not occur... Kilifi CHA 03

Theme 3: misinformation was widespread

Vaccine education and promotion efforts by CHVs were also generally hindered by misinformation. The CHVs gave accounts of how rumors were spreading within their communities regarding the vaccines being linked to causing infertility. Some community members believed that the vaccines caused ill-health and death following rumors or experiences of adverse events. Further, there were some who denied that COVID-19 existed, subscribing to different conspiracy theories.

Sub-theme 3.1: vaccine as a cause of infertility

There were several examples of misinformation affecting vaccine uptake. Some community members believed there was a link between

vaccination and infertility or that vaccines were being used as a family planning tool. Misinformation caused reluctance and resistance to vaccination.

There are others who said that when injected you will lose your ability to have children. Kangemi CHV 02 Script

... at first, the community denied the vaccination. They thought that it was a family planning method, or it was just something that will kill them. Kangemi CHV 03 Script

Yes, there were many challenges with vaccination. [Inaudible] several drives, vaccination drives within the village, within the community. It was because the approach was different, the perception of the COVID jabs was not positive. They took it the African way. Some could say that it's a way of family planning, such kind of funny [inaudible]. That women will not have children, the men will not function, you understand? Kangemi CHV 06 Script

Yeah. Because they were assuming that we are forcing them to get the vaccine, like, they were saying the vaccines are for family planning method and now we were forcing them. They were not believing a vaccine for COVID-19. So, you could get insults, someone could just stop you when talking and then walk away. Kangemi CHV 03 Script

Most people they think they are being done the family planning methods against their will. Yes ... Kilifi CHV 05 Script

Sub-theme 3.2: interference with well-being and death

Some believed that the vaccine interfered with the normal functioning of bodily processes and would result in chronic illness or death. These perceptions increased vaccine hesitancy. Further, some claimed to constantly feel unwell after being vaccinated, increasing reluctance among other community members.

Some they give me something like... {That injection is interfering with the body parts}. That some things have changed. They feel they are sick all the time but for me I remember when I was given the first dose I felt like {I had caught a slight cold}...kind of. Kangemi CHV 04 Script

Others attributed death of friends to the vaccine.

Yes, we were and even, now even that was an issue because some people were refusing. Yes, you will tell some people go and get the Moderna and they would say 'me I don't want that one' or 'if my friend had not received the vaccination he wouldn't have died'. You see they start telling stories about their friends, about other people. Kangemi CHV 05 Script

Further, there were rumors of death due to boosters that also dissuaded community members from taking these up.

The booster has been an issue in the community. People were saying if you take a booster you die, like some of the people who were taking

the booster, they had other underlying issues like one of our CHVs, we lost one of our CHVs. Now the rumour had it that the booster is the one that made the CHV to die. Now, the uptake of boosters is low because many people do not want to take them. They believe that when they take the booster vaccine, they're going to die. Kangemi CHV 03 Script

Sub-theme 3.3: non-existence of COVID-19

Some members of the community believed COVID-19 was a hoax or scam, which negatively affected their adherence to the global guidance on vaccination. Reasons for this denial of COVID-19 included false information and conspiracy theories, and a more pervasive lack of trust in official sources.

Some declined the facts while some said that the COVID-19 just a scam, they don't believe in it. So, they feared to come to the facility to test this, they hid the signs of COVID-19. Yeah, it was not that easy the during the COVID-19 period. Kangemi CHV 03 Script

Theme 4: lack of trust in the government hindered uptake

Participants' narratives shed light on the issues of trust in the government, especially given that the vaccine roll-out was conducted in the lead up to the presidential elections. Some refused vaccine shots because they believed they were a tool used by the government to manipulate them into somehow 'involuntarily voting' or being 'involuntarily sold'. These perspectives on the politicization of the vaccine uptake were pronounced in rural Kilifi.

Sub-theme 4.1: rumors of voting through the COVID-19 vaccine

Analysis indicated a high degree of suspicion in these communities that they were being tricked into voting by accepting the vaccine. This was due to the vaccine roll-out occurring close to the election period. This lack of faith in the government's motives may have been a factor in vaccination reluctance.

That is the only challenge, and I don't have any other. That was the challenge I experienced, you tell someone to go and get vaccinated and others would say that is COVID, another one tells you that we are voting through getting the vaccine. Kilifi CHV 02 Script

Sub-theme 4.2: government accused of selling citizens

Some members of the community believed the distribution of COVID-19 vaccines was tied to nefarious purposes, accusing the government of selling its people. This was linked to a broader lack of faith in the government's motives.

That you should go and get the vaccine because even I am telling you that I have received the vaccine. When you get that, even if one in your houses gets it, it won't attack you much because you'll have

the vaccine that protects you. But people started to say that if the vaccine is given, they are looking for a way to sell people of the country. Kilifi CHV 07 Script

Theme 5: CHVs' efforts were a facilitator to increased uptake

Overall CHVs, mentioned being prioritized for vaccination and used this as an opportunity for positive role-modeling in their communities, encouraging others to follow suit. They also highlighted how crucial their vaccine education and promotion efforts were in increasing uptake in their communities, with most of them reporting vaccine uptake rates of 80% or more among their catchment communities.

Sub-theme 5.1: CHVs prioritized for vaccination

As frontline health workers with increased exposure to SARS-CoV-2, CHVs were prioritized for vaccines. CHVs reported that they saw the importance of leading by example, as they could hardly ask others to be vaccinated if they had not accepted. CHVs are dependable members of the community who can communicate with local people and provide information regarding the effectiveness and safety of COVID-19 vaccines. By serving as role models for the community and advocating vaccination, CHVs appeared to have had a significant influence on vaccine uptake.

they were treated as health workers, so they were given priority for the vaccination so a large percentage of them, approximately ninety six percent have been vaccinated if not a hundred. Kangemi CHA 01

And because I'm among the staff, so we followed that category. And I mobilize the community on the importance of getting that vaccine. Kilifi CHV 10 Script

And you can't mobilize people to get vaccinated once you are not vaccinated yourself so it's for them to lead by example. Kilifi CHA 02

Actually, in the beginning, people were fearing to come. So, at the facility the number was so low but after getting out Kangemi CHV 01 Script

Sub-theme 5.2: CHVs increased vaccination uptake

CHVs worked hard to increase vaccine uptake. They also tracked uptake rates, with most citing that rates within their communities were 80% and above. CHVs promoted vaccination uptake by conducting community sensitization, delivering information, and dispelling myths and misconceptions.

The turnout was quite good. Yes, I think it was almost 80%. From this time that there was that fear maybe those that are vaccinated what will happen but through sensitization and creation of awareness isolation and awareness getting them the right

information there was a positive reaction from the members of their community, of my households Yes. I think most of them are vaccinated. okay. **Kangemi CHV 09 Script**

In my area I have tried so much, up to 80% have received the vaccination. **Kangemi CHV 02 Script**

At start at my community households only thirty had been vaccinated at first. And we had sensitized them and through the TV ... the social media that the importance of vaccination. So, they accepted later on, but at the beginning they declined. **Kangemi CHV 03 Script**

They went for the COVID vaccine...at least three quarters of my households those that I am aware of COVID-19 vaccines and how they can prevent themselves from COVID-19. **Kangemi CHV 04 Script**

Okay, the uptake as of now, many community members have been vaccinated. So up to now, the turnout is good. Just a few now come in because we are still vaccinating up to now. **Kangemi CHV 03 Script**

The turnout was quite good. Yes, I think it almost 80%... **Kangemi CHV 09 Script**

Their areas, okay, the uptake, it's like eighty percent, let's work with percentage they have not achieved one hundred because we have the myths and misconceptions in the community ... **Kangemi CHA 03**

However, despite their efforts, CHVs reported that some community members still refused to be vaccinated.

There were still others who accepted, and others refused... **Kangemi CHV 10 Script**

Wow, That one was also another big challenge for some were appreciative while other refused until today...**Kangemi CHV 02 Script**

They also have to educate on which vaccines are present within the facility to create options for them, these vaccines are administered within this period of time, just quality information about the vaccines. **Kangemi CHA 04 Script**

Discussion

The aim of this qualitative study was to understand the experiences of Community Health Volunteers (CHVs) in promoting COVID-19 vaccine uptake in two areas in Kenya. Our findings revealed five main themes of these experiences: vaccine preferences, fears of side effects, misinformation, lack of trust in government, and vaccine uptake.

Vaccine preference was a major factor influencing uptake in the communities studied. Understanding attitudes toward vaccines requires having a grasp of vaccine preferences. Anxiety regarding certain vaccine types can negatively affect vaccine uptake. Our study

demonstrates the many factors that affect vaccine preferences, including fear, false information, and availability. There was a preference for the Moderna vaccine over AstraZeneca and Johnson and Johnson, which were shunned because of misinformed beliefs that they caused death and insomnia, respectively. Myths and misconceptions about side effects also influenced vaccination preference. Misinformation is known to be a major driver of vaccine hesitancy (26). Individuals may avoid vaccination due to fear and reluctance caused by misinformation. To combat this, communication efforts must prioritize the distribution of correct information. Clear communication about vaccination safety, effectiveness, and the rigorous approval process may help improve confidence and dispel vaccine myths.

It was also evident that certain individuals felt ambiguity about whether vaccines were appropriate for them specifically. Recognizing individual concerns and giving personalized information is key to addressing this issue. Building vaccination confidence and resolving doubts among community members depends on reliable sources. Prioritizing tailored communication and clearly addressing individuals' concerns is crucial in supporting decisions about vaccine uptake. Healthcare providers could assist communities in making informed vaccination decisions by adapting information to their concerns and working with CHVs to provide information about available vaccines, ensuring that information can be understood by community members. There is also a need to maintain a consistent supply of vaccinations to accommodate individual preferences where possible.

As well as affecting vaccine preference, fear of side effects was cited by CHVs as significantly limiting uptake more generally. This finding is in line with those of other studies which have illustrated how vaccine hesitancy in LMICs was fuelled by concerns about side effects, with 57% of people in Kenya and 30% of South Africans reported to have refused the vaccine for this reason (27, 28). Such concerns have also caused hesitancy in other countries (29–31). In our study, the possibility of infertility was one side effect that caused particular concern. A study in Tanzania found that worries over infertility as a negative consequence of the vaccines contributed to COVID-19 vaccine hesitancy (32). To address such problems, focused risk communication and community engagement strategies should be used to dispel misinformation and promote correct information. Further, reassurance could come from community members sharing testimonials about their vaccination experiences. Respected community leaders who openly discuss their experiences and support vaccination campaigns can foster trust and inspire others to do the same increasing vaccine uptake.

Another fear cited in our study is that of lost income through missed days of work (27). Communities needed assurance that short-term discomfort from side effects was minor in relation to the protection conferred against COVID-19's impact on health and well-being. To address this, public health officials should work with employers to provide clear information on vaccine safety and offer assistance for people experiencing side effects. It also points to the need to aid people who might have to miss work due to side effects. This could take the form of compensated sick time or modified work schedules.

We found that some individuals postponed being vaccinated to observe reactions in others. Countering this apprehension requires public health initiatives that promote positive vaccination experiences,

with individuals who have been vaccinated being encouraged to share their experiences to increase trust and confidence in the vaccine. Community leaders and influencers may play an important role in setting a good example for others to follow. Further, it is crucial to communicate possible adverse reactions and the steps that should be taken in such instances.

Misinformation was another factor preventing vaccine uptake. Reports indicated that many believed COVID-19 to be a hoax, an observation that is consistent with findings from Tanzania, Turkey, and the U.S. (31–33). To address misinformation and disinformation, public health officials and healthcare practitioners must prioritize the distribution of correct information. Incorrect beliefs can be dispelled by working with community leaders and influencers to deliver clear information regarding vaccination benefits and safety. Open forums and educational workshops, for example, can address concerns and give evidence-based responses to enable informed vaccination decision-making. Accurate information, community participation, and compassionate communication can help improve public health outcomes.

Lack of trust in the government was also a major hurdle, according to CHVs. This is consistent with findings from a study conducted across countries which found Kenya to rank highest in the correlation between lack of trust in the government and non-acceptance of the vaccine (34). A similar association has been shown in China (35, 36). Belief in conspiracy theories, such as vaccines being state-backed interventions, decreased trust in vaccines and restricted uptake (37, 38). It is important that trust between government and citizens is continuously cultivated and that steps are taken to address sources of mistrust. Campaigns to depoliticize vaccination can help restore faith in government action. Relationships between communities and trusted workers such as CHVs can be vital in this endeavor.

Findings indicated that CHVs were rightly prioritized for COVID-19 vaccination alongside other frontline health workers. This is consistent with WHO guidance (4). CHVs were actively involved in promoting vaccine uptake, with most reporting uptake rates of 80% and above in their communities. Their participation in promoting vaccination, conducting sensitization programs, and providing accurate information had a substantial influence. Through being prioritized, they were able to role-model being vaccinated and encourage communities to also do the same. Similarly, in other contexts, by highlighting the importance of COVID-19 vaccines and showing confidence in them, CHVs positively impacted community uptake (4, 14), with evidence supporting that vaccinated healthcare workers are more likely than unvaccinated ones to encourage the public to receive vaccination (14, 39). CHVs also engaged with the community as trusted members to deliver accurate information on COVID-19 vaccination uptake and sharing success stories of CHVs who had received the vaccine was important in increasing vaccination uptake and counteracting unfavorable narratives. An implication is that vaccination hesitancy can be tackled through focused communication techniques.

Strengths and limitations

This study contributes to a significant research gap regarding LMICs such as Kenya where the experience of CHVs in promoting

COVID-19 vaccine uptake is not well-studied. The questions covered during the interviews enabled establishment of rapport, and guided robust understanding of the overall work of CHVs during the pandemic and how they experienced their work with communities specifically in promoting COVID-19 vaccine uptake. Our findings have the potential to guide the development of risk communication and community engagement materials and inform guidelines and policies on vaccine uptake and acceptance, not only during pandemics but also in routine immunization programs. Recruitment of urban and rural participants is also a strength of our study and for each theme, a comparison of the findings between the two distinct geographical areas has been made.

Despite these strengths, interpretation of our findings may be limited by the study being conducted in just two of 47 counties in Kenya. Also, there is diversity in the experiences of CHVs and our findings may not reflect the perspectives of all CHVs across the country. That said, although findings may not be generalizable to the entire country, they might be transferable. Furthermore, although we did data source triangulation between CHVs and CHAs, a limitation was the lack of triangulation to corroborate findings from CHVs with those from community members. Representation of communities' own narratives would have deepened understanding of how vaccine education and promotion was experienced by community members and would have enhanced the credibility and validity of our study findings. In addition, a limitation to note is that there was no pre/post-intervention study or measurement here to evaluate whether use of CHVs was associated with improved vaccine coverage.

Future research should focus on building upon the findings of this exploration, potentially deploying a mixed methods approach. Further, future studies should focus on co-creating and testing the feasibility of risk communication and community engagement models led by CHVs and their communities, that have a higher likelihood of success in increasing adoption of global guidance and addressing the barriers uniquely identified in the pandemic context.

Conclusion and recommendations

This study affirms the important role CHVs played in mobilizing communities to take up primary vaccines and boosters during the pandemic through vaccine education and promotion. CHVs acting as role models by receiving vaccinations first was a particularly strong driver of community uptake. Our findings support the need to tailor risk communication and community engagement to address myths and misconceptions, while also leveraging factors that can promote vaccination uptake such as the established positive and trusted relationships with CHVs. Further, the findings demonstrate the importance of prioritizing CHVs in the planning and implementation of future vaccination initiatives in Kenya and similar countries. Finally, the findings reveal underlying issues of public trust toward vaccination drives. This points to the crucial role of continual education and awareness raising in communities on the importance of vaccines, increasing the likelihood of vaccine uptake in situations of health crisis such as COVID-19.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Aga Khan Kenya's Institutional Scientific and Ethics Review Committee [Ref: 2020/IERC-89(v3)] and the National Commission for Science Technology and Innovation (EOP/NMS/HS/088). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CS: Conceptualization, Formal analysis, Funding acquisition, Methodology, Validation, Writing – original draft, Writing – review & editing. PK: Data curation, Formal analysis, Investigation, Validation, Writing – review & editing. IK: Methodology, Validation, Writing

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– review & editing. SS: Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 29 March 2024

ACCEPTED 11 July 2024

PUBLISHED 26 July 2024

CITATION

Martínez-Pena I, Puig B and Uskola A (2024)
One Health education for criticality on
vaccination in teacher training.
Front. Public Health 12:1408965.
doi: 10.3389/fpubh.2024.1408965

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One Health education for criticality on vaccination in teacher training

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Introduction: Vaccines are the basis of health of our communities since they prevent severe infectious diseases. However vaccination rates continue to decrease due to the spread of misinformation about their side effects, which enhances vaccine hesitancy and puts at risk public health. Introducing vaccines from the One Health approach can help to develop an integral understanding of their role and to apply critical ignorance as part of criticality to avoid vaccine hesitancy and raise trust in science. This paper presents a design on vaccination for secondary-education teacher training developed toward this goal.

Methods: The design presented in this paper draws from previous studies on critical thinking, on vaccine rejection, and the One Health approach on other health issues in Secondary Education. The focus of this design is engaging secondary-education pre-service teachers in the practice of critical ignorance and criticality to assess diverse pieces of information on vaccination from the One Health approach.

Results: This study discusses the design principles and the activities of an original design that aims to provide Secondary Education teachers with some tools to introduce critical ignorance and criticality for addressing misinformation on vaccines by using the One Health approach.

Discussion: If secondary science teachers are going to successfully confront misinformation on vaccination in their science instruction, we need to develop and test designs and approaches that prepare them for this purpose. Critical ignorance plays a central role in managing misinformation; thus, such instruction should engage future teachers in critical evaluation of information on vaccination, as well as in the application of the One Health approach to take responsible actions.

KEYWORDS

One Health, vaccines, criticality, critical ignoring, biology education, teacher training

1 Introduction

Since their discovery vaccines have contributed to save millions of lives throughout History and allowed the eradication of devastating diseases (1, 2). Recently, the COVID-19 pandemic highlighted the relevance of vaccination. It is estimated that COVID-19 vaccines contributed to save around 1.4 million lives in Europe between December 2020 and March 2023 (3).

Despite the relevance of vaccines to preserve health, there is a concerning growth of vaccine hesitancy among population (4). This is fostered by the quick spread of fallacies and fake-news and increases the likelihood of preventable-disease outbreaks. Education in vaccines is an essential tool to raise awareness about the importance of vaccination and to fight against misinformation. Understanding how vaccines work and why they are important is a complex task that requires considering several dimensions of the problem besides human health. Consequently, vaccine education should integrate approaches that allow the development of a global view of the problem. One Health (OH) is an approach that considers the health of humans, animals, and ecosystems as interdependent, providing a global view of complex health issues, such as vaccination.

Assessing vaccination and managing misinformation also requires the application of critical thinking (CT) skills, especially, critical ignoring (CI) and criticality. CI is the ability to select the information, and avoid low-quality information to control own's informational environment (5). This will help citizens not only to develop their own opinion based on scientific evidence, and to differentiate evidence-based information from pseudoscientific claims, but also to take actions according to their opinion, putting CT in practice by committing to individual and collective actions, as the concept of criticality points out.

The literature review showed that most approaches that introduce vaccination in health education limit to focus on human health, without considering environmental factors that affect this issue (6). This study seeks to make a relevant contribution on this and is in line with current trends regarding the understanding of health as a global issue that not only involves humans, but also the health of animals, plants and ecosystems, a view that is coherent with the OH approach (7). This design seeks to help teachers to promote an integral OH view of vaccination, and to use teaching strategies for managing information and to make responsible actions.

2 Didactical framework

2.1 Educational challenges to promote criticality on vaccination

Even though the benefits of vaccination are widely supported by scientific evidence, vaccine hesitancy is a current concern in our society. Vaccine hesitancy was defined by the World Health Organization (WHO) Strategic Advisory Group of Experts (SAGE) on Immunization as:

“Vaccine hesitancy refers to delay in acceptance or refusal of vaccines despite availability of vaccination services. Vaccine hesitancy is complex and context specific varying across time, place and vaccines. It includes factors such as complacency, convenience and confidence.” (8) (p. 575).

Vaccine hesitancy includes people who show low or no confidence in vaccines but may support vaccination in certain situations and/or contexts. Anti-vaccine movements are located on one extreme of the continuum of vaccine hesitancy. Anti-vaccine individuals deny the efficacy of vaccines, totally rejecting their use independently on the context and circumstances (9).

One of the main concerns of vaccine-hesitants and anti-vaccine individuals is the safety of vaccines (10). This lack of trust is enhanced by the spread of fallacies with no scientific evidence (e.g., vaccines cause autism, contain compounds that poison us, it is better the natural immunity than the immunity generated by vaccines, mRNA vaccines modify our genome...) (11, 12).

In the post-truth era, vaccine misconceptions and fake news are quickly spread by social media promoting hesitancy (4, 13). This leads to a reduction in vaccine coverage among the population increasing the risk of preventable-disease outbreaks. Diseases that have long ceased to be a problem (e.g., measles) are currently experiencing outbreaks due to undervaccination in developed countries like the US and Europe (14, 15).

This also shows the existence of a reducing level of trust in science. The low trust in science might be enhanced by a wide range of factors, such as complex and abstract scientific vocabulary, low ability to manage the uncertainty inherent to the construction of scientific knowledge, and the lack of knowledge regarding the Nature of Science. Moreover, the spread of fake news affects how people deal with scientific information. Science educators seek to promote trust in science taking into consideration these challenges, as well as misconceptions that have been already identified in the literature on vaccination (12). This design aims to provide teachers with tools to introduce efficient strategies for managing information to avoid misinformation and promote trust in science.

2.2 OH education for the practice of criticality in the context of vaccination

Raising awareness about vaccination and reducing hesitation is one of the main goals in health education. Health education is part of the biology curriculum in Secondary Education (12–16 years old) in our country (blinded for review). However, health problems have been introduced as human centered SSIs, without an explicit connection with the environment. In response to this, and according to the new science curriculum (blinded for review) that includes the OH approach, science educators need to promote health education from a systemic perspective aligned with the OH approach to improve teachers' and students' understanding of vaccination from an integral view (16–18). This is the approach followed in this design.

A deep understanding of the socio-scientific dimensions of vaccination and their potential to keep the health of a community requires the development of the OH approach. OH claims that the health of humans, animals, and ecosystems (including plants) are closely interdependent (7). Introducing the OH approach to teach vaccination will allow to comprehend the impact at different levels derived from an individual action (refuse vaccination). Such consequences would be difficult to identify from a human-centered vision. Tackling health problems from the OH approach requires coordination between different social and professional sectors, including education. In fact, there are current initiatives to assess vaccination from the OH approach (19) but few of them are being developed in science and health education.

Teaching the importance of vaccines should be oriented toward empowering students to make informed decisions and take individual and collective actions (10). This is an essential part of health literacy and criticality. A high development of health literacy requires the

development of CT oriented to action, which corresponds to the notion of criticality.

The CT is essential to deeply understand complex phenomena, allowing the development of an independent opinion, thus empowering students (20). As shown by Authors (blinded) (10), promoting CT skills along with knowledge about vaccines would help students to perform better decision-making and develop actions according to current scientific knowledge, avoiding pseudoscientific and non-scientific premises.

As Davies and Barnett (21) pointed out, teaching CT in higher education involves considering at least six CT dimensions: (1) core skills in critical argumentation (reasoning and inference making); (2) critical judgements; (3) CT dispositions and attitudes; (4) critical being and critical actions; (5) societal and ideology critique; (6) critical creativity or critical openness. This work is focused on the second dimension, since critical judgment is essential for a suitable decision-making, and the fourth dimension as it is the most related to criticality.

The term criticality involves CT and attends to the individual identity and the critical action dimension (21). Criticality promotion among students requires the development of complex and global views regarding an issue and we argue that OH could provide the integrated view required to effectively develop criticality regarding vaccination.

Decision-making and action development require differentiating truthful information from non-scientific ideas. For this, critical ignorance (CI) is essential (22). CI can be defined as the conscious decision about ignoring part of information deliberately by selecting and filtering information to minimize the exposure to low-quality information (5). Although CI is fundamental in the post-truth era, most of the literature on vaccines and CT are based on knowledge and evidence-based argumentation to encourage critical decision-making. Despite agreeing that some extent of fundamental knowledge is needed for CT application, it is not always possible for students to have a highly-specific knowledge on each SSI. This is something that Secondary Education teachers should take into consideration and that this design addresses.

Therefore, it is necessary to provide instruction for pre-service/in-services Secondary Education teachers about how to develop the OH approach regarding vaccination to foster CI, and Criticality among their students.

3 Learning environment

3.1 Learning objective

The objective of this design is to engage Secondary Education pre-service teachers in the practice of criticality with a focus on CI to assess information on vaccination from the OH approach. Specifically, it is aimed to:

1. Explore how OH influences the understanding of vaccination.
2. Analyze how CI is mobilized to manage information about vaccination.
3. Assess how OH and CI are articulated in the practice of criticality when assessing information on vaccination.

Objective 1 can be evaluated in Modules 1, 5; objective 2 in Modules 2, 3, 5; while objective 3 in Modules 4, 5.

3.2 Participants

This proposal is designed to be implemented with Secondary Education pre-service teachers with a scientific background (e.g., a degree in Biology, Geology, Chemistry, Physics, Pharmacy ...) who are doing a master's degree in science education in which health controversies are addressed as part of their training in socio-scientific instruction. These pre-service teachers do not have previous experience in the classroom and this training is the first contact with science education topics and vaccination from the OH approach.

The design will be implemented within the subject "Didactic Designs on Science Education" during the next school year 2024–2025. Ethical considerations will be contemplated during this process of implementation and data analysis according to current legislation.

3.3 Design principles

Most of the learning environments and designs proposed in the literature to foster CT are mainly focused on the use of SSIs as a context to promote critical argumentation, due to their complex and controversial nature (23, 24). SSIs related to biology and environmental education, such as vaccination, are considered privileged contexts to foster CT development (25). These designs are mainly based on the CT framework proposed by the Delphi study of Facione (26) and in the notion of CT provided by Kuhn (27) that consider CT a dialogical practice. According to Facione CT involves several cognitive skills, affective dispositions and domain-specific knowledge. Facione's framework is frequently used as an operative tool for teachers training in CT (28, 29).

Although we agree with the Facione (26) framework, current citizens are exposed to large amounts of information, some of which can constitute mis-/dis-/mal-information. Thus, teachers must encourage the skills to manage all this information to make decisions and take actions, even when there is low domain-specific knowledge of a certain SSI. This leads to the need to foster CI along with CT in science education (5, 22, 30). This design provides tools to put in practice CI in science education (Modules 2, 3).

Osborne and Pimentel (31) propose a workflow about how scientific claims and information should be evaluated. This framework is used as a framework for our design (Figure 1) (Modules 2, 3).

Our approach is focused on CI as part of CT to identify the source of information and assess its credibility as an essential dimension of CT in current societies. These are essential skills for improving decision-making, and promoting criticality (Module 4).

Developing an integral vision of vaccination is a valuable tool for criticality and vaccine promotion. We argue that OH is an approach that allows to raise awareness about different factors that affect vaccination and provides a better understanding of vaccine hesitancy. This deeper understanding of the current situation offers the chance to tackle the problem of vaccine hesitancy in a more integral way. Moreover, it allows us to use different skills of CT more efficiently when evaluating the problem. For instance, an OH approach will facilitate the application of CI when assessing information regarding vaccines. This step is essential for decision-making and taking action, when criticality becomes essential. The OH approach is included in Module 1.

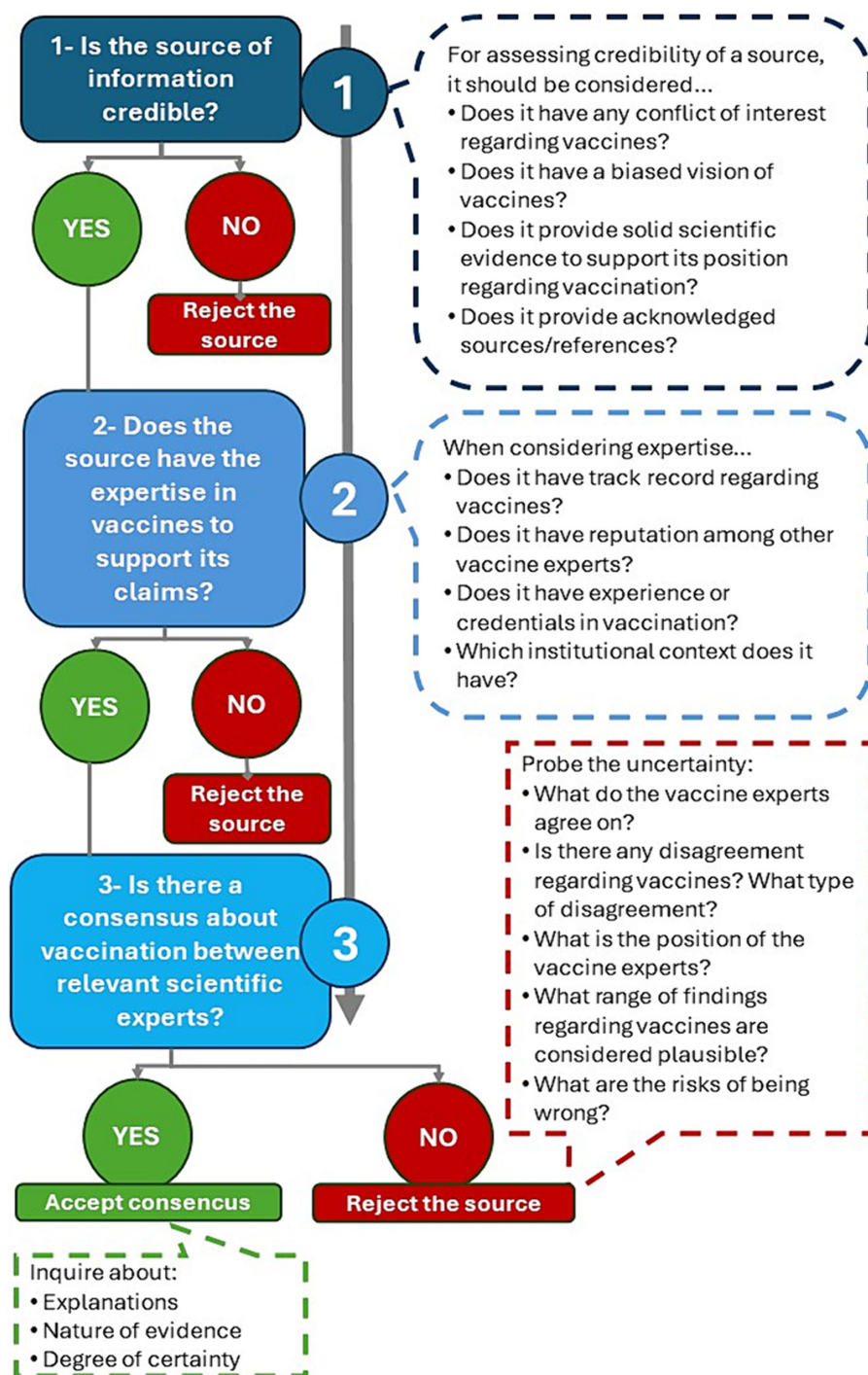


FIGURE 1 Reasoning workflow for decision-making during vaccine information evaluation [based on Osborne and Pimentel (31)].

4 Results: an instructional design for criticality on vaccination from the OH approach

Our design is a 10-h training course for pre-service/in-service Secondary Education science teachers. The instruction is organized in 5 modules (1.5 h/module). It is a flexible instruction that can be adapted to the initial level of the participants, and be scheduled according to

participants' availability. It seeks to provide efficient ways to introduce OH and Criticality to promote vaccination in science lessons. Table 1 provides an overview of the design and highlights the main dimension (OH, CI, or Criticality) addressed in each module. The OH approach underlies the whole design, as the global perspective of the problem provided by OH is necessary to properly put in practice CI and Criticality.

The workflow of this design was elaborated considering the main abilities needed in different moments of information management

TABLE 1 Overview of the course for secondary education teacher instruction “How can I promote vaccination from a systemic, critical, and active perspective?”

Module	Topic/dimension		Objective	CI/OH/criticality	Duration (min)
1	How can we raise awareness about vaccination in science classrooms?		Promoting an integral vision of global risks of undervaccination.	OH	90
2	How can I help students to avoid vaccine fallacies?	(I): Looking for evidence	Providing tools for information management and to avoid over-information in relation to vaccines.	CI	45
		(II): Contrasting information			45
3	How can I raise trust in vaccines?		Developing strategies to teach about the relevance of scientific knowledge and the Nature of Science to increase trust in vaccines.	CI	90
4	What can we do to preserve public health?		Learning how to orient teaching toward critical action regarding vaccination.	Criticality	90
5	Propose a new design using OH approach		Applying the learnt during the instruction to your own classroom and context.	OH CI Criticality	90

that lead to decision-making and taking actions. Firstly, developing a wide and complex understanding of the problem is desirable. This is addressed in Module 1 where OH can be a beneficial approach to this purpose. Afterwards, this multi-step process involves managing information efficiently where CI plays a central role and that is tackled in Modules 2 and 3. The previous steps would lead to decision-making and developing actions to face the problem, when Criticality gains prominence.

4.1 Module 1: how can we raise awareness on vaccination?

This module includes a brainstorming and one activity to help participants understand the role of vaccines in public health and the consequences of low-vaccination coverage. Its main goal is to introduce the OH approach in connection with the problem of vaccination. Also, attention is on the way teachers can raise awareness among the students about the social problem of low vaccination coverage. For this, the concept of OH is introduced and explained.

4.1.1 Activity – brainstorming

Pre-service teachers are asked to express their own opinion about health and vaccination. This will allow us to introduce the topic and also to identify their initial view. The following questions can be used to guide this activity:

- What is health? How would you define it using your own words?
- Do you think that human health can be affected by environmental and animal factors?
- If so, how do they affect human health?

4.1.2 Activity – using the OH approach for assessing vaccination

Teachers are asked to apply the OH approach to the problem of undervaccination and to represent their view in a diagram. We suggest presenting the problem of infectious diseases and undervaccination as a global health problem by using the OH approach. This approach puts into perspective the complexity of new infectious-disease emergence, and the preventable-disease outbreaks. This context allows to highlight the relevance of vaccination as a community tool to prevent infectious diseases. A guiding question can be used to introduce this issue.

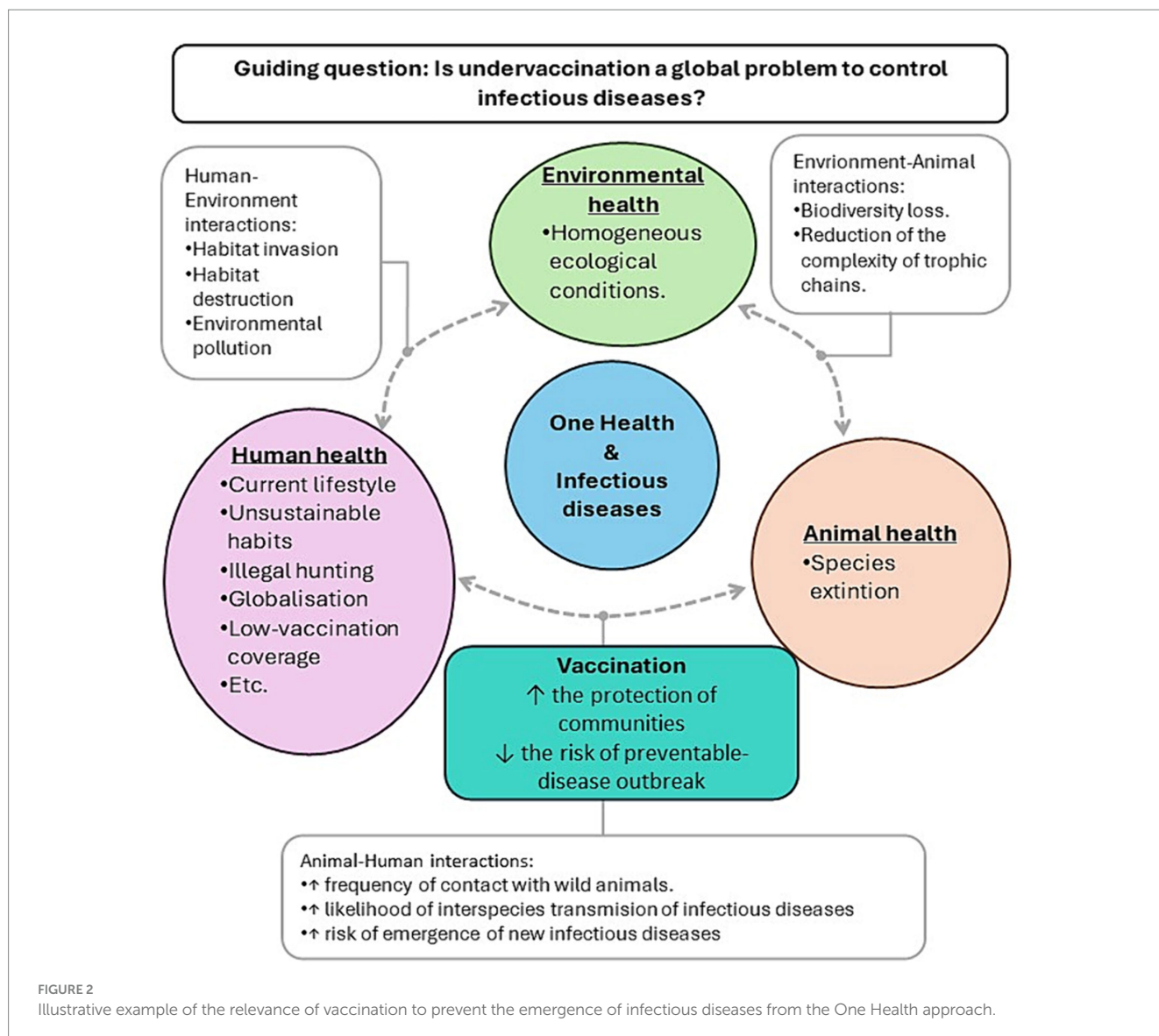
Figure 2 is an example of how OH provides a global view about infectious diseases and the role of vaccination. As showed in Figure 2 vaccination plays an important role in the system of interactions. Vaccinating domestic animals and human communities can potentially limit the risk of emergence of new infectious diseases, and specially protects the population from severe diseases when infection occurs. Hence, it mainly acts in the Animal-Human interactions.

Additionally, human factors (Figure 2, purple bubble) can also be modified to increase vaccination. At this level, vaccine education will raise awareness about the importance of a high vaccine coverage as a community “shield” against infectious diseases.

Secondly, a group discussion will be performed. Participants are asked to explain their OH approach to the rest of the group. All models are discussed among the whole group to enrich the learning. Both activities show the utility of the OH approach, and provide participants with ways to introduce the OH in their lessons.

At the end of this module it would be expected that teachers improve their ability to:

- Foster OH regarding vaccination among students.
- Raise awareness about the risks of low vaccination rates among students.



- Emphasize the importance of vaccination for maintaining a good global health status among students.

4.2 Module 2: how can vaccine fallacies be prevented among students? (I) (II)

After learning about the potential of OH to promote a systemic understanding of vaccination, participants are introduced into the second module, which is focused on promoting CI to avoid fallacies and reduce vaccine hesitancy when looking for information. This module consists of two sections that correspond to the first and second steps of the methodological approach (Figure 1).

To develop an opinion about vaccines, students should look for information about their utility. However, some pieces of information can be misleading, especially in the post-truth era. Thus, teachers should provide their students with tools to manage all the information they are exposed to, and CI plays a central role at this stage. Thus, the

two sections of this module are focused on different steps of putting CI during the analysis of a piece of information.

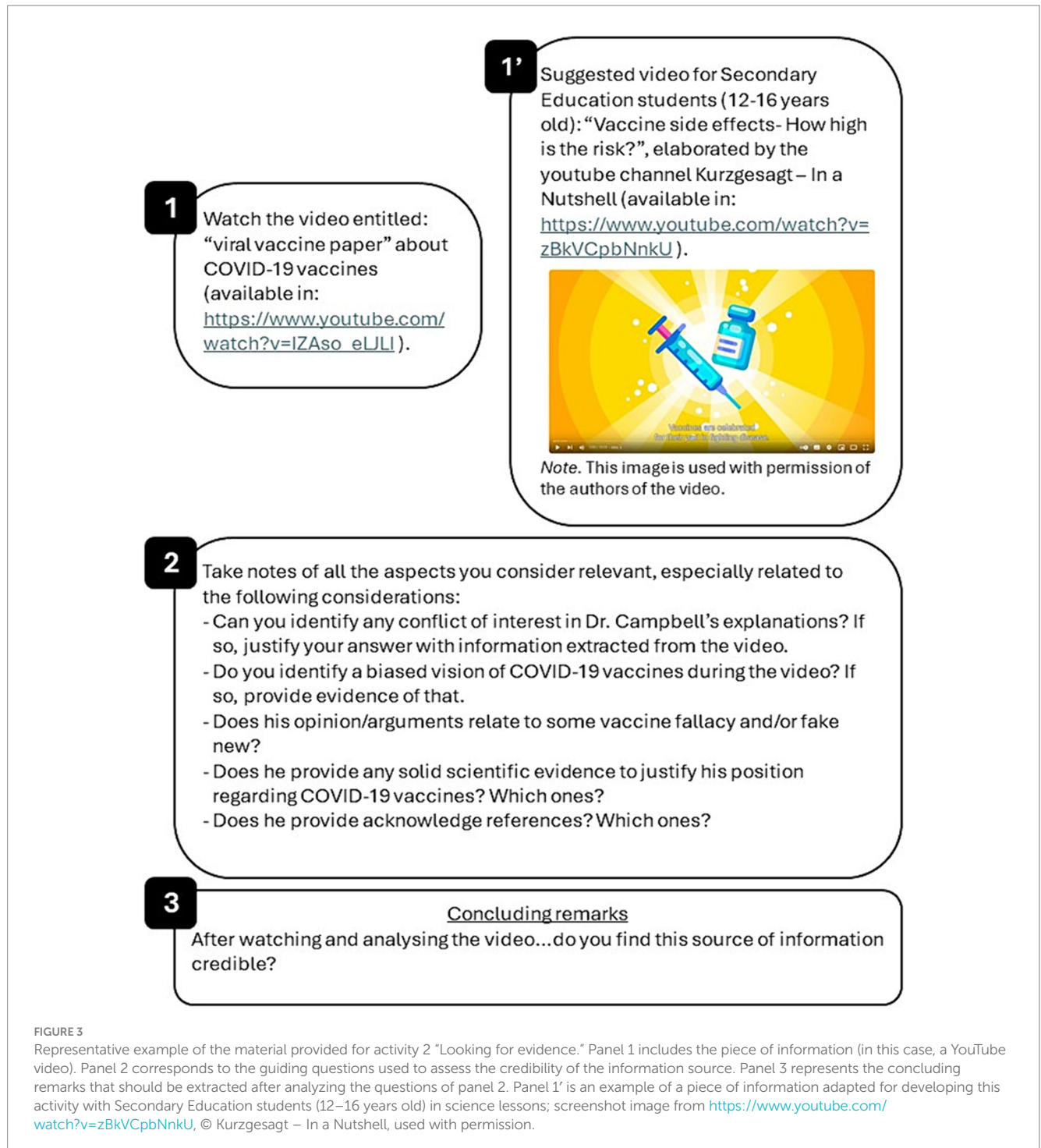
4.2.1 Part (I): looking for evidence

This section includes an activity focused on assessing how to tackle the first question of the methodological approach: “Is the source of information credible?”

A short overview of the process of evaluating vaccine-related information (Figure 1) is performed as this is a useful way to teach students how to manage vaccine over-information and misleading information. For a better understanding of this workflow, illustrative examples that participants must solve are provided.

4.2.1.1 Activity – looking for evidence

Different pieces of information obtained from different sources and/or self-elaborated (i.e., news, comments on the web, videos, scientific papers...) are provided. To answer the question “Is the source of information credible?” guiding questions are also provided (Figure 3).



Note that this is adapted to the level of expertise expected from the participants (pre-service/in-service Secondary Education teachers with a biology/nature sciences/biomedical degree, or similar). However, guiding questions can be applied to any piece of vaccine information and to different levels of expertise of students (Figure 3), and so does the rest of the following activities.

At the end of this section, it would be expected teachers to improve their ability to:

- Help students to look for evidence when evaluating a piece of information to avoid vaccine fallacies.

4.2.2 Part (II): contrasting information

Participants will assess the second question included in the design (Figure 1) “Does the source have the expertise in vaccines to support its claims?” This section includes an activity focused on the expertise of the source/author of a piece of information to accept/reject a source as trustable.

4.2.2.1 Activity – is expertise a criterion for credibility?

Different sources of information are provided for their analysis. Participants are required to look for additional information related to the source/author of each piece of information. The additional

information allows them to evaluate the level of expertise of each source. Guiding questions will be included to guide the analysis (Figure 4).

The pieces of information selected for this activity (Figure 4) represent different levels of expertise and come from different types of sources. Text A is part of the website of the European Information Vaccination Portal. It can be seen that it is an official institution website of the European Centre for Disease Prevention and Control (ECDC), in partnership with the European Commission and the European Medicines Agency (EMA). It uses official data, and they intend to provide accessible and reliable information about vaccines and their surveillance. Therefore, it should be considered as a source with suitable expertise to be considered on this matter.

Text B may appear as a well-established scientific claim made by a professional. However, when additional information about the author is considered, the author happens to be a non-trustable source of information since he has a reputation of repeatedly misleading information about different topics. In fact, the claim of text B was proven false by a science fact-check website (32).

Text C is a comment from an anonymous user in a YouTube video. Since there is no possibility to assess his/her expertise, it will not be considered as a trusting source of information.

A high expertise in vaccines should be considered as a positive indicator to accept the information of the source as reliable. Nevertheless, this step should not be considered as the only indicator of reliability when assessing scientific information, as it can lead to accepting a source that is not truly evidence-based. This indicator should be considered along with the analysis performed in previous steps. An example of this is the case of the virologist Luc Montagnier, who won the Nobel Prize in Physiology or Medicine (2008) for the co-discovery of Human Immunodeficiency Virus. Taking into consideration Luc Montagnier's wide expertise in infectious diseases, we could find all of his claims as reliable. However, he is also well known for defending homeopathy, an alternative therapy with no current scientific evidence, and for opposing vaccination, especially regarding COVID-19 vaccines (33).

At the end of the section it would be expected teachers to improve their ability to:

- Provide efficient strategies to guide students in the process of contrasting information to avoid vaccine fallacies.

4.3 Module 3: how can trust in vaccines be raised?

This module includes an activity to assess the third question of the design tool (Figure 1) "is there a consensus about vaccination between relevant scientific experts?," tackling trust in science and consensus reached by the scientific community.

Teachers are aware that the pro-vaccination position of the scientific community is based on a wide range of evidence. However, vaccine hesitancy increases when the public experiences first-hand the construction of scientific knowledge, like happened during the development of COVID-19 vaccines. In this situation, vaccine education plays a central role.

4.3.1 Activity – what do we currently know about vaccines?

Teachers should try to inform about the status of scientific knowledge construction regarding vaccination. This means that they should make emphasis on the process of scientific knowledge construction rather than on the results. This is vital when students are dealing with an SSI as vaccination.

Participants are divided into small groups (3–4 participants/group). Different pieces of information like the examples above mentioned (Figures 3, 4) are provided. They are asked to think about the following aspects of vaccination when dealing with vaccine-related information:

1. Do the experts agree on the safety of vaccines?
2. Do the experts agree on the efficacy of vaccines?
3. What is the position of scientific experts regarding vaccination?
4. Is there any disagreement in the scientific community regarding vaccines? If it is the case, what type of disagreement?
5. What is the evidence that supports pro-vaccination claims?
6. What is the risk of being wrong when making decisions about vaccination?

These questions will lead participants to accept the piece of information when it agrees with the predominant position of the scientific community, or to reject it when it is not aligned with the scientific community position on vaccines.

At the end of the session, we would expect teachers to improve their ability to:

- Effectively communicate the uncertainty as something inherently associated with the construction of scientific knowledge.
- Teach that science-in-the-making involves discussing positions/options based on evidence and that discrepancies can enrich this process.
- Effectively transmit the idea that when the scientific community reaches a general agreement it is supported by a well-established set of evidence.

4.4 Module 4: what can be done to preserve public health?

Promoting a systemic OH view of the role of vaccines (Module 1) and fostering skills related to CI when evaluating vaccine information (Modules 2, 3) can enable the empowerment of students during decision-making. Decision-making is essential to engaging them in the practice of Criticality. Criticality is the focus of this module, which includes an activity oriented toward developing actions based on the evidence and the information analyzed in the prior modules.

4.4.1 Activity – action!

In this activity participants should use the OH models elaborated in 1.1/1.2 to think about the risks and benefits of a high-vaccinated population, and a low-vaccine coverage. The vaccination OH models will help them to solve a case in which they would act as the parent/

1 Identify the source/author of each piece of information.

A

"When people in a population are vaccinated against an infectious disease, it becomes much less likely to spread from person to person. [...] This helps to protect not only those vaccinated but also, indirectly, those who are more vulnerable to disease. Young children, the elderly, people with weak immune systems[...]"

European Centre for Disease Prevention and Control (ECDC), 2024.
Link to the source: <https://vaccination-info.europa.eu/en/about-vaccines/benefits-vaccination>

B

(Regarding excess of mortality during COVID-19 pandemic) *"It seems a pity that countries that have spent a lot of money on vaccines aren't benefiting from lower rates of mortality overall. It just seems a real pity that the most sophisticated countries, the richer countries are having more excess mortality compared to the poorer European countries".*

Dr. John Campbell (Youtube video "Sad excess deaths", minutes 1:45-2:12).
Link to the source: https://www.youtube.com/watch?v=naopp_KF678

C

"I am so leery of governmental medical experts after the pandemic. The more I learn about the mRNA vaccines, their inflammatory effects, excess death rates, etc., the more my distrust in the WHO grows, not to mention the CDC. Lots of people have lost trust in vaccines because of how the pandemic was handled. I predict greater vaccine hesitancy with the next pandemic, even if it is a lot more lethal than COVID-19 was".

User comment on the Youtube video "Disease X: how to prepare for the next pandemic", from the Youtube channel MedCram.
Link to the source (video and comments):
<https://www.youtube.com/watch?v=qWN7DCQliE4>

Then search for additional information of each source/author and analyse its expertise. For helping with the analysis, you can use the following guiding questions:

- Does it have track record regarding vaccines?
- Does it have reputation among other vaccine experts?
- Does it have experience or credentials in vaccination?
- Which institutional context does it have?

2 Concluding remarks

After analysing the source/author of each piece of information...do you conclude that the source/author have expertise enough to support its claims about vaccines?

FIGURE 4

Examples of different pieces of information provided for activity 3 "Is expertise a criterion for credibility?". Panel 1 includes different texts, whose author/source has a level of vaccine expertise that participants should evaluate using the guiding questions below the texts. Panel 2 corresponds to the concluding remarks in regard to the author/source expertise after the analysis of information in panel 1.

family of a newborn and must decide whether or not to vaccinate their child with the new vaccine for preventing the respiratory syncytial virus (RSV). The case is discussed in pairs and each participant is assigned to a pro-/anti-vaccination position. The following questions should be answered and justified:

1. (Both) What are the reasons for (not to) vaccinate your child?
2. (Both) How would you protect your kid from RSV and other infectious diseases?
3. (Only “anti-”) What would you do if RSV vaccination is compulsory for accessing kindergarten education?
4. (Only “pro-”) What would you do if there is any RSV unvaccinated child in the kindergarten?

At the end of the session, we would expect teachers to be able to:

- Encourage students to suggest individual and collective actions to vaccinate.
- Help students to come up with OH actions, that means proposing actions related to animal health, ecological actions, human health regarding vaccination.

4.5 Module 5: propose a new design using OH approach

Participants are required to put in practice their abilities to foster Criticality and CI by using the OH approach. For this, they are asked to design their own learning situation using the approach proposed in this work. The output will be a table similar to [Table 1](#). Besides, this module is used to solve doubts and apply the learned in the previous modules into participants' real contexts in science lessons.

For elaborating their own design participants can use the following steps as a guide:

- Select an educational level, and a specific subject. This is essential to adapt the learning situation to the target group you would like to teach.
- Select the SSI topic. The context selected for introducing the SSI should be a relevant one to engage and motivate students during the teaching-learning process.
- When teaching the topic in science lessons, pay attention to the following dimensions of the SSI:
 - Social relevance of the SSI (using the OH approach).
 - SSI current situation (using the OH approach).
 - Introduce the main misconceptions related to the selected SSI.
 - Promote trust in science.
 - Make students aware of the uncertainty inherent to science-in-the-making.
- Use the questions included in the workflow of [Figure 1](#) as a guide to teach students about how to manage information regarding the SSI through the practice of CT and CI.
- Orient the SSI learning to criticality. Make students aware of their ability to develop individual actions and to participate in collective actions.

- Formulate appropriate guiding questions to help students during the assessment of all the dimensions mentioned above.
- Provide strategies and instruments for the evaluation of the design.

At the end of the session, we would expect teachers to be able to:

- Design an original learning situation to foster vaccination from OH using CT and CI.
- Apply the workflow presented in the activities ([Figure 1](#)) to design a new learning situation for the practice of criticality.
- Apply this knowledge to other complex SSIs.

This module also includes a final questionnaire ([Supplementary Figure S1](#)) that participants should fill and that will be helpful to assess how useful this instruction is.

4.6 Evaluation of the design

The initial brainstorming developed in Module 1 will be used as an initial evaluation to identify the starting point of the participants. To evaluate the initial view of the participants a rubric for the questions included in the brainstorming will be used ([Supplementary Table S1](#)).

The performance of the participants during the activities will also be considered for evaluating the utility of this design. The written diagrams elaborated individually in Module 1 will give us information about their understanding of OH approach in relation to vaccines; the analysis of a piece of information in Module 2 will allow to assess if the participants are able to apply skills related to CI ... This analysis will allow to introduce modifications in the design to improve its utility.

The final evaluation will be performed by analyzing the productions elaborated in Module 5. The design of their own activities will show an improvement in their ability to introduce criticality paying attention to CI regarding vaccination using the OH approach, thus helping them to achieve the learning objective. [Supplementary Table S2](#) shows the evaluation instrument to analyze participants' design of Module 5.

The final evaluation will also include a questionnaire to know the opinion of the participants about the utility for the instruction, shown in [Supplementary Figure S1](#).

5 Discussion and practical implications

To our knowledge this is an original contribution to prepare Secondary Education teachers to address vaccination in science instruction using OH and engaging students in the practice of criticality.

This is an original design developed based on previous research about the practice of CT ([21](#)) and the model of OH ([7](#)) that uses as design principles the ones provided by Osborne's and Pimentels' ([31](#)) framework.

Its implementation will take place in teachers training on SSIs for Secondary Education (12–16 years old) during the second semester of 2024–2025 as part of the master's degree subject “Didactic Designs on

Science Education” at the University X (blinded). We expect that data from implementation would allow to expand the knowledge on how to promote CT and OH view in a controversial context as vaccination, and to check the adequacy of the design and the principles that oriented it. Data collection during the implementation of the activities will be oriented to this purpose, as well as to explore pre-service teachers’ performance and their understanding of the activities. This will be relevant to introduce improvements in our design.

Teaching strategies for information management are essential to avoid vaccine misconceptions and to promote vaccination. Until recent years, CT research in science education has been concerned with promoting the development of this competence among students through argumentation, the use of evidence, critical reading of texts, etc.

However, the situation in science lesson has changed considerably. The digital revolution has transformed the way we relate to each other and inform ourselves, with social networks being the main information source and exchange of ideas space. The spread of fake news is neither a new phenomenon nor characteristic of the current digital era, but the development of new technologies has facilitated its expansion and magnified its scope. CT teaching in science lessons is more difficult due to dis-/mis-/mal-/over-information as they require a greater emphasis on the development of meta-reflection, and CI. Promoting CT among students involves being able to control their own information environment rather than involving them in the process of assessing information in a way that does not allow them to ignore low-quality information (5). This design seeks to equip to teachers to adapt their lessons to the current and future challenges where tackling SSIs require an integral understanding of the problem and also CI to ignore fake news and pseudo-scientific statements.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the research ethics committee of the Universidade de Santiago de Compostela (USC) (Spain) (code: USC 41/2024). Written

informed consent to participate in this study will be obtained from participants prior to the commencement of the study.

Author contributions

IM-P: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. BP: Writing – review & editing, Writing – original draft, Supervision, Conceptualization. AU: Writing – review & editing, Supervision, Conceptualization.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. We would like to thank the project Meta-Scientific Literacies in the (Mis-) Information Age. SciLMi (Ref. 101104523), and to PID2022-137010OB-I00 research project, funded by MCIN/AEI/10.13039/501100011033/FEDER, UE, for their support.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1408965/full#supplementary-material>

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OPEN ACCESS

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RECEIVED 10 April 2024

ACCEPTED 29 July 2024

PUBLISHED 21 August 2024

CITATION

Zilver SJM, Rietveld AL, Schonewille NN,
Bakker PCAM, Broekman BFP,
van Leeuwen E and de Groot CJM (2024)
Pregnant individuals perspectives towards
receiving COVID-19 vaccination during their
pregnancy: an in-depth qualitative study.
Front. Public Health 12:1415548.
doi: 10.3389/fpubh.2024.1415548

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Pregnant individuals perspectives towards receiving COVID-19 vaccination during their pregnancy: an in-depth qualitative study

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Introduction: Pregnant individuals have an increased risk of severe illness from coronavirus disease 2019 (COVID-19) infection. Vaccination is an effective strategy to prevent severe illness and complications for pregnant individuals. Pregnant individuals are often excluded from research and remain hesitant to receive vaccination against COVID-19. It is pivotal to study factors related to vaccine uptake and hesitancy among pregnant individuals. We studied barriers and facilitators for pregnant individuals choice and motivation regarding vaccination against COVID-19 during pregnancy to aid future pregnant individuals in their decision to vaccinate against various infectious agents.

Methods: In this qualitative study, pregnant individuals were interviewed between October 2021 and January 2022 using a semi-structured approach. A topic list was used to explore their feelings, perceptions and ideas regarding vaccination against COVID-19 during pregnancy. Interviews were transcribed verbatim and thematic analyses was performed using MAX QDA.

Results: After nine interviews, saturation was reached. Three main themes were identified that influenced pregnant individuals choice and motivation regarding vaccination: health consequences, ambiguity of information and societal motivation. Health consequences mainly concerned the effect for their offspring, and the unknown long-term effects of COVID-19 vaccination. The advice from the Dutch institute for Public Health and Environment changed from not vaccinating pregnant individuals after release of the developed vaccine, to routinely vaccinating all pregnant individuals after research data were available from the United States of America (USA). This change of policy fuelled doubt and confusion for vaccination. Arguments in favor of vaccination from the social perspective were specific behaviour rules and restrictions due to the pandemic. E.g. without vaccination people were unable to travel abroad and having to take a COVID-19 test every time entering a public place.

Conclusion: Pregnant individuals need clear, unambiguous information concerning health consequences, short- and long-term, particularly for their offspring, in the decision-making process regarding COVID-19 vaccination.

Additionally, the societal perspective needs to be addressed. Besides the aforementioned themes, general counselling should focus on misperceptions of vaccine safety and the role of misinformation which are also important in the non-pregnant population. This study underlines the importance of including pregnant individuals in research programs to obtain specific information targeted to their needs.

KEYWORDS

pregnancy, pregnant individuals, COVID-19, vaccine hesitancy, SARS-CoV-2

1 Introduction

The COVID-19 pandemic has an enormous global impact, and therefore is different from other recent infectious disease outbreaks (1–3). Disease burden, social isolation and distancing, loss of work, mental health problems and economic implications were unique in intensity, abruptness and severity and many of these still continue to have an effect on society.

Vaccines against the virus that causes COVID-19, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), were developed in a very fast and novel manner, enabling protection against the sequelae of an infection with the virus, especially the mRNA vaccines. More than 70% of the general population accepted the vaccine (4). During the pandemic, pregnant individuals were more hesitant to receive a vaccination compared to the general population (5–8). This is particularly important, since pregnant individuals were more vulnerable to complications from COVID-19. Although severe COVID-19 is uncommon, compared to non-pregnant individuals, pregnant individuals showed higher rates of intensive care unit (ICU) admission, invasive ventilation, extracorporeal membrane oxygenation (ECMO) and higher mortality rates (9). Furthermore, pregnant individuals with severe COVID-19 have higher rates of iatrogenic preterm birth, leading to higher rates of neonatal intensive care unit (NICU) admissions (10). When comparing pregnant individuals with COVID-19 to pregnant individuals without COVID-19, severe neonatal complications are higher in pregnant individuals with COVID-19 (11). Fajardo-Martinez et al. found neurodevelopmental delay in children age 5–30 months who were exposed to maternal Sars-CoV-2 *in utero* (12).

Initially, in 2020, pregnant individuals were excluded from phase 2 and 3 COVID-19 vaccine trials, due to safety regulations (13). However, in several countries, e.g., in the USA, pregnant individuals were able to receive the vaccine (14). As a result, data on the safety and effectivity of the vaccine became rapidly available. These data and data from individuals who inadvertently became pregnant during the COVID-19 vaccine clinical trials showed similar immunogenicity for pregnant individuals compared to non-pregnant individuals (15) and no specific risks, including side effects or adverse birth outcomes (16, 17). This resulted, at first, in an advice for pregnant individuals with underlying medical health conditions or an occupation with high risk of contact with SARS-CoV-2, to get vaccinated (18). When more data became available, the (international) advice changed from vaccination for this selection of pregnant individuals to vaccination of all pregnant individuals (19). In Netherlands, pregnant individuals were advised to receive a mRNA vaccine (Pfizer BioNTech BNT162b2 and Moderna mRNA-1273). Additionally latter data showed maternal COVID-19

vaccination was associated with lower risk of COVID-19 related hospitalization in infants <6 months of age (20). However, pregnant individuals remained hesitant to receive a COVID-19 vaccine (21); with an estimated acceptance percentage of 49% worldwide (4, 22).

Vaccine hesitancy has been defined as “a delay or refusal of vaccination despite the availability.” There are several determinants that influence vaccine hesitancy which vary across time, between diseases, vaccines and communities (23). To investigate what determinants are of influence, two commonly used models are available to explain vaccine hesitancy. The first model is the 3 C’s model, comprising of complacency, convenience and confidence (23). Within this model, complacency is the perceived notion that the risk of vaccine-preventable disease is low and therefore vaccination is not a necessary preventive measure. Convenience comprehends factors such as geographical accessibility, affordability, physical availability and the ability to understand in terms of health literacy. Confidence is defined as trust in the safety and effectiveness of vaccines and the system that delivers them. This includes the competence of health care workers providing the vaccine. The Health Believe Model (HBM) is another concept that is used to explore and explain the rationale behind vaccine hesitancy, as it is a widely used to predict health behaviour (24). The HBM relies on self-efficacy in explaining health behaviour and perceived susceptibility, severity, benefits, and barriers. The HBM is based on the hypothesis that the response to a health threat is determined by a person’s perceived severity of the threat and susceptibility to the threat. Engaging in health protective behaviour is determined by the estimated benefits of the protective behaviour and potential barriers against the behaviour.

Predictors of COVID-19 vaccine acceptance in pregnant individuals among different studies include: advanced maternal age, occupational status (employed individuals were more likely to receive vaccination), higher educational level, white race, having a previous influenza vaccination, third trimester of pregnancy, comorbidities, knowledge about COVID-19 (25–28). During the COVID-19 pandemic, an additional and unaddressed issue possibly contributing to vaccine hesitancy in pregnant individuals was physician hesitancy to recommend the vaccine to pregnant individuals (29).

Due to the unique challenges and changes during the COVID-19 pandemic, we hypothesize that different and perhaps unique factors can be identified in the decision-making process regarding vaccination against COVID-19 during pregnancy. This knowledge is important in the perspective of upcoming diseases and necessity of newly developed vaccines (30, 31).

Therefore, the aim of this qualitative study is to explore barriers and facilitators for individuals in their decision regarding vaccination against a new virus, COVID-19, during pregnancy. The results of this

study help to provide insight into which specific information will help pregnant individuals to make an informed decision about using newly developed vaccines and facilitates implementation of new vaccines in the near future during pregnancy.

2 Materials and methods

2.1 Design

We conducted a qualitative study of lived experiences of pregnant individuals regarding the decision-making process for vaccination against COVID-19. A qualitative design was chosen as we aimed to gain a comprehensive understanding of the barriers and facilitators that pregnant individuals encounter in the decision-making process. Semi-structured interviews were conducted that took a narrative approach. We hypothesized that pregnant individuals' perspectives on vaccination are fuelled by their personal experiences and opinions, but also interact with the society surrounding them (32). A thematic analysis was chosen to analyse the data, as this methodology fits within the constructionist paradigm and holds space for an inquiry in the reality of participants.

2.2 Research team

A multidisciplinary research team ensured variety in perspectives. The research team included three gynaecologists, a psychiatrist, a gynaecologist in training and two PhD candidates in the field of pregnancy, mental health and COVID-19.

2.3 Setting and recruitment of participants

Pregnant individuals who received prenatal care in a tertiary care centre, Amsterdam University Medical Centre –location VUmc (Amsterdam UMC – VUmc) and low-risk pregnant individuals in midwifery practices in the Amsterdam area were asked to participate in the study. Purposive sampling was conducted to obtain a sample of pregnant individuals from diverse backgrounds including variations in maternal age, parity, country of birth, educational level and vaccination status. Pregnant individuals ≥ 18 years and with sufficient knowledge

of the Dutch or English language were found eligible to participate in the study. Eligible individuals were initially approached by their health care professional and subsequently by the first author (SJMZ), to be informed about the study. Participants received an information letter, including an informed consent form. After informed consent was obtained, an interview date was scheduled. Participants could withdraw consent at any time. Participants were allowed to bring a support person to the interview. Interviews were scheduled until no new themes emerged from the data.

2.4 Data collection

All data were collected between October 2021 and January 2022 (see Figure 1, timeline of lockdowns, vaccination availability and study period).

During a four-month period, semi-structured interviews took place by phone, video call or onsite at the Amsterdam UMC, depending on the preference of the participant. Onsite interviews were conducted in a private consultation room within the hospital's outpatient clinic. The space was furnished with a desk, two chairs, and a small side table with informational pamphlets. This location was chosen to create a secure, calm environment for the participant. Despite the clinical setting, efforts were made to make the participant feel comfortable, with the interviewer offering drinks and explaining the purpose of the interview clearly at the outset. The choice of a hospital setting was intended and in consultation with the participant to make it convenient for the participant, who was already visiting the clinic for an appointment. Interviews lasted between 25 and 45 min and were conducted by the first author (SJMZ). All interviews were audio-recorded.

The self-developed interview guide (see Appendix 1) included a short list of background and general questions. To address the thoughts and ideas regarding vaccination and in particular COVID-19 vaccination, the interview started exploring subjects such as; general ideas on vaccination, prior vaccinations, thoughts about COVID-19 in general, experiences with COVID-19, sources of information on COVID-19, opinions of healthcare providers, relatives and friends on the subject of COVID-19 vaccination. Depending on the answers, more in-depth questions were asked to elaborate on the previous answers.

The study design and reporting adhered to Consolidated Criteria for Reporting Qualitative research (COREQ).



2.5 Data-analysis

Interviews were recorded and transcribed ad verbatim, followed by coding according to the principles of thematic analysis (33) using the qualitative analysis software MAX QDA. The analysis included a process of familiarizing with the data (by reading and rereading transcripts), coding and interpretation. Initially, open coding of all transcripts was performed by the first author (SJMZ). To enrich the variety of codes and to complement each other's coding, two interviews were also coded by the second author (ALR) and three by the third author (NNS). Subsequently, interpretive coding was conducted by the research team in a group meeting offering diverse perspectives to enhance reliability. Themes were constructed from the selective codes as we extracted patterns of shared meaning from the data. The transcripts and findings were not returned to the participants for member checking.

2.6 Ethical considerations

The Medical Ethics Review Committee of VU University Medical Centre examined the study protocol (2021.0245). Official approval was not required. The protocol was in accordance with Dutch privacy regulations.

3 Results

A total of nine pregnant individuals participated in the study. During the recruitment period of the study, eight individuals declined to participate in the study, six of these individuals were not vaccinated. Their main reason for not participating was unwillingness to discuss the topic. The other two individuals were vaccinated and did not give a particular reason for not wanting to participate in the study. Out of the nine interviews, one interview was conducted in English.

Participant characteristics are shown in Table 1. Maternal age ranged from 28 to 40 years. Most of the participants were multiparous and had received care at the Amsterdam UMC. None of the interviewed individuals were in their first trimester, gestation ranged from 22 to 39 weeks.

After analyses, three main themes, related to decision-making regarding vaccination in pregnancy, were identified: (1) Health consequences, (2) Ambiguity of information, and (3) Societal motivation. Themes and subthemes are described in Table 2. Translated quotes support the themes. In addition, Table 3 shows the themes with the main explanations in vaccinated versus unvaccinated pregnant women.

3.1 Health consequences

Participants particularly expressed the importance of health for their unborn child. The unknown consequences of vaccination for their offspring were a main concern. This led to insecurities regarding the safety of vaccination versus the importance of vaccination, and also to insecurity versus confidence in their own health.

TABLE 1 Background characteristics of the participants.

	Participants (N = 9)
Age (mean, SD)	34.8 (3.8)
Country of birth	
Belgium	1
Bulgaria	1
India	1
Morocco	1
Netherlands	4
Suriname	1
Educational level	
Secondary vocational education	3
Higher professional education	3
University education	3
Marital status	
Single	0
Living apart together	1
Living together	5
Married	3
Previous treatment for psychological distress	
Yes	4
No	4
Unknown	1
Parity	
Primipara	2
Multipara	7
Gestational age in weeks (mean, SD)	32.4 (6.2)
Gestation	
First trimester	0
Second trimester	3
Third trimester	6
Prenatal care	
Hospital	8
Midwifery practice	1
Previous COVID-19 (self-reported)	
Yes	6
No	2
Unknown	1
Vaccinated against COVID-19	
Yes	5
No	4

The bold values state the background characteristics.

3.1.1 Insecurity versus confidence in importance of vaccination

The majority of the participants recalled that prior to their pregnancy they were more open to receipt of a vaccine. However,

participants perceived pregnancy to have a “special status”. This status concerns responsibility for the safety of the unborn child resulting in being extra careful with dietary restrictions and taking medication and, in addition, reluctance towards vaccination.

“Yes, 100%. If I had not been pregnant, I would have taken it immediately” (P2).

“Especially because during pregnancy you try really hard and do your best not to eat certain foods, take a lot of vitamins, you take all these things into consideration, and then you take a vaccine of which you do not know the long-term effects, this causes mixed feelings” (P1).

3.1.2 Insecurity versus confidence in own health

Perceived physical health is an important theme but differs among participants. Some participants perceived their health as good and therefore were reluctant to choose vaccination.

“Because basically, I see myself as a healthy person” (P9).

Interestingly, another participant described the opposite. Explaining that the physical disability she already felt from being (heavily) pregnant made her unsure of what would happen if she would get a COVID-19 infection as well.

“Because now I really noticed that my breathing is high and shallow, and standing up, I immediately felt dizzy and out of breath, and I felt shortness of breath at night when I woke up. If this is how I feel just because of the pregnancy, then I do not think it will be okay if I have that (COVID-19) on top” (P4).

TABLE 2 Overview of themes and subthemes.

Themes	Subthemes
Health consequences	• Insecurity versus convinced of importance of vaccination • Insecurity versus confidence in own health • Consequences for offspring • Consequences of illness
Ambiguity of information	• Information provision • Trust versus scepticism
Societal motivation	• Altruism • External motivation/government rules and restrictions

TABLE 3 Main themes with associated factors in vaccinated versus unvaccinated women.

	Vaccinated pregnant individuals (n = 5)	Unvaccinated pregnant individuals (n = 4)
Health consequences	■ Insecurity regarding own health during pregnancy and additional risks of COVID-19 infection	■ Unknown consequences for offspring
Ambiguity of information	■ Trust in information from health care providers/family	■ Sceptical about scarce research (at the time) ■ Ambiguous information provision, with advise changing from not vaccinating pregnant individuals to routinely vaccinating pregnant individuals
Societal motivation	■ Unable to live a “normal” daily life ■ Not being able to travel without vaccination	■ Feeling defensive, due to negative comments from society but this strengthened their own decision

Other participants described having experienced COVID-19 in the past without severe symptoms being one of the reasons not to choose vaccination. As described above, vulnerability of health during pregnancy was an important theme. Whether or not that vulnerability was a reason for vaccination, differed between participants.

One participant described that she felt like her immune system was weaker and she was not sure if she wanted to receive a second vaccination during pregnancy, due to fear of feeling ill from the side effects of vaccination instead of from COVID-19 infection.

“Because I feel that my immunity is now a bit lower. I am afraid that those side effects from a possible second dose are more intense, and that I will get sick of that” (P4).

3.1.3 Consequences for offspring

One of the items that was repeatedly mentioned during the interviews was not being able to know if there would be any adverse long-term effects of vaccination, in particular for their offspring. Some participants specifically expressed a fear for birth defects and long-term effects regarding for example infertility or attention disorders in their offspring.

“[...]I was only allowed an mRNA vaccination, but the long-term effects are just not known and of course you have those diethylstilbesterol (DES) children and the Softenon and you have more things that happened in the past with medication that turned out not to be such a good idea in the longer term, I just did not dare to take this” (P7).

“Yes, I find that hard to say. [...]. I find it difficult if my child turns 30 and wants to have children of its own and then it turns out he or she is less fertile. I do not believe my child will come out with 5 arms, or that sort of thing, but maybe he or she will have an attention deficit disorder or something like that, and that that could be linked to the vaccine. I would find that very difficult” (P1).

3.1.4 Consequences of illness

Another factor that influenced decision-making regarding COVID-19 vaccination are personal experiences. Some participants described how they felt when they had COVID-19.

“No, I just had a little muscle ache, just like when I have flu. Other than that, I have had no complaints” (P9).

“Well it was not pleasant, it was hard, but luckily I was at home. I did not have to go to the hospital. But I had to cough a lot and I have never been this sick in my life. Let me put it this way, it was much more than a flu” (P5).

Other participants described having family or friends who had COVID-19 without any severe symptoms or hospital admission. One participant shared that she had lost a family member due to complications of a COVID-19 infection and another participant described how someone she knew had delivered a baby while she had a COVID-19 infection and the aftermath of the infection.

“She really did not have enough oxygen to push and she was between life and death. After she gave birth, she also walked through her house with an oxygen tank and a baby on the other arm for months” (P7).

3.2 Ambiguity of information

A second theme focuses on the relation between information provision and decision-making regarding vaccination. In general, participants found it important that information is provided in a clear and concise way. Information was available from health care providers and through different platforms, such as television, newspapers, online and social media. Participants were having difficulties to determine which information was reliable.

3.2.1 Information provision

Several participants have pointed out the difficulty of the vaccination advice changing over time from not (routinely) vaccinating pregnant women due to lack of data about the safety during pregnancy, to the advice of vaccinating all pregnant women.

“The conversations were overall good, the funny thing was, that people who got pregnant at the same time as me, were also advised not to get vaccinated [...]. But after the government advised everybody to get vaccinated, people who have gotten pregnant since follow that advice” (P1).

In addition, participants searched for information online, ranging from scientific websites to news websites and to national vaccination advisory boards. Multiple participants expressed that information on social media did not influence their decision, because they did not take this information platform seriously.

“Through the internet, but I try to seek scientific articles, not Wikipedia or a pregnant person's personal blog. I also looked for simple things such as: how long has the vaccine been used, how many years has it been tested, in which countries, all those sorts of things” (P1).

3.2.2 Trust versus scepticism

Despite the fact that participants felt the decision regarding vaccination was a decision they had to make on their own, some participants were influenced by opinions from people around them, including relatives and health care professionals. One participant

pointed out that her midwife advised against vaccination. Another participant with multiple relatives working in the medical field, trusted their opinion when they explained that vaccination is recommended based on conducted research.

“I discussed it with my family, because they are all doctors. Two GP's and a neurologist and they said yes, go ahead, it's safe. We have already seen a lot of studies, I would definitely recommend it” (P4).

Another participant described how the combination of research, media, her partner and his colleagues made her change her mind regarding vaccination.

“Yes, sure, because at first I did not want it [...]. Until at one point, the news reported that pregnant women were at high risk, especially towards the end of the last trimester. Your belly is bigger and you have less lung capacity, so the chance is higher that you end up in the ICU. [...] I thought: oh, I will soon be heavily pregnant in the winter, during the cold and flu season. [...] Colleagues of my husband that are doctors also said: all pregnant women we know, including doctors, had the vaccination themselves. Then I thought: I just have no choice, vaccination is probably safer than I think. The risk of the longer term does not outweigh the actual risk for me and the child that may have to be delivered early if I get COVID” (P2).

One participant was sceptical about the research on which the advice to routinely vaccinate all pregnant women was based on. Another participant explained that she became more doubtful when she came across links on websites that asked her to participate in research regarding COVID-19 vaccination during pregnancy. To her it was a confirmation that vaccination for COVID-19 was still subject of research.

“At first it is discouraged and then strongly recommended after a study in America [...]” (P5).

“Especially when I was on the website of the National Institute for Public Health and the Environment (RIVM), links of pregnant women kept popping up: participate in a study so we can see what the vaccine does, and I understand 100%, I fully understand that it is something very normal that this is being investigated. Only with me personally, I do not know, it made me doubt even more, that I thought: oh yes, see, they actually still have to investigate this” (P2).

3.3 Societal motivation

The third theme relates to societal motivation and influences to the decision-making process regarding COVID-19 vaccination. Most of the participants spoke about different ways in which COVID-19 influenced society. Participants also reported different ways in which society influenced the decision-making process regarding vaccination. For some participants altruism played a role in the decision to receive vaccination against COVID-19, for other participants external motivation due to additional rules and restrictions for people who were not vaccinated made them decide to get the vaccination.

3.3.1 Altruism

Some participants felt an obligation to consider the consequences for the whole society, in particular vulnerable people and therefore decided to receive vaccination.

“[...] I have not had the feeling that I have to protect myself that much, but [...] I just think it is important that as many people as possible get vaccinated in order to prevent this and I wanted to contribute to that myself, so that has been the reason that I just had to get vaccinated” (P8).

3.3.2 External motivation

As previously described, some participants initially did not want to receive vaccination because they were not particularly concerned for their own health and were bothered by the unknown long-term effects. However, due to the Dutch government rules, some participants changed their mind. Requiring a negative COVID-19 test prior to visiting public facilities if not vaccinated was a logistic challenge for participants, especially with a newborn. In addition, the risk of social isolation also provided a new reason to choose vaccination.

“I thought, if the little one is here, and I am up on my feet again, I cannot go anywhere during the winter months, then I would feel very isolated. [...] So now I received my first vaccination two weeks ago and I am going to get the second one next week and then I have a QR code once the baby is here. This is due to the rules that are in place right now [...] I felt forced, that sounds heavy, but that is kind of what happened” (P1).

International travel restrictions were also a potential factor influencing the decision. Some of the participants were not originally born in Netherlands and without vaccination unable to visit family in other countries.

“For example Morocco, my parents live there, so if I want to visit my parents, I have to receive the vaccination, because it is mandatory if you want to go there” (P6).

One participant described how she felt judged by society and government for her choice not to vaccinate during pregnancy.

“My vulnerability, so to speak, was completely put aside, as if I did it because I want to be difficult, as if I am a crazy person, it does not matter how you want to call it, but you are not seen nor acknowledged that the position as a pregnant woman is difficult, even aside from all the other factors. I found that very intense” (P7).

4 Discussion

4.1 Main findings

In this study we explored the barriers and facilitators for pregnant individuals choice and motivation regarding vaccination against COVID-19 during pregnancy in Netherlands.

We found three themes that capture the perspectives of pregnant individuals regarding vaccination against COVID-19: health

consequences, ambiguity of information and societal motivation. Health consequences referred to their own health, but also the health and possible consequences for their offspring. Lack of long-term data and therefore uncertainty on possible adverse long-term effects for their offspring, were a main point of concern. In addition, unambiguous information provision based on evidence, with regard to why pregnant individuals were advised to receive vaccination, is an important topic that needs to be addressed. Not only for health care providers, but also for policy makers, national health institutes and societies for maternal and foetal medicine. Furthermore, provided information should also match individuals specific ideas, feelings and perceptions regarding vaccination and in addition take life experiences into account. The unique restrictions resulting from COVID-19 being a pandemic, added societal motivation as a reason for vaccination. Without vaccination there were restrictions to traveling and entering public places. From the societal point of view, altruism was also important and resulted in deciding to get vaccination to protect vulnerable people in society. The three main themes, health consequences, ambiguity of information and societal motivation, indicate that pregnant individuals perspectives for vaccination are shaped by personal experiences and interactions with the broader societal context.

4.2 Interpretation of findings

Literature has provided numerous models to explain decision-making in healthcare. In comparison to the 3C model we found that confidence and complacency aligned with the findings from our study. We found a confidence barrier due to safety concern of the vaccine and a complacency barrier regarding not being convinced that contracting a COVID-19 infection negatively impacts their lives. However, our study did not show any convenience barriers, instead we found convenience facilitators such as being able to travel abroad after vaccination and avoiding having to take a COVID test prior to entering public places.

Furthermore, the Health Believe Model (HBM) that is used to explore and explain the rationale behind vaccine hesitancy, also provides similarities to our findings (24, 34). The HBM is based on the hypothesis that the response to a health problem is determined by a persons perceived severity of the threat and the individual perceived susceptibility to the threat. Both of these themes, perceived severity and susceptibility to COVID-19 were also seen in our study. However, in addition to HBM two noteworthy considerations specific for pregnant individuals were identified in our study: (1) the responsibility for their unborn child and (2) the vulnerability to complications from a COVID-19 infection due to the pregnancy.

Although some similarities between our findings and both models are evident, these models do not acknowledge the profound influence of society on individuals decision-making regarding vaccination. A model that would better fit this part of our findings is a conceptual framework of social values in health priority settings, showing the principal of solidarity, described in a few different ways, such as; decisions which give priority to those who are worst-off in health terms which is similar to altruism in our study (35). In addition, the World Health Organization Strategic Advisory Group of Experts on Immunization (SAGE) working group on vaccine hesitancy describes the complex determinants of vaccine hesitancy in three categories: (1) contextual influences, (2) individual and group influences, and (3) vaccine-specific issues (36).

4.3 Strengths and limitations

The strength of this study is the study design, a qualitative approach with semi-structured interviews and in-depth questioning, allowing for an open conversation resulting in a broad spectrum of information. We included individuals with variety in maternal ages, parity, educational level, vaccination status, and country of birth, to gain insight from different perspectives, and reached saturation after nine interviews. A team of researchers from various backgrounds and perspectives used interpretative thematic analyses.

One of the limitations of this study is that most participants received care from an academic hospital. This may have introduced selection bias, as academic hospitals predominantly house complicated or high-risk pregnancies which might (unconsciously) influence the decision-making process. Future studies should purposively sample low risk pregnant individuals without a medical or obstetric history. Another possible limitation is that, due to the COVID-19 pandemic, some participants preferred to do the interview by phone or video call, which might have influenced the depth and quality of the interview. In addition, we did not interview any individuals in their first trimester of pregnancy. The first trimester is an important phase in embryonal development and might therefore provide other considerations, like teratogenicity, when it comes to vaccination.

4.4 Comparison to other literature

Our results are in line with a previous study from the US showing a paradox regarding foetal wellbeing between vaccinated and unvaccinated pregnant individuals. Whereas unvaccinated individuals were concerned with the paucity of research and potential impact on the development of the foetus and therefore did not receive vaccination, vaccinated pregnant individuals chose vaccination for maternal and foetal protection against possible COVID-19 complications, that might lead to negative effects for the foetus (37). This is similar to our findings, showing that all pregnant individuals thought about consequences for the foetus, but this led to different conclusions on whether or not to choose vaccination.

A previous qualitative study in Turkey has shown similarities, but also differences regarding the opinions of pregnant individuals about COVID-19 vaccines (38). In concordance with our findings pregnant individuals reported that they believe that vaccines may help protect against disease and if recommended by health care professionals this improves the feeling of security. However, in the Turkish study, individuals were afraid for themselves and their babies to die from COVID-19. This is not a particular fear mentioned by pregnant individuals in our study. These differences may be due to general cultural differences and differences in trust in the different health care systems.

Another qualitative study in the United Kingdom (UK), conducted before vaccines became available, highlighted that pregnant individuals perceived a COVID-19 vaccine as riskier than COVID-19 itself (39). This is in line with our findings showing that some pregnant individuals perceived their own health as excellent and were overall worried about the risks and unknown adverse long-term effects of vaccination.

4.5 Future recommendations

It is likely that new pandemics will arise in the future, which will also require adaptation and possibly vaccination to prevent illness and spreading of the virus. In addition, there are more infectious diseases, such as respiratory syncytial virus (RSV), for which vaccines are developed to administer during pregnancy (40). However, in recent years trust in vaccination programs has declined, due to doubt about possible side effects and increasing distrust of government organizations in general (41).

Furthermore misinformation through social media is relatively new and should not be underestimated (42).

This highlights the importance of providing an open discussion to explore pregnant individuals needs regarding vaccination, enhance knowledge and understanding, and provide specific information to different groups of pregnant individuals, instead of only providing standard information for all pregnant individuals, to reduce vaccine hesitancy (Figure 2).

5 Conclusion

Pregnant individuals are a specific and important group when it comes to vaccine hesitancy. They must weigh their own risks and benefits, as well as possible risks and benefits for their unborn child. This study highlighted three main themes that reflect considerations of pregnant individuals in the decision-making process about a new vaccine against COVID-19: health consequences, ambiguity of information and societal motivation. Perceived physical health and information provision regarding the risk of infection during pregnancy and the risks and benefits of vaccination for a pregnant individual and her unborn child are factors that need to be addressed during prenatal consultations discussing vaccination. The different ways in which society influences the decision-making is an important topic for health care workers and policy makers as well.

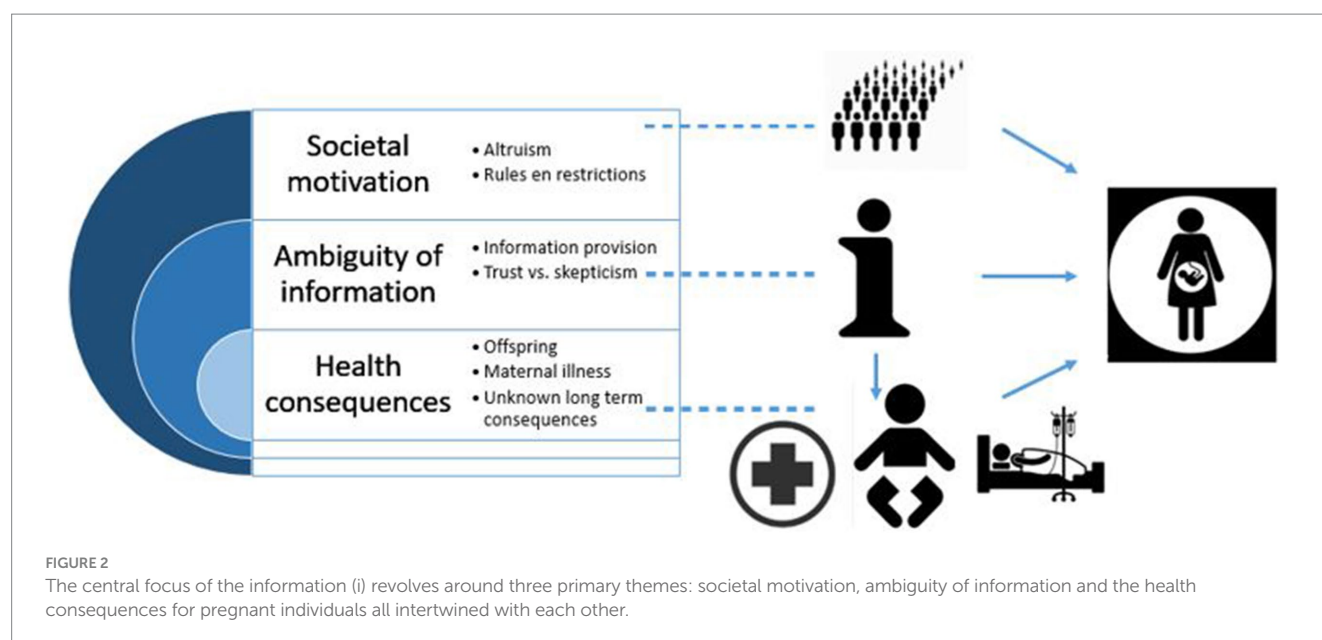
Our findings can contribute to understand the key points that need to be addressed during conversations between health care providers and pregnant individuals regarding COVID-19 vaccination, and in addition can also be important for future vaccinations during pregnancy. This study underscores the importance of including pregnant individuals in research programs regarding vaccination, considering that the efficiency and adverse effects have a clear impact on successful implementation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The Medical Ethics Review Committee of VU University Medical Centre examined the study protocol (2021.0245). Official approval was not required. The protocol was in accordance with Dutch privacy regulations. Written informed consent from the patients/ participants to participate in this study was obtained in accordance with the national legislation and the institutional requirements.



Author contributions

SZ: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. AR: Conceptualization, Data curation, Methodology, Writing – review & editing, Writing – original draft. NS: Formal analysis, Writing – review & editing, Writing – original draft, Methodology. PB: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – review & editing, Writing – original draft. BB: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – review & editing, Writing – original draft. EL: Conceptualization, Data curation, Methodology, Supervision, Writing – review & editing, Writing – original draft. CG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing, Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1415548/full#supplementary-material>

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OPEN ACCESS

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RECEIVED 27 June 2024

ACCEPTED 09 August 2024

PUBLISHED 29 August 2024

CITATION

Chang S, Xu B, Xi H and Shao Y (2024)
Investigating the influencing factors of
vaccination decisions for newly developed
and established vaccines: a comparative
study based on latent class logit models in
China.

Front. Public Health 12:1455718.

doi: 10.3389/fpubh.2024.1455718

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Investigating the influencing factors of vaccination decisions for newly developed and established vaccines: a comparative study based on latent class logit models in China

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Background: The factors influencing vaccination decision-making for newly developed vaccines may be similar to and different from those for established vaccines. Understanding these underlying differences and similarities is crucial for designing targeted measures to promote new vaccines against potential novel viruses.

Objective: This study aims to compare public vaccination decisions for newly developed and established vaccines and to identify the differences and similarities in the influencing factors.

Method: A discrete choice experiment (DCE) was conducted on 1,509 representatives of the general population in China to collect data on preferences for the coronavirus disease 2019 (COVID-19) and influenza vaccines, representing the newly developed and established vaccines, respectively. The latent class logit model was used to identify latent classes within the sample, allowing for an analysis of the factors distinctly influencing choices for both types of vaccines.

Result: Participants valued similar attributes for both vaccines. However, concerns about sequelae were more significant for the newly developed vaccine, while effectiveness was prioritized for the established vaccine. Class membership analysis revealed these differences and similarities were significantly correlated with age, health, yearly household income, acquaintances' vaccination status, and risk perception.

Conclusion: The study highlights the need for tailored communication strategies and targeted vaccination interventions. For the newly developed vaccines, addressing concerns about side effects is more crucial. For long-standing vaccines, emphasizing their effectiveness can enhance uptake more significantly. Engaging healthcare providers and community influencers is essential for both vaccines to increase public confidence and vaccination rates. Clear communication and community engagement are critical strategies for addressing public concerns and misinformation, particularly during periods of heightened concern.

KEYWORDS

COVID-19 vaccines, influenza vaccines, latent class logit model, choice experiment, vaccine preferences

Highlights

- We identified the similarities and differences in factors influencing preferences for newly developed and established vaccines.
- Vaccine sequelae were prioritized for the newly developed vaccines.
- Vaccine effectiveness was regarded as most important for the established vaccines.
- Medical experts' vaccination experiences influenced preferences for the new vaccines.
- Friends/relatives' vaccination experiences impacted preferences for long-standing vaccines.

1 Introduction

Over the past decades, the world has experienced multiple infectious disease outbreaks, with seasonal influenza causing up to 650,000 deaths each year and COVID-19 causing over 7,000,000 deaths since its outbreak (1, 2). The world will continue to face serious virus threats, posed by variants of existing viruses but also novel diseases (3). Vaccination has emerged as a crucial strategy for preventing and controlling morbidity and mortality associated with viruses (4, 5). New vaccines not only reduce the incidence and severity of novel infections but also alleviate the burden on healthcare systems, thereby safeguarding public health and safety (6).

However, for new vaccines against emerging viruses, there is often a lack of extensive clinical trials and data supporting their credibility and safety (7). Compared to well-established vaccines, distrust and inadequate confidence in newly developed vaccines are more pronounced, especially during urgent epidemics (8). This can be exemplified by the influenza and COVID-19 vaccines. Influenza vaccines, with their long history of use, are generally seen as safer. In contrast, during the COVID-19 pandemic, the rapid development and deployment of "rush" vaccines under emergency use authorizations led to more public skepticism and concerns about their efficacy and safety, as well as the credibility of pharmaceutical companies (4, 9, 10).

As a result, despite the availability of new vaccines, vaccine hesitancy is more prevalent than existing vaccines during emerging pandemics (8). Vaccine hesitancy refers to delay or refusal of vaccination despite the availability of vaccines (5). In other words, individuals exhibit varying decision-making processes and preferences when confronted with newly developed or established vaccines, each with its different characteristics. To address a potentially large-scale virus outbreak in the future, it is insufficient to solely depend on the previous old vaccine data. Understanding public decisions for both types of vaccines and how various factors influence these decisions is crucial for enhancing new vaccine uptake and designing effective public health strategies for potential novel outbreaks in the future. In recent years, there have been numerous studies on vaccines for long-standing viruses, alongside an increasing focus on vaccines for newly emerged viruses, particularly since the COVID-19 pandemic (11, 12). Previous studies have provided preliminary data suggesting a strong overlap among various concerns related to diverse types of vaccines (13). In addition to vaccine attributes, public preferences are also influenced by non-attribute factors.

All influential factors can be summarized into:

(1) Vaccine characteristics: Individuals primarily prefer vaccines with higher effectiveness (14–16), fewer side effects (17–20), and longer protection (19, 21, 22). Besides, they secondarily pay attention to vaccine source (23), costs (24, 25), number of doses (11), vaccination location, etc. (26–30).

(2) Individual characteristics: Most evidence has proven older adults (9, 20), males (31–33), or healthier individuals (32, 34) are more likely to accept vaccination. Some studies have indicated that individuals with lower levels of education or income express a greater willingness to get vaccinated (35, 36), while others present conflicting evidence (8, 37, 38). Additionally, in areas with significant ethnic diversity, ethnicity is also a contributing factor (9, 20, 39). Moreover, when vaccination decisions involve kids, individuals exhibit more concerns about vaccines, making parental status another influencing factor (40–42).

(3) Social support: The behaviors of family, friends, authority, and healthcare providers make a difference in individuals' vaccination decision-making (43, 44). Political movements, recommendations from trusted healthcare professionals, and positive endorsements from social networks can enhance vaccine acceptance (12, 44–46). Shared information and news coverage in media can change public attitudes toward vaccination (26, 44, 47). The government also plays an essential role in public vaccination decisions (21). For example, if one specific vaccine was free for the public or was mandated by the government, individual vaccination perceptions and concerns could be greatly changed.

(4) Psychological factors: Individuals tend to experience fear, anxiety, and mistrust when faced with uncertainty and risk (12), which can be attributed to the risk perception affecting the decision-making process. Risk perception toward injection and vaccines is pivotal to vaccination decision-making, mainly including perceived susceptibility to injection, perceived severity of injection, perceived susceptibility to vaccine side effects and perceived severity of side effects (8, 33, 44, 48–51). Additionally, individuals can perceive benefits from and barriers to vaccination. For instance, perceived vaccine effectiveness and safety encourage individuals to get vaccinated; conversely, perceived cost, misinformation, or complex procedures deter individuals from getting vaccinated (41, 48, 52).

Nevertheless, most existing studies focus on the preferences for one specific vaccine. There is limited research comparing public preferences for new vaccines and old vaccines, particularly identifying the differences and similarities in the influencing factors. This study aims to fill the gap. Our study initially aims to elicit differences and similarities in public preferences for newly created and well-established vaccines. The second objective is to analyze the factors influencing different public preferences for both types of vaccines.

The COVID-19 vaccines provide the opportunity for this comparison. China, in order to respond quickly to the pandemic, expedited the deployment of vaccines, such as Sinovac (53). The COVID-19 vaccines were characterized by their accelerated development, limited testing, and urgent deployment, making them an ideal example of the newly created vaccine in our study. In contrast, seasonal influenza was chosen as the established vaccine because both influenza and COVID-19 are respiratory illnesses with similar modes of transmission. Additionally, the influenza vaccine has been in long-standing use, providing extensive data on its effectiveness in

preventing influenza and reducing its severity, owing to its seasonal nature.

To our knowledge, our study is the first to explore differences and similarities in preferences for newly created and well-established vaccines based on DCEs. This study can provide insights into designing tailored communication and distribution strategies to enhance the uptake of established vaccines such as the influenza vaccine, as well as future novel vaccines developed for potential emerging virus outbreaks, thereby addressing vaccine hesitancy based on vaccine type.

2 Methods

2.1 Discrete choice experiments

DCEs were utilized to capture public preferences for vaccines. This quantitative method involves choice scenarios presenting respondents with a series of hypothetical vaccine profiles, each varying in specific vaccine characteristics, namely attributes and levels (e.g., attribute: effectiveness, safety, and costs of the vaccine; attribute levels: for the effectiveness of a vaccine: 40, 70, and 90%) (54). The DCE approach is a suitable method for eliciting preferences, effectively reflecting trade-offs that individuals are willing to make among different vaccine attributes (54). This method has been widely validated in health research, ensuring its reliability in understanding which attributes most influence vaccine choices (18, 55).

2.2 Choosing attributes and attribute levels

As the COVID-19 vaccines were chosen as the newly created vaccines, and the influenza vaccines as the established vaccines, the attributes and levels used in the DCE were carefully selected based on literature review, expert consultation, and preliminary qualitative research specific to these vaccine types.

First, by searching for literature review, eight important attributes were initially identified: effectiveness, duration of protection, vaccine source, out-of-pocket costs, vaccine sequelae, number of doses, vaccination location, and frequency of vaccination (11, 17–19, 21, 23–30, 56, 57). Next, we conducted interviews with six experts in the field of vaccination and four focus groups with the general population aged over 18 years old, which allowed us to select the final key attributes: vaccine effectiveness, protection duration, sequelae, origin, and out-of-pocket costs.

It is essential to ensure that the attribute levels cover a meaningful range and reflect realistic scenarios faced by individuals when making vaccine-related decisions. Therefore, for the effectiveness and protection duration attributes, their levels were categorized based on clinical trial data. For the sequelae following vaccination, sequelae are more commonly reported with the COVID-19 vaccines compared to the influenza vaccines, so this attribute was ranked into three levels for the COVID-19 vaccines and two for the influenza vaccines (15, 16, 22, 58–61). For the origin of vaccines, respondents can choose between imported and domestic options. For the cost attribute, while COVID-19 vaccines may be free of charge in many countries, including cost as an attribute can help understand individuals' perceived value. Its levels were similarly based on real-world vaccine

TABLE 1 Attributes and levels in the DCEs.

Notation	Definition	Levels	
		COVID-19	Influenza
Effectiveness (%)	The degree to which vaccination reduces the risk of disease compared with the non-vaccinated	75 and 95%	40, 70 and 90%
Protection duration (year)	The durability of the vaccine effect	0.5,1, and 5	0.5 and 1
Sequelae	Probability of disability, hospitalization, life-threatening reaction or death following vaccination	Low, middle and high	Low and middle
Country-of-origin	Origin of product	Imported and domestic products	
Out-of-pocket cost (CNY)	Money individuals need to pay on their own	0, 150, and 300	

CNY, the Chinese Yuan.

prices (62, 63). The descriptions of the attributes and attribute levels are summarized in Table 1.

2.3 Experimental design and questionnaire

The study design involved creating a questionnaire that included the DCE tasks and additional questions on other information. The questionnaire was pre-tested to ensure clarity and relevance. We selected 30 individuals from various demographic backgrounds, including different age groups, education levels, and socio-economic statuses. Participants completed the questionnaire under conditions similar to those of the actual survey, and we observed their responses to identify any issues with understanding or interpretation. After completing the questionnaire, participants provided feedback on confusing, ambiguous, or irrelevant questions, and suggested improvements for clarity and comprehension. We analyzed the feedback and refined the wording of questions, adjusted response options, and ensured alignment with the study's objectives before implementation for data collection. Survey questions and information were designed to be clear and unbiased to minimize inaccuracies in reporting. Particularly, we have asked the participants in the pre-test if they viewed influenza vaccines as established and COVID-19 vaccines as newly developed. They consistently agreed with this statement. To further ensure the different opinions toward these vaccines, the timeline for each vaccine's development and use was provided in the questionnaire. Additionally, we assured participants of the confidentiality and anonymity of their responses in the questionnaire to reduce social desirability bias.

The DCE tasks consisted of a series of choice sets where respondents were asked to select their preferred vaccine from pairs of

hypothetical profiles. Each choice set presented vaccines with different combinations of the selected attributes and levels. A fractional factorial design was used to reduce the number of potential combinations to a manageable number while ensuring that the main effects and key interactions could be estimated. The D-efficient design was used to generate 40 choice tasks in STATA 17.0.

To reduce the burden brought by excessive choice tasks, the 40 choice sets were randomly divided into 4 versions, with each version containing 10 choice sets. Each choice set consisted of two hypothetical alternatives, and respondents were asked to indicate their preference and whether they would choose to be vaccinated in reality. An example of one such choice task is shown in Figure 1. The procedure was consistently applied to both the COVID-19 vaccine group and the influenza vaccine group.

The other part of the questionnaire collected information on respondents' background characteristics, vaccination status, and risk perception. Background characteristics comprised age, gender, educational level, health condition, place of residence, occupation, marital status, and yearly income. Vaccination status involved four questions asking whether respondents, their friends/relatives, and acquainted leaders and doctors have been vaccinated. Risk perception encompasses the assessment of both the severity of virus infection and potential adverse effects following receiving a vaccine, as well as the likelihood of contracting viruses and the potential adverse effects.

2.4 Data collection

The survey was conducted between October and December 2021 in China, a period shortly after the rollout of new COVID-19 vaccines and during the flu season.

Initially, a stratified random sampling method was used to select four provinces (Guangxi, Henan, Anhui, and Jiangsu), one autonomous region (Xinjiang), and one municipality (Shanghai), based on geographical location and GDP *per capita*. Following this, 20 cities were randomly chosen from the selected provinces and the autonomous region according to GDP *per capita*. Subsequently, two or three typical communities were selected from each city (or municipality) that had vaccination sites capable of providing vaccination services.

Next, to determine the required sample size, a power analysis was conducted using G*Power 3.1. For a medium effect size ($d = 0.5$), with an alpha level of 0.05 and power of 0.80, the analysis indicated that a minimum sample size of 64 participants for each type of vaccine was needed. Generally, a sample size of over 100 respondents is highly recognized and recommended for DCE studies (64). Considering the vast geographic scope and diverse population of China, as well as the study's focus on sample heterogeneity, we decided to expand the sample size to 800 respondents for each vaccine. This would help better capture variability across different regions and population groups, enhancing the stability and accuracy of model estimates.

Then, the survey was promoted both online and offline within the communities to encourage participation among residents. Residents aged 18 years or older in each community were invited to participate in our survey. Respondents were randomized into two hypothetical vaccine scenarios (COVID-19 vaccine group or influenza vaccine group), and four versions of choice sets were evenly distributed within each group. In each version, 10 choice tasks were sequence-randomized to mitigate order bias. This methodology ensured a comprehensive and unbiased representation of preferences regarding vaccination in the target population.

We collected respondents' preferences for the vaccines and additional individual information via Sojump, a web-based platform designed for conducting online surveys. We provided participants with the questionnaire link or quick response (QR) code. Before answering the questionnaire, key terminologies were explained and notes were provided to guide respondents to complete the survey. For those with difficulties in understanding the questions, our research team offered assistance, including one-on-one support and clarification of any confusing items, to ensure that all respondents could participate fully. This approach helped enhance the quality and reliability of the data collected. As a result, a sample of 1,509 adult respondents was recruited from 20 cities and 1 municipality, providing a representative sample of the population in these regions.

Ethical guidelines were strictly followed, and all participants provided informed consent prior to participating. The study has been approved by the Medical Ethics Sub-Committee of the Ethics

Attributes and levels	Vaccine 1	Vaccine 2
Effectiveness	95%	75%
Protection duration	0.5 years	5 years
Vaccine sequelae	Low	High
Country-of-origin	Imported	Domestic
Out-of-pocket cost (CNY)	300	0
Would you consider getting vaccinated with the chosen vaccine in reality?		

FIGURE 1
Example of choice sets.

Committee for Science and Technology at Nanjing University (Approval Number: OAP20230407001).

2.5 Statistical analysis

In analyzing the DCE data, we used two models: the conditional logit model (CLM) and the latent class model (LCM). The CLM was applied to focus on how vaccine attributes influence individual vaccine options. The LCM allowed for individual heterogeneity by incorporating individual-specific characteristics beyond just vaccine attributes, which is crucial for uncovering distinct population segments that may prioritize different vaccine attributes. This approach provides segment-specific insights, allowing for a more nuanced understanding of the factors influencing vaccine decisions among various subgroups, making it suitable for our study's objectives.

All data analyses were conducted using Stata 17.0. The various indicators obtained from the analysis are categorized into two main types: (1) Preference indicators: Odds ratio (OR) indicate the direction and magnitude of attribute preferences. Regression coefficients explain whether socio-demographic characteristics influence preferences. Number of classes indicates the existence of preference heterogeneity. (2) Model fit indicators: likelihood ratio test statistics, pseudo- R^2 , Akaike Information Criterion (AIC), Consistent Akaike Information Criterion (CAIC), and Bayesian Information Criterion (BIC).

In the CLM, it is assumed that preferences are consistent across individuals. The probability of choosing an option i is given by Eq. (1):

$$P_i = \frac{e^{v(\beta, X_i)}}{\sum_j e^{v(\beta, X_j)}} \quad (1)$$

where $v(\beta, X_i)$ represents the utility function of option i , which is a linear combination of its attributes x and their corresponding coefficients β .

The LCM divided participants into several classes, each with its own set of preference regression coefficients, which implies homogeneity within classes and heterogeneity across classes. In other words, each class represents a CLM. The probability of selecting the option i for participants belonging to the class q is given by Eq. (2):

$$P_i(\text{class} = q) = \frac{e^{v(\beta_q, X_i)}}{\sum_j e^{v(\beta_q, X_j)}} \quad (2)$$

The LCM can also incorporate a set of covariates (such as demographic characteristics, vaccination behaviors of acquaintances, and risk perception) to classify the sample. The class membership probability is given by Eq. (3):

$$P(\text{class} = q) = \frac{e^{v(\alpha_q, Z)}}{\sum_q e^{v(\alpha_q, Z)}} \quad (3)$$

where $P(\text{class} = q)$ is the probability that each individual belongs to class q given their characteristics Z and α are the coefficients for the covariates Z .

3 Results

3.1 Characteristics of respondents

The sample consists of 746 respondents for the COVID-19 vaccine group and 763 respondents for the influenza vaccine group. For both subgroups, the mean age of respondents was approximately 40 years old, and the age distribution was similar, with the majority falling into the age range of 18–24 and 25–34, followed by other age groups up to 65 and above. For the COVID-19 and influenza groups, slightly over half of the respondents were female (56.43 and 64.22%), married (54.96 and 58.72%), lived in rural regions (52.14 and 51.38%), and had a yearly income between 50,000 and 200,000 yuan (52.01 and 63.30%); and a significant proportion of respondents were students (32.04 and 39.45%), had a bachelor's degree or above (59.92 and 65.14%), and reported good health or above (82.71 and 82.57%).

Although the percentages of respondents and their acquaintances who have been vaccinated were remarkably high in both groups, the proportions in the COVID-19 group were generally higher than those in the influenza group. While respondents perceived a higher severity of harm from COVID-19 infection compared to influenza infection (81.10% versus 64.22%), they perceived a lower-than-average probability of COVID-19 infection compared to influenza infection (58.10% versus 21.10%). Similarly, there were more perceptions of the severity of vaccine sequelae from COVID-19 vaccines than influenza vaccines (49.87% versus 47.71%), but respondents perceived a lower-than-average probability of experiencing COVID-19 vaccine sequelae compared to influenza vaccine (56.84% versus 26.61%) (Table 2).

3.2 CLM results

In both groups, five attributes were significant ($p < 0.1$ for all attributes but $p < 0.05$ for 5-year protection duration) and have expected signs, indicating that all attributes were important and respondents preferred domestic vaccines with more effectiveness, longer protection duration, lower probability of vaccine sequelae, and less out-of-pocket cost. In the COVID-19 vaccine group, the vaccine sequelae attribute emerged as the most influential factor, followed by the effectiveness attribute. The protection duration, origin, and out-of-pocket cost attributes appeared to have relatively less impact on individuals' preferences. In the influenza vaccine group, the vaccine sequelae and effectiveness attributes were identified as the primary and secondary drivers of preferences, respectively, while the importance of the other three attributes was comparatively lower (Table 3).

3.3 LCM results

Prior to LCMs used to analyze preference heterogeneity, it is essential to consider a range of possible class numbers to improve the model's performance. This study evaluated the fit of models using fit indices. Lower values of BIC and CAIC, as well as higher values of log-likelihood indicate better fit, but it is also important to consider the interpretability and substantive meaning of the classes. In both groups, the model performed better when the number of classes

TABLE 2 Participants' demographic characteristics, vaccination, and risk perception.

Variables	COVID-19 vaccine (N = 746)		Influenza vaccine (N = 763)	
	N	%	N	%
Demographic characteristics				
Age (mean; std.dev)	40.03	19.16	40.04	24.43
Age range				
18–24	233	31.23%	294	38.53%
25–34	116	15.55%	84	11.01%
35–44	131	17.56%	84	11.01%
45–54	78	10.46%	63	8.26%
55–64	48	6.43%	84	11.01%
≥65	140	18.77%	154	20.18%
Gender				
Male	325	43.57%	273	35.78%
Female	421	56.43%	490	64.22%
Marital status				
Unmarried	309	41.42%	301	39.45%
Married	410	54.96%	448	58.72%
Others	27	3.62%	14	1.83%
Education				
Elementary school or below	84	11.26%	77	10.09%
Middle school	110	14.75%	84	11.01%
High school or technical secondary school	105	14.08%	105	13.76%
Bachelor degree	390	52.28%	2,205	57.80%
Master, PhD or above	57	7.64%	56	7.34%
Health				
Very good	344	46.11%	189	24.77%
Good	273	36.60%	441	57.80%
Moderate	111	14.88%	98	12.84%
Poor	13	1.74%	35	4.59%
Very poor	5	0.67%	0	0
Place of residence				
Urban	357	47.86%	371	48.62%
Rural	389	52.14%	392	51.38%
Occupation				
Student	239	32.04%	301	39.45%
Employee in private organization	169	22.65%	140	18.35
Public official	68	9.12%	91	11.93%
Others	270	36.19%	231	30.28%
Yearly household income (CNY)				
≤K	102	13.67%	98	12.84%
50–100 K	174	23.32%	217	28.44%

(Continued)

TABLE 2 (Continued)

100–200 K	214	28.69%	266	34.86%
200–400 K	126	16.89%	126	16.51%
400–600 K	74	9.92%	49	6.42%
600–1,000 K	21	2.82%	7	0.92%
≥1000 K	35	4.69%	0	0
Get vaccinated				
Individuals	716	95.98%	80	10.48%
Acquainted doctors	598	80.16%	64	8.39%
Acquainted friends/relatives	705	94.50%	67	8.78%
Acquainted leaders	647	86.73%	79	10.35%
Risk perception				
Harm of infection				
Severe	605	81.10%	490	64.22%
Moderate	107	14.34%	203	26.61%
Mild	34	4.56%	70	9.17%
Probability of infection				
Higher than the average	191	25.60%	350	45.87%
Similar to the average	129	17.29%	252	33.03%
Lower than the average	426	58.10%	161	21.10%
Harm of vaccine sequelae				
Severe	372	49.87%	364	47.71%
Moderate	218	29.22%	329	43.12%
Mild	156	20.91%	70	9.17%
Probability of vaccine sequelae				
Higher than the average	173	23.19%	196	25.69%
Similar to the average	149	19.97%	364	47.71%
Lower than the average	424	56.84%	203	26.61%

reached 4. Therefore, the four-class model incorporating individuals' characteristics was chosen (Table 4).

In the COVID-19 vaccine group, most attributes in the LCM similarly influenced public preferences significantly. However, the impact of attributes varied among the four classes. A total of 35.22% of respondents were assigned to Class¹ 2, 29.60% to Class¹ 4, 25.66% to Class¹ 3, and 9.52% to Class¹ 1. For Classes¹ 1, 2, and 4, the sequelae attribute was still the most important attribute, while the out-of-pocket cost became the priority consideration in Class¹ 3. However, the estimates of most attributes in Class¹ 3 were similar, indicating this class exhibited unobvious preferences among five attributes. The effectiveness attribute was still the second important one in Classes¹ 1, 3, and 4. The protection duration produced a more significant effect in Classes¹ 1 and 2 than Classes¹ 3 and 4.

According to the class membership, the individual characteristics significantly associated with classes included age, marriage, education, health, residence, yearly household income, vaccination of acquaintances, and risk perception. Class¹ 1 was less-educated respondents with a relatively high level of income, who were influenced by the vaccination behavior of leaders in their community or workplace, without personally knowing vaccinated doctors, and

TABLE 3 Conditional logit model of public preferences affected by vaccine attributes.

Attribute	COVID-19 vaccine (N = 746)		Influenza vaccine (N = 763)		
	OR	95% CI		OR	95% CI
Effectiveness (base: 75%)			(base:40%)		
95%	1.86 ^a	1.72, 2.00	70%	1.37 ^a	1.21, 1.54
			90%	3.65 ^a	3.32, 4.02
Protection duration (base: 6 months)					
1 year	1.10 ^a	1.00, 1.21	1 year	1.18 ^a	1.09, 1.27
5 years	1.65 ^b	1.50, 1.80			
Sequelae probability (base: high)			(base: middle)		
Middle	2.05 ^a	1.85, 2.27	Low	1.86 ^a	1.72, 2.01
Low	4.67 ^a	4.23, 5.16			
Country-of-origin (base: imported products)					
Domestic products	1.50 ^a	1.39, 1.62		1.24 ^a	1.16, 1.34
Out-of-pocket cost (CNY) (base:0)					
150	0.65 ^a	0.60, 0.70		0.85 ^a	0.78, 0.93
300	0.46 ^a	0.41, 0.50		0.42 ^a	0.37, 0.46
Model fit					
Log-likelihood	−4242.5836		−4244.3159		
Pseudo R2	0.1795		0.1975		
AIC	8501.167		8502.632		
BIC	8562.051		8556.063		
Observations	14,920		15,260		

^a Significance: $p < 0.01$.^b Significance: $p < 0.05$.

perceiving a low probability of COVID-19 infection. Class¹ 2 was younger, unmarried, and healthy adults with low level of income, living in rural areas, acquainted with vaccinated doctors, and perceiving high severity of infection, mild vaccine sequelae, but a high probability of vaccine sequelae. Class¹ 3 was those unmarried, healthy, and living in rural areas, and they perceived mild vaccine sequelae (Table 5).

In the influenza vaccine group, most respondents were assigned to Class² 1, accounting for 34% of those who had identical preferences, ranking of attributes, and similar ORs with their significance to those in the CLM. Similarly, the ranking of the attributes in Class² 3 (22.41%) was the same as that in the CLM, except for that the sequelae

were placed before the effectiveness attributes. Class² 2, taking up 27.75%, was the only class placing the most importance on the out-of-pocket attribute, and less attention on the effectiveness attribute, showing great differences from the whole sample. A minority of respondents were assigned to Class² 4 (15.84%), and non-significant estimates of attributes were higher than any other classes.

The estimates of individual characteristics indicated that classes were significantly correlated with age, marriage, education, residence, health, yearly household income, work engagement, vaccination of acquaintances, and risk perception. For Class² 1, respondents were characterized by older age, lower education level, good health, and living in urban regions. They were acquainted with vaccinated doctors and perceived a low probability of infection and a low risk of vaccine sequelae. The individuals in Class² 2 were unmarried and healthy adults without occupations, earning less money, and having vaccinated friends or relatives. They showed a higher perceived risk of influenza infection and a higher perceived probability of influenza vaccine sequelae. Class² 3 was older, unhealthier, had vaccinated friends or relatives, was not acquainted with vaccinated doctors, and perceived a high risk of infection but a low risk of vaccine sequelae (Table 6).

4 Discussion

This study explored the differences and similarities in individuals' preferences for a newly created vaccine (COVID-19) and a well-established vaccine (influenza) and individuals' characteristics affecting these preferences. The findings indicate that participants have the same preferences for both types of vaccines, significantly preferring domestic vaccines with higher effectiveness, longer protection duration, a lower probability of vaccine sequelae, and less out-of-pocket cost. Moreover, no matter which vaccine group, effectiveness and sequelae emerged as the most prominent factors in shaping preferences. However, these two attributes differ in two groups. Vaccine sequelae were viewed as more significant than effectiveness when facing the choices of COVID-19 vaccines, whereas the order was reversed for the influenza vaccine.

The finding in the COVID-19 vaccine group is consistent with the research by Antonopoulou et al. (65), Leng et al. (35), and Chan et al. (17), which emphasizes that vaccine safety is predominantly associated with vaccination intentions. However, this contrasts with other studies that list effectiveness as the most essential factor (11, 23, 24). This discrepancy is understandable, as the survey was conducted during a COVID-19 pandemic peak from October to December 2021, a period marked by heightened concerns about vaccine side effects due to extensive media coverage and public discourse. In addition, the sequelae attribute was ranked into three levels in our study, which further enhanced the perceived risk of sequelae.

TABLE 4 Model performance with different number of classes.

	COVID-19 vaccine (N = 746)				Influenza vaccine (N = 763)			
	2	3	4	5	2	3	4	5
Number of latent classes								
Log-likelihood	−4162.210	−4047.660	−3952.929	−3881.149	−4044.581	−3941.215	−3792.420	−3756.619
CAIC	8538.249	8481.856	8465.101	8494.248	8227.863	8113.597	7908.475	7929.339
BIC	8564.249	8528.856	8533.101	8583.248	8212.863	8088.597	7873.475	7884.339

TABLE 5 Four classes in the COVID-19 vaccine group.

COVID-19 vaccine (N = 746)								
Class ¹	1		2		3		4	
Share	9.52%		35.22%		25.66%		29.60%	
Attribute	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Effectiveness (base: 75%)								
95%	2.21 ^a	1.87, 2.62	1.60 ^a	1.58, 1.62	1.03 ^a	1.02, 1.03	1.19 ^a	1.08, 1.32
Protection duration (base: 6 months)								
1 year	NS		1.29 ^a	1.26, 1.33	0.98 ^b	0.97, 0.99	0.90 ^b	0.83, 0.98
5 years	1.99 ^a	1.32, 3.04	4.07 ^a	3.92, 4.23	NS		NS	
Sequelae probability (base: high)								
Middle	2.21 ^a	1.68, 2.90	NS		1.02 ^a	1.00, 1.02	1.15 ^a	1.04, 1.28
Low	4.26 ^a	3.05, 5.94	5.21 ^a	4.99, 5.43	NS		1.36 ^a	1.16, 1.61
Country-of-origin (base: imported)								
Domestic	0.54 ^a	0.45, 0.66	NS		NS		0.93 ^a	0.90, 0.97
Out-of-pocket cost (CNY) (base:0)								
150	NS		0.39 ^a	0.38, 0.40	1.04 ^a	1.03, 1.06	0.92 ^a	0.88, 0.97
300	NS		0.16 ^a	0.16, 0.17	1.03 ^a	1.01, 1.05	0.88 ^a	0.81, 0.96

Class membership	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Baseline	
Age	NS		−0.02 ^a	−0.03, −0.01	NS			
Married	NS		0.54 ^a	0.20, 0.89	0.63 ^a	0.28, 0.97		
Education	−1.70 ^a	−2.35, −1.04	NS		NS			
Unhealthy	NS		−0.33 ^a	−0.51, −0.16	−0.35 ^a	−0.54, −0.16		
Urban regions	NS		−0.28 ^c	−0.58, 0.02	−0.84 ^a	−1.15, −0.53		
Income (CNY)	0.51 ^a	0.24, 0.78	−0.19 ^a	−0.29, −0.09	NS			
Vaccinated acquaintances								
Doctors	−1.65 ^b	−3.00, −0.30	0.63 ^a	0.24, 1.02	0.69 ^a	0.28, 1.10		
Leaders	2.11 ^a	0.66, 3.57	NS		−0.54 ^b	−1.02, 0.10		
COVID-19 infection								
Low probability	0.43 ^a	0.05, 0.81	NS		NS			
Mild harm	NS		−0.49 ^a	−0.65, −0.32	NS			
Vaccine sequelae								
Low probability	NS		−0.13 ^b	−0.25, −0.01	NS			
Mild	NS		0.25 ^a	0.13, 0.38	0.14 ^b	0.00, 0.28		
Observations	14,920							

Only significant variables were displayed.

Class¹: Class in the COVID-19 vaccine group.

^a Significance: $p < 0.01$.

^b Significance: $p < 0.05$.

^c Significance: $p < 0.1$.

The results of the influenza group align with most influenza studies (18, 66). The perception that an established vaccine is safer than a fast-paced, developed vaccine contributed to listing sequelae as the first priority (8). Influenza vaccines are often perceived with less uncertainty due to the availability of long-term data. In contrast, COVID-19 vaccines are viewed with greater concern. The differences in risk perception lead to different vaccine preferences and decision-making (8, 9, 52, 67–69).

The preferences incorporated with class membership suggest that populations with varying characteristics exhibit heterogeneous preferences. According to the results for the COVID-19 vaccine subgroup, younger respondents belonging to Class¹ 2, compared to older samples in other classes, attached more weight to the protection duration. Respondents with different levels of income had distinct attitudes toward the origin and out-of-pocket costs. Class¹ 1 earning more money preferred imported COVID-19 vaccines and gave little

TABLE 6 Four classes in the influenza vaccine group.

Influenza vaccine (N = 763)								
Class	1		2		3		4	
Share	34.00%		27.75%		22.41%		15.84%	
Attribute	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Effectiveness (base:40%)								
70%	1.39 ^a	1.27, 1.53	1.07 ^a	0.99, 1.15	1.60 ^a	1.18, 2.16	NS	
90%	2.14 ^a	1.96, 2.34	1.09 ^a	1.03, 1.16	5.71 ^a	4.08, 8.15	4.44 ^a	1.40, 6.04
Protection duration (base: 6 months)								
1 year	1.23 ^a	1.14, 1.31	NS		1.96 ^a	1.06, 3.63	NS	
Sequelae possibility (base: Middle)								
Low	1.48 ^a	1.36, 1.61	1.13 ^a	1.07, 1.18	6.72 ^a	2.88, 15.64	1.21 ^a	0.56, 2.63
Country-of-origin (base: imported products)								
Domestic	1.17 ^a	1.11, 1.22	0.88 ^a	0.83, 0.93	1.60 ^a	1.20, 2.13	0.64 ^a	0.14, 2.99
Out-of-pocket cost (CNY) (base:0)								
150	0.56 ^a	0.52, 0.61	1.27 ^a	1.19, 1.35	0.40 ^a	0.22, 0.72	NS	
300	0.37 ^a	0.32, 0.43	1.21 ^a	1.12, 1.31	0.21 ^b	0.05, 0.85	0.77 ^b	0.34, 1.72

Class membership	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Baseline	
Age	0.04 ^a	0.02, 0.06	NS		0.04 ^a	0.02, 0.06		
Married	NS		0.36 ^a	0.16, 0.57	NS			
Education	−0.20 ^b	−0.38, −0.01	NS		NS			
Unhealthy	−0.16 ^a	−0.29, −0.03	−0.07 ^a	−0.13, −0.02	0.51 ^a	0.34, 0.68		
Urban	0.27 ^a	0.12, 0.42	NS		NS			
Having a job	NS		−0.11 ^b	−0.23, −0.01	NS			
Income (CNY)	NS		−0.75 ^b	−1.27, −0.22	NS			
Vaccinated acquaintances								
Doctors	0.71 ^a	0.40, 1.01	NS		−0.87 ^a	−1.62, −0.13		
Friends/relatives	NS		0.66 ^a	−0.01, 1.34	2.87 ^a	2.05, 3.68		
Influenza infection								
Low probability	0.43 ^a	0.29, 0.58	−0.15 ^a	−0.24, −0.06	−0.17 ^a	−0.28, −0.06		
Mild harm	NS		−0.21 ^a	−0.31, −0.11	−0.40 ^a	−0.59, −0.21		
Vaccine sequelae								
Low probability	0.07 ^b	0.01, 0.12	−0.37 ^a	−0.52, −0.24	0.23 ^a	0.12, 0.34		
Mild	0.44 ^a	0.26, 0.62	NS		0.44 ^a	0.33, 0.56		
Observations	15,260							

Only significant variables were displayed.
Class²: Class in the influenza vaccine group.
^a Significance: $p < 0.01$.
^b Significance: $p < 0.05$.
^c Significance: $p < 0.1$.

consideration to the cost, while low-earning individuals in Class¹ 2 considered lower cost as a driver of their preferences and had no significant preferences for the origin of vaccines. Risk perception generated the largest impact on Class¹ 2. Despite perceiving mild sequelae, high severity of infection and probability of sequelae rendered them to prioritize the vaccine sequelae attribute. For most classes, the vaccination status of acquainted medical experts or leaders was outstandingly significantly correlated with preferences.

Based on the results of the influenza vaccine subsample, Class² 3 was more sensitive to vaccine attributes and easily influenced by risk perception than other classes. Individuals in this class perceived mild risk of the influenza vaccine but prioritized considering the sequelae attribute, which can be explained by their older ages and poorer health. Additionally, age and health may render them at increased risk of virus infection, making the effectiveness attribute the second most important factor. By contrast, the older but healthier respondents in

Class² 1 seemed insensitive to each attribute, perceiving a low risk of both infection and sequelae. To our surprise, in Class² 2, out-of-pocket cost was highly emphasized prior to effectiveness and sequelae attributes regardless of a high-risk perception of influenza infection and a perceived high probability of vaccine sequelae, perhaps in that individuals were healthy, not engaged in work, and had a lower level of income. Most class preferences were significantly correlated with the vaccination status of acquainted doctors or friends, as well as risk perception.

To sum up the similarities in both vaccines, lower-income individuals in both vaccine subgroups took out-of-pocket as an important consideration, which is in line with Dong et al.'s (24) finding that the public with lower incomes will pay more attention to vaccine prices. The classes sensitive to effectiveness and sequelae attributes were significantly associated with their risk perception. The more individuals value vaccine efficacy and safety, the higher they perceive risk (44, 48, 49). Health conditions and knowing vaccinated acquaintances in both subgroups were significant for respondents to assess the utility of a vaccine. Being in good health can lessen individuals' concerns about the benefits and side effects of a vaccine. The impact of vaccinated acquaintances is consistent with previous studies (12, 26, 44, 47).

For differences between subgroups, compared to the COVID-19 vaccine, the impact of the influenza vaccine attributes varied more noticeably across different classes, including the vaccine effectiveness, sequelae, and out-of-pocket cost attributes. As for the inconsistency in the effectiveness and sequelae attributes, the first reason is related to the characteristics of viruses; second, rapidly developing new vaccines can cause a common high-risk perception of vaccines; however, as new vaccines become established, perceived risk will differ among populations. The difference in the cost attribute can be explained by the Chinese context, where COVID-19 vaccines are provided free of charge to citizens, while influenza vaccines require payment. In terms of influence from acquaintances' vaccination status, doctors played a more important role in shaping COVID-19 vaccine preferences, while influenza vaccine preferences were more impacted by friends or relatives. Plenty of existing studies have found that vaccination decision-making can be impacted by social networks (12, 26, 44, 47). Our findings reaffirm the roles of doctors, friends, families, and influencers and make a further distinction. When it comes to a newly created vaccine, people may assume that medical professionals possess more specialized knowledge and information about the new vaccines, and tend to reference medical experts' vaccination behaviors. However, for established vaccines, there are more vaccination experiences, so people are more likely to be influenced by friends' and relatives' behaviors.

4.1 Implications

The results of this study can provide insights into vaccination interventions and policy-making. For newly developed vaccines, such as the COVID-19 vaccines, several strategies can effectively address public concerns. Firstly, given the heightened concern about potential long-term effects of new vaccines, public health campaigns should focus on transparently addressing these concerns. Providing comprehensive information about potential side effects, how to manage them, and the overall safety of the vaccine can help

alleviate fears. Secondly, the influence of doctors and medical professionals on vaccine preferences is significant and should be considered. Policies should encourage healthcare providers to actively discuss the benefits and risks of novel vaccines with their patients. Training programs can enhance their ability to communicate effectively about vaccines.

For long-existing vaccines such as the influenza vaccines, highlighting their effectiveness should be prioritized. First, messaging should focus on the benefits of vaccination, especially for older adults and those with poorer health who are more vulnerable to influenza complications. Apart from doctors, friends or relatives also impact vaccine decisions. Public health initiatives should engage these groups, encouraging them to share positive vaccination experiences and information within their networks.

For general strategies, clear and accurate communication about vaccine risks and benefits is essential, particularly during times of heightened public concern, such as pandemic peaks. Especially, to address the specific concerns and needs of unhealthy individuals, it is essential to provide information on the benefits of vaccination for their particular health conditions, potential side effects, and the importance of vaccinations in preventing complications. This includes regularly updating the public on the latest research findings and swiftly addressing misinformation. Moreover, to ensure that cost is not a barrier to vaccine uptake, policies should consider implementing income-based subsidies or free vaccination programs. Finally, mobilizing community leaders, influencers, and vaccinated individuals can help disseminate positive vaccination messages and experiences. Public health campaigns should leverage these trusted voices to increase vaccine confidence and uptake.

5 Limitations

There are some limitations to this study, which can be addressed by future research. First, to reduce the burden on respondents, only the five most important attributes were included in the DCEs, excluding factors such as vaccination convenience, sites, and doses, which may also significantly impact vaccine preferences. Similarly, some potentially influential factors, such as government mandates, political movements, news, and personal beliefs in vaccines, were excluded for the same reason. Future studies could incorporate these additional factors for a more comprehensive analysis. Second, despite our efforts to mitigate biases, self-reported data are inherently subject to social desirability and inaccurate reporting biases. Therefore, our findings should be interpreted with caution. Additionally, the DCEs rely on predefined attributes and hypothetical scenarios that are different from the real world, failing to capture the nuances of individual vaccine preferences and additional factors. Future research incorporating qualitative methods, such as interviews or focus groups, could provide a more comprehensive understanding of the factors influencing vaccination decisions. Moreover, the latent class logit model used in this study has limitations in fully capturing the complexity of vaccination decision-making. Future research should explore alternative modeling approaches to provide a deeper understanding of the factors influencing vaccination decisions. Furthermore, our study captured vaccine preferences at a specific time, which might not reflect changes as new information becomes available. Future

research can be longitudinal studies to track how preferences evolve. Finally, our study is specific to the Chinese context, these results may not be generalizable to other countries or cultures due to differences in healthcare systems, vaccination experiences, and public perceptions.

6 Conclusion

In conclusion, this study aimed to investigate the influencing factors of vaccination decisions for newly developed and established vaccines in China using latent class logit models. Our findings reveal significant similarities and differences in the determinants of vaccination decisions between COVID-19 and influenza vaccines. Key factors include vaccine safety and effectiveness, income, health status, risk perception, and vaccination behaviors of acquaintances. Understanding these factors can help public health authorities design targeted interventions to improve vaccination rates and address vaccine hesitancy. Future research should continue to explore these dynamics in different populations and contexts to further enhance our understanding of vaccination behavior.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Medical Ethics Sub-Committee of the Ethics Committee for Science and Technology at Nanjing University (Approval Number: OAP20230407001). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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SC: Conceptualization, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. BX: Funding acquisition, Supervision, Visualization, Writing – review & editing. HX: Supervision, Writing – review & editing. YS: Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. Financial support for this study was provided by the National Natural Science Foundation of China (71874080, 72374101), the Fundamental Research Funds for the Central Universities, and the Jiangsu Planning Office of Philosophy and Social Science (20JD001). The funding agreement ensured the authors' independence in designing the study, interpreting the data, writing, and publishing the report.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

APPROVED BY
Frontiers Editorial Office,
Frontiers Media SA, Switzerland

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RECEIVED 11 October 2024
ACCEPTED 30 October 2024
PUBLISHED 13 November 2024

CITATION

Chang S, Xu B, Xi H and Shao Y (2024)
Corrigendum: Investigating the influencing
factors of vaccination decisions for
newly-developed and established vaccines: a
comparative study based on latent class logit
models in China.
Front. Public Health 12:1509718.
doi: 10.3389/fpubh.2024.1509718

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Corrigendum: Investigating the influencing factors of vaccination decisions for newly-developed and established vaccines: a comparative study based on latent class logit models in China

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KEYWORDS

COVID-19 vaccines, influenza vaccines, latent class logit model, choice experiment, vaccine preferences

A Corrigendum on

[Investigating the influencing factors of vaccination decisions for newly developed and established vaccines: a comparative study based on latent class logit models in China](#)

by Chang, S., Xu, B., Xi, H., and Shao, Y. (2024). *Front. Public Health*. 12:1455718.
doi: 10.3389/fpubh.2024.1455718

In the published article, there was an error regarding the corresponding author. The corresponding author was incorrectly assigned as the submitting author. However, the second author should have been designated as the corresponding author. The corrected corresponding author appears below.

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The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

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RECEIVED 08 May 2024

ACCEPTED 19 August 2024

PUBLISHED 02 September 2024

CITATION

Wang X, Xing Y, Zhang E, Dai Z, Li Y, Shang S,
Hu J, Zhang X and Fang Q (2024)
Understanding herpes zoster vaccine
hesitancy and information asymmetry:
a qualitative study in China.
Front. Public Health 12:1429522.
doi: 10.3389/fpubh.2024.1429522

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Understanding herpes zoster vaccine hesitancy and information asymmetry: a qualitative study in China

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Background: Herpes zoster is more prevalent among the older adult due to the age-related immune decline, leading to significant pain and complications. Although vaccination effectively prevents viral infections, vaccine hesitancy remains a major barrier to achieving high vaccination rates. To address this, we conducted a qualitative survey using Vaccine Hesitancy Determinants Matrix and 5C model to understand and improve vaccination rates in this group.

Methods: Descriptive qualitative research design based on the philosophical underpinnings of naturalistic inquiry and purposive sampling methodology was conducted on adults aged 50 and above, as well as community health workers. Data were collected through semi-structured, in-depth personal interviews. The interview outline was constructed following a comprehensive review of the literature and consideration of the theoretical framework.

Results: Seventeen adults over 50 years and four community healthcare workers were included in this study. The study found that information asymmetry in immunization planning was evident at all stages of vaccine supply, dissemination and demand. The main manifestations included limited access to authoritative information, insufficient community awareness of herpes zoster as a route of vaccination, insufficient vocational training, significant gaps in vaccine knowledge, and high levels of complacency among individual residents.

Conclusion: Herpes zoster vaccine hesitancy is prevalent among middle-aged and older adults in China due to information asymmetry, vaccine complacency, inadequate community services, and other multiple layers of factors. Public health strategies should aim to reduce cognitive biases and information gaps by disseminating diverse and credible vaccine information through social media, medical institutions, and offline channels to promote higher vaccination rates.

KEYWORDS

vaccine hesitancy, information asymmetry, herpes zoster, 5C, qualitative

1 Introduction

In recent years, the incidence of herpes zoster, particularly among the older adult, has been on the rise. Advanced age is a major risk factor for the reactivation of the varicella-zoster virus (1). Globally, the incidence ranges from 3 to 5 per 1,000 person-years in the general population, increasing to 5 to 11 per 1,000 person-years in those aged 50 years and older (2). Apart from acute-phase lesions and pain, 9 to 34% of patients face the potential risk of developing postherpetic neuralgia (3). Overall, the healthcare burden of herpes zoster is substantial. A study by Kawai et al. found that the annual rate of herpes zoster-related hospitalizations ranges from 2.1 to 25.0 per 100,000 individuals, with hospitalization rates increasing with age (2). Additionally, the economic burden following infection is significant (4), with the average hospitalization cost for adults aged 50 and above estimated at 4,502.4 RMB (approximately \$630) (5).

Vaccination against herpes zoster is an effective and feasible means of preventing infection with the herpes zoster virus and its serious complications (6). The U.S. FDA approved the recombinant herpes zoster vaccine in 2017 for preventing herpes zoster in adults aged 50 and above. It was officially launched in China in June 2020, becoming the only approved herpes zoster vaccine in this country (7). However, herpes zoster vaccination rates in China, even in cities like Shanghai (8) and Beijing (9), are strikingly low. Recent data from the past 2 years indicate that the vaccination rate for HZV among adults aged 50 years and older is less than 3.0%, significantly lagging behind some developed countries like the United States (25.8%) (10) and Greece (20.0%) (11). In China, a dedicated herpes zoster (HZ) vaccination program specifically for older adult individuals or those with weakened immune systems has not yet been established, and the HZ vaccine is not part of the mandatory immunization schedule. Despite the increasing recognition of the importance of vaccination in preventing HZ and its complications, the implementation of widespread vaccination programs remains limited.

Understanding factors associated with herpes zoster vaccine hesitancy among middle-aged and older adult individuals is crucial for improving vaccination rates in these key populations. The Measuring Behavioral and Social Drivers of Vaccination (BeSD) working group defines vaccine hesitancy as *delay in acceptance or refusal of vaccination despite availability of vaccination services. Vaccine hesitancy is complex and context specific, varying across time, place and vaccines* (12, 13). Vaccine hesitancy is notably context-specific and complex, given the diversity of vaccine types and settings. The Strategic Advisory Group of Experts introduced the Vaccine Hesitancy Determinants Matrix, which thoroughly examines potential influences on vaccine hesitancy concerning individual/organizational, societal contextual, and vaccine/vaccination factors (14). Additionally, the 5C model of vaccine hesitancy links it to psychological factors and interprets its role from various dimensions (15). According to this model, factors such as the communication and media environment, regional culture, vaccine safety and efficacy, and trust in government and healthcare organizations are considered important in influencing vaccine hesitancy (16).

The transmission of vaccine-related information, including its source, demand, and operation, typically undergoes several stages before reaching the end-user. It's crucial to recognize the information asymmetry inherent in this process, where both information providers and recipients may not have equal access to

or possession of all necessary information for informed decision-making (17). This information gap, compounded by potential challenges related to digital literacy and internet usage among certain middle-aged and older adult individuals, renders them susceptible to encountering information barriers or delays. Consequently, this impedes their ability to trust medical information (18).

To gain insights into the current landscape of herpes zoster vaccine hesitancy among individuals aged 50 and above in China, and to develop strategies for enhancing vaccination and immunization planning, this study will combine the vaccine hesitancy determinants matrix with the 5C model. Through qualitative exploration, we will investigate the factors influencing herpes zoster vaccine hesitancy from the perspectives of individuals aged 50 and above, as well as healthcare professionals. The goal is to understand the influence of information asymmetry in this context and devise strategies to mitigate it.

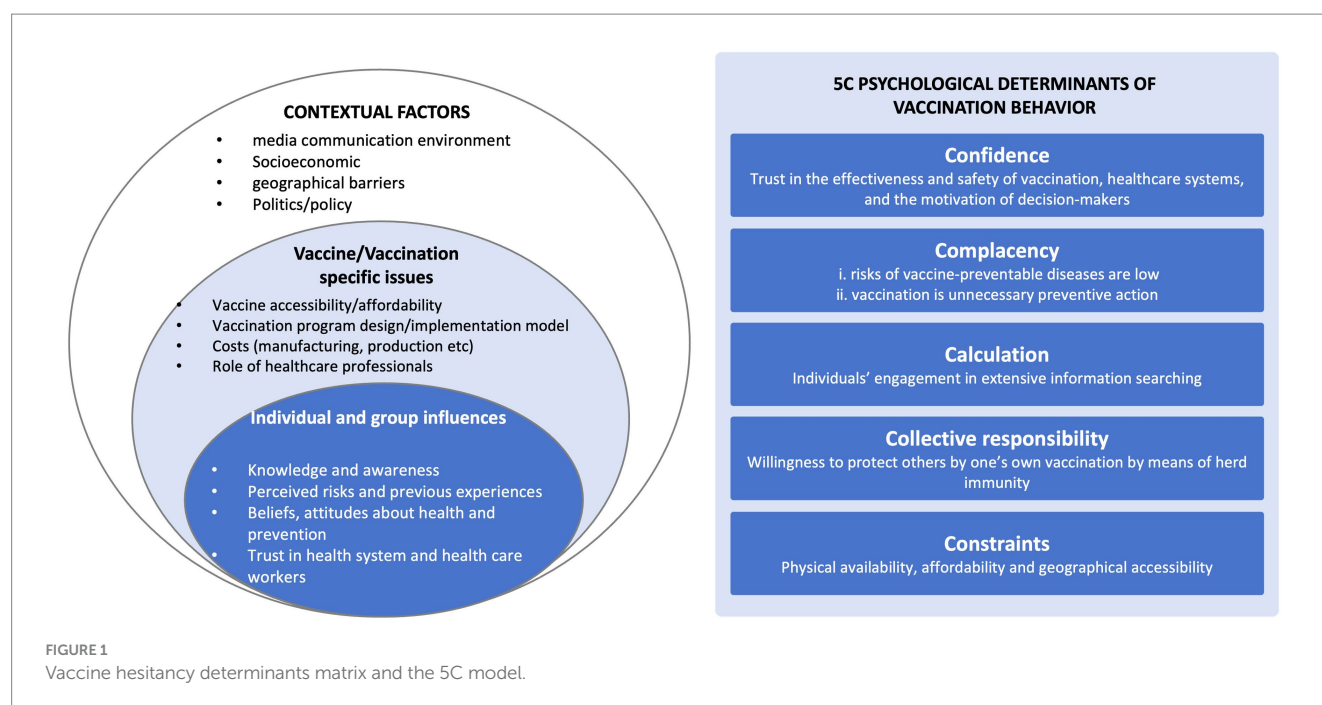
2 Materials and methods

2.1 Study design

Following the methodology of descriptive research, we gathered data through face-to-face semi-structured in-depth interviews. Initially, we developed an interview outline based on the WHO Vaccine Hesitancy Determinants Matrix and the 5C model (Figure 1), aligning with the study's objectives and literature review. The research design, analyses, and findings were reported following the Consolidated Criteria for Reporting Qualitative Research (COREQ) (19).

2.2 Participates

From October 2023 and December 2023, we employed purposive sampling at two community health centers in downtown and suburban Shanghai, China. Eligible participants were required to meet the following criteria: (1) aged ≥ 50 years, (2) residing in the community for ≥ 6 months, (3) capable of clear communication, and (4) providing informed consent. The study excluded people with poor health status unfit to participate in, as well as those with cognitive impairments that prevented from providing accurate and clear information. To comprehensively capture factors influencing vaccine hesitancy, we did not distinguish between participants based on herpes zoster vaccination status. Additionally, medical staff from both communities were recruited to participate in the survey, contributing to the comprehensive analysis. We conducted 17 in-depth interviews. The sample size was determined based on achieving thematic saturation, where no new themes were emerging from the data. Saturation was assessed through iterative data collection and analysis until consistent themes were identified. Specifically, the team conducted discussions to assess whether new interviews continued to contribute to understanding key themes related to vaccine hesitancy. We also employed thematic coding to monitor the emergence and repetition of themes. The decision to conclude data collection was based on the absence of new major themes (Supplementary material).



2.3 Data collection

Adhering to the principle of informed consent, prior to conducting the interviews, participants were provided with a detailed explanation regarding the purpose, methodology, and content of the interviews. The researcher had prior involvement in research projects on qualitative research at Fudan University and the University of Cambridge (online). Interviews were conducted in Chinese Mandarin in a comfortable, private setting, lasting 20 to 30 min each. All interviews were audio-recorded with participant consent. The research adhered to informed consent principles, with assurances of confidentiality and anonymity. Ethical approval was obtained from the Public Health and Nursing Research Ethics Committee of Shanghai Jiao Tong University School of Medicine (SJUPN-202018).

2.4 Data analysis

Transcriptions were completed within 48 h of interviews by researchers XL and YF. NVivo 14.0 was used for data management. During the transcription process, ambiguous sections were referred back to the interviewees for clarification. Data analysis involved open coding to identify and label themes, which were then categorized into a framework based on the 5C model and SAGE matrix. Categories included contextual factors, individual and group-related factors, and vaccine-related factors. Disputes in data categorization were resolved with input from a third researcher, FQ.

3 Results

3.1 General information on interviewees

A total of 17 adults aged 50 years and older (N1~N17) and 4 healthcare workers (M1~M4) working in the community were

recruited for the study. The sample of middle-aged and older adults came from both urban and rural areas, comprising 5 males (29.4%) and 12 females (70.6%). The four healthcare workers' job scope covered administration, general practitioner, and public health nursing. (See [Supplementary Appendix 2](#) for more details about the participants).

3.2 Themes

Within the context of the three broad themes of the VHDM—individual and group influences, contextual factors and vaccine/vaccination-specific issues—the analysis yielded 10 themes ([Table 1](#)).

3.2.1 Contextual factors

3.2.1.1 Access to the internet and social media

The Internet and social media serve as crucial channels for information dissemination. However, they can also be platforms for spreading misinformation, exaggerations, or negative narratives, thereby exacerbating vaccine apprehensions, and fostering vaccine hesitancy.

According to phone information, this vaccination is more likely to be contaminated, and I'm not sure if the imported vaccine is suitable for Chinese people... this condition appears to be merely suffering. (N17).

Furthermore, the information offered via official channels may be insufficient to meet the needs of the public, or official information may not be disseminated as quickly or in the same manner as social media. This may result in a higher reliance on social media or other unofficial routes for information.

I do not know that the community has publicized this, but neighborhood councils are allowed to take on the job of publicizing

TABLE 1 Overview of themes.

Categories	Theme	Subtheme
Contextual factors	Access to the Internet and social media	Negative information
		Credibility of information
		Official authoritative information
	Community vaccination service	Proactive awareness
		Inconvenience of vaccination
	Socio-economic circumstances	Disparities in vaccine allocation
Social insurance coverage		
Individual and group influences	Disease and vaccine perception differences	Unfamiliar medical terminology
		Less information access initiative
	Negative disease experience and vaccination experience	Negative vaccine incidents
		Positive vaccination experience
	Vaccine complacency and risk perception	High vaccine complacency
		Misalignment of risk and benefit assessment
	Natural immunity preference	Preventing external vaccine damage
		Poor physical fitness
Vaccine/vaccination specific issues	Vaccine supplier experience	Vaccine supply source effects
		Attention from medical personnel
	Vaccination costs	Pressure on vaccine prices
		Health service prioritization
	Vaccination program design/implementation model	Optimization of vaccination plan
		Inadequate follow-up medical care

vaccines... such as the effectiveness of the vaccine, the price, and where to get vaccinated. (N3).

I did not notice a news program pushing people to obtain this vaccine... Older people like me who aren't as familiar with cellphones tend to glance at roadside advertisements more. (N7).

There are fewer sources of information in the official media, making it difficult for citizens to determine which information is real and reputable, and some may not be authoritative enough.

Some official media, such as the Health Commission and the CDC, can use tiktok or WeChat platforms to advocate vaccination among the public. (N16).

3.2.1.2 Community vaccination service

The absence of supply-side information in the community, which is the primary source of firsthand and reliable information, may result in poor public understanding of the herpes zoster vaccine and its immunization services.

I have not been informed about the availability of HZV in my neighborhood. Before the COVID-19, the community used to call me whenever there was a need for vaccination. (N12& N17).

Inadequate or unavailable community-based vaccination services can hinder herpes zoster vaccination. Factors such as long distances

to vaccination sites, inflexible vaccination scheduling, or insufficient vaccination staff create significant constraints. These constraints, as described in the 5C model, can all impact an individual's decision regarding vaccination.

This is the closest community where I can obtain HZV... I still hope that the country would increase the vaccine's popularity and provide adequate support to people who wish to get vaccinated. (N3).

Individuals with limited access to community vaccination information may turn to unreliable sources such as word of mouth, unofficial channels, or unconfirmed information. This lack of reliable information undermines their confidence in the vaccination process, leading to uncertainties and concerns.

If the community had not pushed and publicized it with the necessary text messages, I would not have known about it. (N5).

I came to my community to inquire about the shingles vaccine after reading about it online, and I'm not sure whether what the internet claims is accurate. (N16).

3.2.1.3 Socio-economic circumstances

Individual immunization may be more convenient in urban regions due to the higher accessibility of healthcare resources and services. In contrast, suburban or economically disadvantaged

communities may lack proper health care or immunization locations.

Our community is one of the only locations in the surrounding community centers to offer the hzv, and we will increase the number of vaccines in time to meet the public's demand. (M1).

Compared to other immunization program vaccines, this community hospital has minimal interactions regarding shingles visits... If you require the herpes zoster vaccine, schedule an appointment at a tertiary care facility. (M4).

HZV is currently not covered by Medicare, which makes some seniors more hesitant to acquire it because they will have to pay for it themselves.

This vaccination is quite expensive and does not qualify for Medicare. The older adult are more likely to get this illness, and many of them are retired and have limited resources. (N11).

I would absolutely consider getting the vaccination if it was reimbursable, like the COVID-19 vaccine, which is free, or reasonably priced, like the flu shot. (N15).

prevent recurrence, while also being more concerned about the vaccine's efficacy and reliability.

My parents and classmates have contracted this sickness, and the symptoms include severe discomfort... I'm willing to be vaccinated against this virus because it is vaccine-preventable, if the vaccine is effective. (N3).

Individuals who have had an active vaccination experience may be more likely to acquire HZV and have greater confidence in its safety and efficacy.

I've had the flu shot a few times, and I believe the vaccine is tested before it's made available to the public, so I'm willing to receive the hzv as well. (N5).

Individuals who have suffered adverse effects from previous immunizations may carry this worry over to the shingles vaccine, where they are more concerned about potential side effects.

I experienced a fever after the COVID-19 vaccination previously, and because side effects might occur with a vaccine like this one that everyone is getting, I'm not sure how HZV will affect my health. (N1).

3.2.2 Individual and group influences

3.2.2.1 Disease and vaccine perception differences

Most middle-aged and older persons have insufficient knowledge about vaccines and the diseases they protect against. In terms of disease awareness, respondents may be familiar with the symptoms of herpes zoster infection, such as “blisters” and “pain,” but they are unfamiliar with the disease's precise name, how it is caught, and how it is treated.

Is herpes like a snake wrapped around abdomen? It causes a red rash in a circle around the stomach and is extremely painful. (Key information-N13, N15, N17).

Most urban inhabitants have only heard of vaccines by name and rarely initiate conversations concerning vaccines and diseases. Lack of initiative in information acquisition is a significant predictor of vaccine reluctance.

I had no idea that this illness had a vaccine? I'm more inclined to go when the community suggests that a vaccine is accessible than when I proactively inquire. (N4).

I visit the neighborhood hospital primarily for medical examinations, immunizations are not very important to me. (N12).

3.2.2.2 Negative disease experience and vaccination experience

Patients who have been infected with shingles, or who have had the disease in close relatives or friends, are more aware of the disease's seriousness and impact, and are thus more willing to be vaccinated to

3.2.2.3 Vaccine complacency and risk perception

Higher vaccination complacency in middle-aged and older populations refers to a person's confidence in their pre-existing immune system, believing that their body is already capable of fighting off diseases and possible infections. This sense of complacency, which is a key component of the 5C model, leads individuals to believe that shingles do not constitute a severe threat to their health. As a result, individuals with higher levels of complacency are hesitant to be vaccinated.

The reason I did not think about it is that I have a very low probability of getting sick, and I have not had an infection at my age. (N9& N10).

People tend to believe that treatment is more expensive than vaccination, underestimating their chance of contracting the illness and having insufficient knowledge about the advantages and effectiveness of HZV, both in terms of its protective effect and financial benefits.

I used ointment to the rash every day after the infection, and it did not take much money... I do not think the vaccine is necessary. (N2& N9).

3.2.2.4 Natural immunity preference

Those who support natural immunity may be more likely to employ natural methods to increase the immune system, believing that naturally acquired immunity is more long-lasting and effective, and that external immunizations are hazardous.

A vaccine is always something else shot into the body, and something foreign is damaging to the body. (N12).

Herpes zoster is thought to appear when you have a weakened immune system, thus I believe it is best to rely on your immune system. (N13).

In addition to preferring autoimmunity against viruses because they are concerned about the harm caused by external immunizations, persons with objectively lower body mass prefer natural immunity to avoid difficulties and consequently lower health.

I've had chronic nephritis and proteinuria for a long time... Personal health is a major reason why poorer health is not appropriate for immunizations. (N8).

3.2.3 Vaccine/vaccination specific issues

3.2.3.1 Vaccine supplier experience

Healthcare providers-pharmaceutical corporations, government agencies, and public health organizations, play a critical role in vaccine supply and management, as well as vaccination service delivery. The imported recombinant herpes zoster vaccine is now approved in China, and while the indigenous vaccine is available in 2023, the two vaccines differ significantly in terms of efficacy, target demographics, and vaccination protocols. According to studies, the source of vaccine supply influences an individual's likelihood of receiving the vaccine, with more participants showing greater trust in imported vaccines.

Domestic vaccine appears to have been out only last year, whereas the imported vaccination is already accessible in so many nations. I would favor the foreign vaccine. (N3).

Currently, only imported shingles vaccination is accessible in our area. Although the domestic vaccine increases the age range for vaccination to over 40, the current guideline recommendation remains the imported recombinant shingles vaccine. (M1).

Although compared to the middle-aged and older adult populations, the healthcare professionals interviewed did not exhibit significant vaccine hesitancy toward the herpes zoster vaccine, it is noteworthy that only one individual had actually received the vaccine. Even among medical professionals, awareness and prioritization of the herpes zoster vaccine remain insufficient. This lack of attention and expertise regarding the vaccine raises concerns about the accuracy of the information provided, resulting in insufficient access to vaccination information for the public and influencing their decision-making.

My wife had gone to the hospital for herpes a few times before, but the physicians did not know much about the disease and did not recognize it as shingles at first. (N9).

I've got two vaccinations, but I'm not completely aware of the vaccine information... Indeed, as the group of persons in the community who have the most contact with older people, all community health professionals should be gathering to learn and train. (M2).

My expertise of shingles may be restricted to symptoms, location, and so on.... When someone asks about the content, there is no way to provide accurate information or fast immunization assistance. (M3).

3.2.3.2 Vaccination costs

The immunization cost of approximately 3,200 yuan for two doses may increase the financial burden on the middle-aged and older adult. This could be a major reason for vaccine hesitancy, particularly among individuals with low incomes or who are retired.

My prior immunization cost roughly 3,000 RMB, which is quite pricey, and this vaccine is not covered by health insurance, unlike the flu vaccine, which I can probably obtain for a couple of hundred dollars. (N5).

For interviewees with high incomes, the vaccine's cost was not a big impediment. Rather, the vaccine's effectiveness and hazards were important issues.

Price does not matter to me if the outcomes are good enough and the side effects aren't too awful, I'm willing to get immunized. (N4).

Respondents from the suburbs stated that high-cost immunizations constitute an additional burden for families, which is likely to be a substantial role in vaccine hesitation. Still, if the shingles vaccine was free, like the COVID-19 vaccine is, more people would consider taking it.

This price is always slightly more for the older adult, because we are more remote, and no one makes much money... If the state implements a policy allowing the older adult to get for free, there will undoubtedly be many eager participants. (N16).

Individual health service priorities vary, and some middle-aged and older persons may allocate their limited health-care resources to more urgent or severe health issues rather than immunizations.

There is a significant difference between 200 and 3,000 RMB, and with two shots costing me roughly half a month's pension, I'd much rather spend the money on useful treatments or vaccinations for diseases with a larger incidence, such as the flu. (N1).

3.2.3.3 Vaccination program design/implementation model

The absence of large-scale immunization campaigns or poorly designed/implemented models may lower middle-aged and older persons' desire to accept the shingles vaccine. For example, immunization sites may be remotely located, making transportation problematic; or vaccination schedules may be less frequent and prevalent than for the COVID-19 vaccine or flu vaccine.

HZV is not as well-known as the flu or the COVID-19 vaccine, and we will often warn older adult individuals attending our clinics that 'flu season', 'pneumonia is common', etc., but there is actually very little discussion of shingles.... The community currently offers

vaccine appointments, but there are no large-scale programs to promote and vaccinate. (M2).

There are relatively few shingles vaccination campaigns or programs in the suburbs, and as a healthcare practitioner, I am aware of only a few community hospitals in urban regions that offer vaccinations. As a result, in addition to internal community awareness initiatives, all parties should work together to publicize the campaigns at the social and governmental levels. (M4).

The adequacy of follow-up medical protection also influences the public's motivation to get vaccinated. If people experience unpleasant responses or require more medical care following vaccination, a lack of proper support and protection may diminish their willingness to get vaccination.

Post-vaccination complications are a concern.... I think the community must do a good job with post-vaccination because a lot of people get vaccinated for the first time, and if anything, horrible happens instead, it's a method of undermining people's trust. (N10).

Not only HZV, but also the community is now actively improving the process of immunization planning vaccination, from vaccine appointment to post-vaccination observation, and I hope that adequate support can be given, which is also a guarantee for the public's safety. (M1).

4 Discussion

The 5C model and the vaccine hesitancy determinants matrix have been used in research on influenza (20), COVID-19 (21), and Monkeypox (22) vaccines to explore and organize influencing factors. In this study, these frameworks were applied to examine information asymmetry in the formation of herpes zoster vaccine hesitancy among adults aged 50 years and older across different vaccine processes (Figures 2, 3). Individual/group-level impacts include disparities in disease and vaccine perceptions, bad disease and vaccination experiences, vaccine complacency, and natural immunization preferences. Access to the Internet and social media are among the most important contextual factors, as they can contribute significantly to negative information provision and a lack of official authoritative information, as well as inconvenience and instability in community-based vaccination services and socioeconomic differences. Vaccine considerations encompass factors such as the experience of vaccine suppliers, costs, and the inadequate dissemination of essential vaccination information. Inequities and differences in the availability of information at various levels—ranging from broad external sources to individual access—significantly contribute to vaccine hesitancy.

4.1 Personalized vaccine information support to improve cognitive level and information acquisition initiatives for the middle-aged and older adult population

Several sub-themes, including cognitive variances, past vaccination experiences, and preferences for natural immunity, are encompassed within the factors influencing individuals and groups. Prior studies

underscore the pivotal role of trust and mistrust in vaccine hesitancy when making vaccination decisions (23). Trust serves as a linchpin for individuals and communities to heed regulatory agency and medical personnel recommendations. However, establishing trust necessitates information acquisition, where individuals must decide whether to place trust or distrust based on the information received (24). Therefore, rectifying information asymmetry and addressing information gaps are pivotal in tackling herpes zoster vaccine hesitancy among the middle-aged and older adult population in China. Our findings indicate that individuals harboring lower levels of trust in authorities and healthcare providers may exhibit reluctance toward embracing new or relatively unfamiliar vaccines due to previous negative disease encounters or vaccine-related incidents, aligning with prior research (25). Those personally afflicted by herpes zoster, exposed to accounts of its agonizing symptoms, or having vaccinated family members or acquaintances are more inclined to comprehend the vaccine's significance and benefits, thereby manifesting more favorable vaccination attitudes (26). Furthermore, individuals adopting a complacent stance toward the herpes zoster vaccine often showcase heightened levels of vaccine hesitancy, consistent with Abdou et al.'s (27) findings. Complacent individuals may perceive vaccination as superfluous, relying instead on their immune system's defense mechanisms and shunning foreign vaccine interventions (28). Even after elucidating the vaccine's active constituents, a significant portion of individuals still misconstrues vaccination as akin to inoculating the virus itself, potentially triggering the disease.

Understanding the expected benefits of vaccination through accurate information is essential in shaping vaccine attitudes. When individuals receive reliable information about how vaccination can effectively reduce the risk of infection, they are likely to have lower vaccine hesitancy (21). In numerous studies, 'misinformation' (29), 'information gap', and 'trust deficit' (18) stemming from negative information have been pinpointed as primary causes of hesitancy regarding various vaccines, such as the influenza vaccine and the COVID-19 vaccine. However, the shingles vaccine remains unpopular among Chinese adults aged 50 years and older (8). The emergence of information asymmetry due to information scarcity is gradually becoming a salient characteristic of the healthcare service landscape. The specialized nature of medical services coupled with the high cost of acquiring information among the middle-aged and older adult population has rendered many respondents' passive recipients of medical services. Insufficient information significantly influences individuals' trust levels and propensity to vaccinate (30). Therefore, enhancing publicity and educational efforts for herpes zoster vaccination is crucial for preventing and reducing vaccine hesitancy among middle-aged and older adult populations. Delivering personalized, easily comprehensible, scientifically accurate information in a manner that accommodates the information needs and preferences of the population could elevate disease and vaccine awareness levels. Consequently, improving access to accurate vaccine information may help correct misunderstandings and encourage more people to get vaccinated.

4.2 Access to the internet and social media diversifies authoritative information and increases the reliability of sources

Addressing the unique causes of vaccine hesitancy needs not only an individual focus, but also the collaboration of communities, health

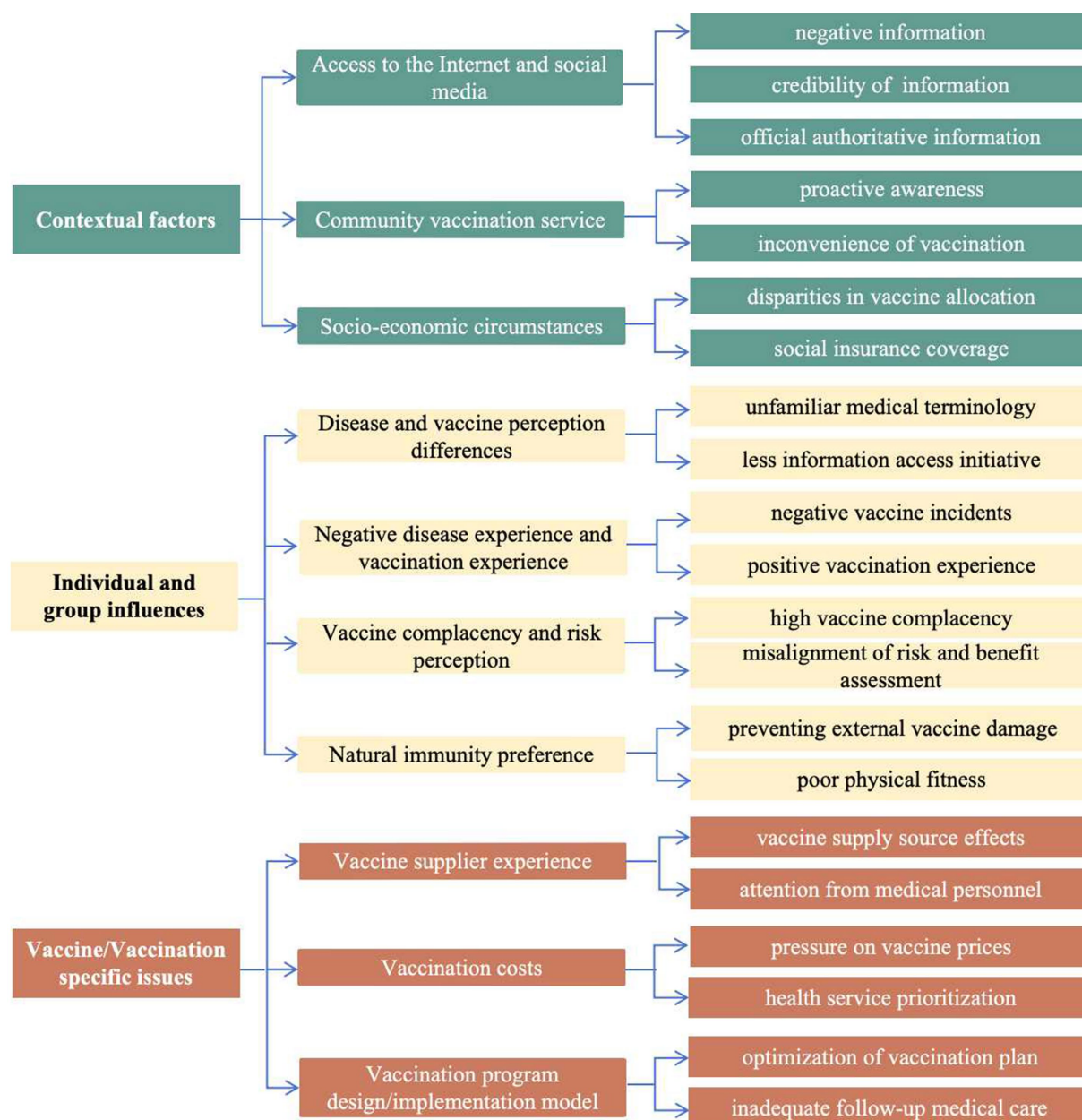
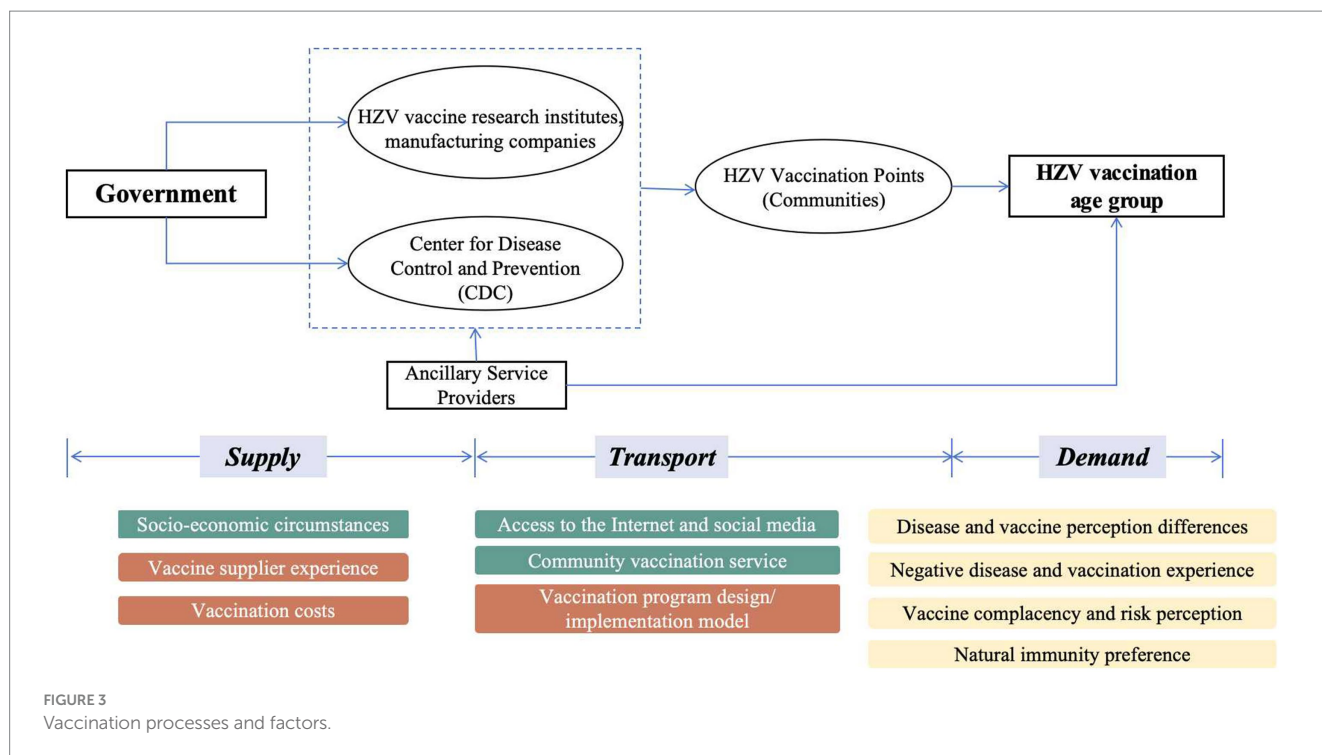


FIGURE 2
Visualization of interview themes.

institutions, social media, and outside influences. The rise of social media has revolutionized information distribution, enabling both accurate and misleading information to spread rapidly (31). While social media offers a new and expansive platform for information dissemination, it has also allowed anti-vaccine advocates to reach and influence a large audience more effectively than traditional channels (32, 33).

The study showed that a lack of formal authoritative information can make it difficult for people to access correct and reliable vaccine-related information. When people want to learn about the vaccine's efficacy, side effects, or the target population, they may rely on WeChat text messages, television advertisements, and other news and social media if they cannot get accurate information from official

authoritative sources, which may be misleading or inaccurate, adding to people's doubts and confusion about vaccination (18). As indicated by a study from India (21), respondents who trusted information shared by family members, friends, relatives, and health workers exhibited less vaccine hesitancy. In contrast, information from mass media and social media was associated with higher vaccine hesitancy. Respondents in the survey also stated that a lack of ambiguity in official information may call into question its credibility and authority, contributing to distrust of vaccination. Second, due to information occlusion, access to community vaccination is limited, and the combination of insufficient vaccine supply and unstable information sources contributes to individual obstacles to immunization. As a result, government officials can provide accurate, easy-to-understand



vaccine-related information by developing a clear information dissemination plan, using electronic platforms such as WeChat, official Twitter and TikTok accounts, organizing regional health lectures, and establishing special consultation hotlines and vaccine clinics in the community to answer vaccine questions (34, 35). The strategies described above may improve the accuracy and transparency of official authoritative information, reduce the information gap between officials and the public, and boost individuals' willingness to be vaccinated.

Limited understanding of the herpes zoster vaccine among middle-aged and older adults further hinders immunization efforts. Many individuals are unaware of the vaccine's benefits and its relationship to the disease. A systematic review (36) found that 67.1% of respondents from 17 countries had limited knowledge about the herpes zoster vaccine, including its onset, progression, and treatment options. Information occlusion and limited community vaccination access also pose obstacles to immunization. To address these challenges, government officials should implement strategies to enhance the accuracy and transparency of vaccine information. This includes developing a clear information dissemination plan, utilizing electronic platforms such as WeChat, official Twitter and TikTok accounts, organizing regional health lectures, and establishing consultation hotlines and vaccine clinics. These measures can help bridge the information gap, improve public trust, and increase vaccine uptake.

4.3 Increasing the emphasis of community vaccine suppliers and accelerating vaccinations at the last mile

Interviews with community healthcare workers revealed that, compared to the middle-aged and older adult populations, they were

more supportive of herpes zoster vaccination. This may be due to their frequent exposure to vaccines in their professional roles (37). However, the actual vaccination rate among healthcare workers was low. This discrepancy can be attributed to two main factors. Firstly, unlike the COVID-19 vaccine, there are no mandatory regulations for herpes zoster vaccination in China (38), which means there are no clear requirements or guidelines for its administration. Secondly, a lack of awareness and understanding about the herpes zoster vaccine persists, even among medical professionals (39). Our study found that healthcare workers had gaps in their knowledge about herpes zoster, and they had received minimal specialized training or education on the subject, with few professional courses on herpes zoster available.

As a result, healthcare providers are unable to effectively communicate the importance of the herpes zoster vaccine, leaving the public unaware or skeptical about its benefits (40). Interviews with four healthcare professionals highlighted substantial gaps in their knowledge about herpes zoster in both suburban and urban communities. This lack of specialized courses and training results in many residents not receiving professional vaccine advice.

Previous research has indicated that healthcare professionals' knowledge and guidance are critical for individual immunization (41). Because the community is the most convenient location for residents to seek medical care, it serves as the primary channel for disseminating authoritative information about vaccines. This setting is ideal for explaining the importance, safety, and benefits of vaccines, sharing actual vaccination experiences, and understanding patients' specific needs and concerns (42, 43). However, due to China's large older adult population and the high volume of community outpatient clinics, our study found that community physicians struggle to find time to address the vaccine needs of the middle-aged and older adult populations. Therefore, it is recommended to establish specialized clinics with dedicated staff to efficiently recommend various types of vaccines (44).

In addition, vaccine affordability, including the cost and individual economic circumstances, may contribute to vaccine hesitancy among the middle-aged and older adult. In this survey, a number of respondents indicated that the high price may be an important reason for discouragement after learning the relevant information, which is consistent with the findings of a Hong Kong study (26), in which knowledge of the disease and the vaccine played a secondary role in vaccination decision-making when compared to the economic burden of the herpes zoster vaccine. In China, the herpes zoster vaccine is currently available only through self-funded, voluntary vaccination. There are no conditions for providing the vaccine free of charge at this time. However, offering economic incentives might be a feasible alternative. For instance, community-level support could include providing daily necessities or vouchers as incentives for vaccination (45, 46).

This study had limitations. First, the participants were middle-aged and older individuals from two community health centers in both urban and suburban areas of Shanghai. The relatively small sample size and localized focus may restrict the generalizability of the findings and not capture all factors related to vaccine hesitancy. Second, while the study highlights the role of information asymmetry and examines the perspectives of middle-aged and older adults as well as healthcare providers, it does not include viewpoints from leaders of National Health Commission or relevant government departments. Finally, the study employs qualitative methods, focusing on in-depth interviews and thematic analysis. As such, the findings are illustrative rather than universally applicable. Future research should consider incorporating a broader range of data sources and methods to enhance the generalizability and applicability of the conclusions.

5 Conclusion

Herpes zoster vaccine hesitancy remains a significant issue among middle-aged and older adults in China. Most individuals lack understanding of vaccination-related information, compounded by problems of information asymmetry, vaccine complacency, and inadequate community services. Vaccine hesitancy is influenced by various factors such as online information, individual vaccination history, and trust levels. These findings suggest that public health departments can reduce individual cognitive bias, overcome information gaps and disparities, and promote higher vaccination rates by disseminating diverse and credible vaccine information through multiple channels, including social media, medical institutions, and offline contact.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Public Health and Nursing Research Ethics Committee, School of Medicine,

Shanghai Jiao Tong University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

XW: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Conceptualization. YX: Writing – original draft, Visualization, Investigation, Formal analysis, Conceptualization. EZ: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation. ZD: Writing – review & editing, Visualization, Data curation. YL: Writing – review & editing, Visualization, Formal analysis, Data curation. SS: Writing – review & editing, Visualization, Validation, Data curation. JH: Writing – review & editing, Validation, Supervision. XZ: Writing – review & editing, Supervision, Conceptualization. QF: Writing – review & editing, Supervision, Project administration, Conceptualization.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work was supported by the 3-year action plan for the construction of Shanghai's public health system (2020–2022), academic leaders cultivating project [number GWV-10.2-XD33].

Acknowledgments

We would like to express our sincere gratitude to the older adult and medical professionals who participated in the interviews.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1429522/full#supplementary-material>

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RECEIVED 19 June 2024

ACCEPTED 03 September 2024

PUBLISHED 18 September 2024

CITATION

Li M, Zhang F, Shi Y, Shi K, Li X and
Bai H (2024) Awareness of HPV and HPV
vaccine among college students in China.
Front. Public Health 12:1451320.
doi: 10.3389/fpubh.2024.1451320

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Awareness of HPV and HPV vaccine among college students in China

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Background: Cervical cancer is the fourth most common cancer among women, HPV vaccine can reduce the incidence of cervical cancer by approximately 70%. Sexual behavior is a direct risk factor for HPV infection, and sexually active college students, therefore, receive attention for HPV vaccination. This study aimed to investigate the awareness of HPV and its vaccine among college students in Zhengzhou, and to explore the factors influencing their awareness of HPV vaccine, to understand college students' willingness to receive the vaccine. The findings of this study will lay a foundation for cervical cancer prevention.

Methods: Using a multistage random sampling method, 650 college students from four universities in Zhengzhou were selected. A self-administered questionnaire on the awareness of HPV and its vaccine, and willingness to receive HPV vaccination was carried out. Logistic regression was used to analyze the factors influencing students' awareness of the HPV vaccine.

Results: 58.0% of college students had heard of HPV, and 72.8% of college students had heard of HPV vaccine. Logistic regression showed that gender, major, grade, mean monthly consumption level, sexual history, and mother cervical cancer screening participation significantly influenced the awareness of HPV vaccine ($p < 0.05$). Only 27(4.2%) college students had received the HPV vaccine. 63.2% of college students expressed their willingness to get vaccinated.

Conclusion: The awareness of HPV and its vaccine among college students in Zhengzhou needs improvement. Although the vaccination rate is low, most college students are willing to be vaccinated. Diverse health education programs should be conducted for different groups to improve awareness of cervical cancer prevention and promote vaccination.

KEYWORDS

human papillomavirus, vaccine, cervical cancer, willingness to vaccination, college students

1 Introduction

Gynecological cancers are a common type of malignant reproductive system tumors in women. The latest statistical report from the International Agency for Research on Cancer showed that in 2022, there were an estimated 1.42 million new cases of gynecological cancers worldwide. This accounts for approximately 14.5% of all new cancer cases in women globally, with about

660,000 deaths representing 15.3% of all female cancer deaths (1). Cervical cancer is the fourth most common cancer among women, and the age of onset is trending toward a younger age. A total of 661,021 new cases and 348,189 deaths from cervical cancer annually have been recorded, with approximately 6.8% of new cases and 8.1% of deaths occurring in the world (1). China had more than 258,000 new cases of gynecological cancers in 2022, of which 111,820 were cervical cancers, accounting for 43.2% of gynecological cancers, making it the country with the highest incidence of cervical cancer worldwide (2). Cervical cancer poses a considerable threat to women's health and imposes a substantial economic burden on society and families, especially because the age of onset is trending toward a younger age. Therefore, accelerating the elimination of cervical cancer has become a global public health strategy (3). Up to 99% of cervical cancer cases are associated with high-risk human papillomavirus (HPV). Although most HPV infections resolve spontaneously without causing any symptoms, persistent infections can lead to cervical cancer in women (4, 5). HPV vaccines can reduce the incidence of cervical cancer by approximately 70% and prevent other diseases, such as anal cancer, genital warts, and oropharyngeal cancer (6, 7). As of March 2022, 60% of World Health Organization member countries had incorporated the HPV vaccine into their national immunization programs, with most being high-income countries. However, global HPV vaccine coverage remained low, with only 12% of women receiving a full two-dose series (8). In China, free HPV vaccination policies for eligible girls have been introduced in some cities like Jinan, Xiamen, and Wuxi, setting a positive example, however, the HPV vaccination rate still has a significant gap compared to developed countries (6). Sexual activity is a direct risk factor for HPV infection, therefore, college students have become a focus of attention (9).

This study aimed to investigate the awareness of HPV and HPV vaccine among college students in Zhengzhou, explore the factors influencing their awareness of the HPV vaccine, and understand college students' willingness to receive the vaccine. The findings of this study will lay the foundation for cervical cancer prevention and vaccination promotion.

2 Materials and methods

2.1 Design, setting, and participants

This cross-sectional study was conducted from October to November 2020 in Zhengzhou, Henan Province, China. A stratified cluster random sampling method was used based on students' majors and classes. At each university, one class was selected randomly according to the grade level. The study protocol was reviewed and approved by the Third Affiliated Hospital of Zhengzhou University Committee for the Protection of Human Subjects (approval no. 2021-032-01). The participants provided informed consent before enrollment in the study. All study aspects, including voluntary participation, withdrawal, study risks, confidentiality, and secured data storage, were explained.

2.2 Measurement

We designed a questionnaire based on expert consultations from relevant studies (9–12). The questionnaire was anonymous, and the researcher explained the purpose and significance of the study to each

class and collected it promptly with the assistance of a counselor. A preliminary survey was conducted before the formal investigation, and the final questionnaire was completed after modification. The questionnaire included participants' demographic characteristics, awareness of HPV and HPV vaccine, and whether they had received the HPV vaccine. The demographic characteristics included age, major, grade, place of residence, education level, average monthly consumption level, etc.

2.3 Data collection

Three research assistants were hired to collect data. Before the formal investigation, they were trained on the study protocol, and the principal researcher explained the questionnaire items. All research assistants passed the exam and were allowed to participate. Trained investigators conducted the study and collected the questionnaires on-site. Any missing or incorrect entries were promptly supplemented or corrected to ensure the validity and completeness of the responses. A total of 650 questionnaires were distributed and collected, with an effective response rate of 100%.

2.4 Statistical analysis

Data were analyzed using SPSS v22.0 software (IBM Corp., Armonk, NY, United States). Measurement data were expressed as mean $\pm$ standard deviation ($X \pm S$), and count data were expressed as frequency and percentage (%). Factors influencing college students' awareness of HPV and the vaccine were analyzed using the chi-square test. Logistic regression was used for multiple covariate analysis to investigate the factors influencing college students' awareness of the HPV vaccination. A p -value of <0.05 indicated statistical significance.

3 Results

3.1 Demographic characteristics

A total of 650 questionnaires were distributed, and all were completed, with a response rate of 100%. The mean age of the participants was 19.71 ± 1.25 , and 548 (84.3%) college students were females. In addition, 332 (51.1%) were medical students and 318 (48.9%) were nonmedical students. The demographic characteristics of the participants are summarized in Table 1.

3.2 Awareness of HPV among college students

A total of 377 (58%) college students had heard of HPV. Of these participants, 52% were males and 59.1% were females, with no statistically significant difference ($p > 0.05$). Statistically significant differences existed in the awareness of HPV among the different groups regarding major, grade, place of household registration,

TABLE 1 Demographic characteristics of the participants (*n* = 650).

Variable	Categories	Frequency(n)	Percent (%)
Gender	Male	102	15.7
	Female	548	84.3
Major	Medical	332	51.1
	Non-medical	318	48.9
Grade	Freshman	198	30.5
	Sophomore	170	26.2
	Junior	170	26.2
	Senior	112	17.2
Place of household registration	Rural	421	64.8
	Urban	229	35.2
Education level	College and below	278	42.8
	Undergraduate and above	372	57.2
Mean monthly consumption level (yuan/month)	<1,000	172	26.5
	1,000 ~ 1,999	409	62.9
	>2,000	69	10.6
Cancer history of family members or friends	Yes	121	18.6
	No	529	81.4
Sexual history	Yes	102	15.7
	No	548	84.3
Mother's participation in cervical cancer screening	Never	152	23.4
	Occasional	89	13.7
	Regular	47	7.2
	Unclear	362	55.7

education level, mean monthly consumption level, sexual history, and mother's participation in cervical cancer screening ($p < 0.05$). Detailed information is provided in [Table 2](#).

3.3 Univariate analysis for the awareness of HPV vaccine among college students

The associations between the participants' characteristics and awareness of HPV vaccine are shown in [Table 3](#). A total of 473 (72.8%) college students had heard about the HPV vaccine. Significant differences were observed in the awareness of HPV vaccine between different groups in terms of gender, major, grade, place of household registration, mean monthly consumption level, sexual history, and mother's participation in cervical cancer screening ($p < 0.05$). No statistically significant differences were found in education level and cancer history of family members or friends ($p > 0.05$).

3.4 Logistic regression with multiple covariates for the awareness of HPV vaccine among college students

To identify factors influencing awareness of HPV vaccine after adjusting for confounders among college students in Zhengzhou, logistic regression analysis was performed with a dichotomous variable ([Table 4](#)). The binary dependent variable was whether the college student had heard of the HPV vaccine, with 0 indicating "No" and 1 indicating "Yes." Independent variables included gender, major, grade, place of household registration, mean monthly consumption level, sexual history, and mother's participation in cervical cancer screening (inclusion criteria $\alpha = 0.05$, exclusion criteria $\beta = 0.10$). The results showed that gender, major, grade, mean monthly consumption level, sexual history, and mother's participation in cervical cancer screening entered the regression model. The overall model was significant ($\chi^2 = 170.513$, $p < 0.001$). The Hosmer–Lemeshow test indicated good model fit ($\chi^2 = 11.765$, $p = 0.162$).

3.5 HPV vaccination status among college students

Only 27 (4.2%) college students had received the HPV vaccination. Of the college students, 63.2% expressed willingness to receive the HPV vaccine, while 36.8% were unwilling. Among those who were unwilling, 25.7, 22.9, 22.9, and 20% cited reasons such as few people around them being vaccinated, high costs, and concerns about vaccine safety, respectively. Of the students, 48.8% believed that the cost should be shared between individuals and the government, whereas 34.0% thought that it should be covered by health insurance. A total of 404 (62.2%) college students indicated willingness to learn about the HPV vaccine through WeChat or Weibo, and 398 (61.2%) wanted to learn through promotional brochures ([Table 5](#)).

4 Discussion

4.1 Awareness of HPV among college students in Zhengzhou

In this study, 58% of college students in Zhengzhou had heard of HPV, with 52.0% of males and 59.1% of females aware of it. This result is slightly higher than that reported by Shi et al. for students in North China, where 52.8% had heard of HPV, but lower than the awareness levels among international students ([12–14](#)). Nkwonta et al. conducted a health belief model-based study on college students in the United States and found that more than two-thirds of participants had heard of HPV infection ([13](#)). This difference could be attributed to regional variations, educational levels, and cultural differences. Foreign countries have conducted earlier research on cervical cancer, resulting in a broader dissemination of related prevention and treatment knowledge. Australia was among the first nations to implement a national HPV vaccination program in 2007, providing three doses of a quadrivalent vaccine to girls aged 12–13. The program was

TABLE 2 Univariate analysis for the awareness of HPV among college students [(n)%].

Variable	Categories	Have you heard of HPV?		χ^2	<i>p</i> -value
		Yes	No		
Gender	Male	53(52.0)	49(48.0)	1.811	0.178
	Female	324(59.1)	224(40.9)		
Major	Medical	228(68.7)	104(31.3)	31.744	<0.001
	Non-medical	149(46.9)	149(46.9)		
Grade	Freshman	71(35.9)	127(64.1)	66.355	<0.001
	Sophomore	105(61.8)	65(38.2)		
	Junior	112(65.9)	58(34.1)		
	Senior	89(79.5)	23(20.5)		
Place of household registration	Rural	226(53.7)	195(46.3)	9.148	0.002
	Urban	151(65.9)	151(65.9)		
Education level	College and below	139(50.0)	139(50.0)	12.762	<0.001
	Undergraduate and above	238(64.0)	134(36.0)		
Mean monthly consumption level (yuan/month)	<1,000	80(46.5)	92(53.5)	19.804	<0.001
	1,000 ~ 1,999	244(59.7)	165(40.3)		
	>2,000	53(76.8)	16(23.2)		
Cancer history of family members or friends	Yes	75(62.0)	46(38.0)	0.968	0.325
	No	302(57.1)	227(42.9)		
Sexual history	Yes	73(71.6)	29(28.4)	9.144	0.002
	No	304(55.5)	244(44.5)		
Mother's participation in cervical cancer screening	Never	102(67.1)	50(32.9)	51.759	<0.001
	Occasional	70(78.7)	19(21.3)		
	Regular	38(80.9)	9(19.1)		
	Unclear	167(46.1)	195(53.9)		

expanded in 2013 to include boys and girls (15). The United Kingdom's national HPV immunization program launched in 2008 successfully prevented HPV infections, with most boys and girls vaccinated in schools (16). Consequently, their awareness of HPV infection is relatively high.

This study indicates that medical students have a higher level of awareness of HPV than nonmedical students. College students with higher grades, education levels, and mean monthly consumption levels also had a better understanding of HPV. Students whose mothers regularly participated in cervical cancer screening, hold urban household registrations, and have a sexual history generally possess a greater awareness of HPV. This aligns with domestic and international studies (9, 12, 13). This could be because, in general, more educated students have greater knowledge. Owing to their specialized fields, medical students can understand HPV comprehensively through textbooks, classroom lectures, internships, and other methods, leading them to be more concerned about their physical and mental health. In contrast, nonmedical students have relatively limited access to information on cervical cancer. Therefore, it is essential to promote HPV knowledge among college students and raise their awareness of disease prevention.

4.2 Awareness of HPV vaccines among college students in Zhengzhou

Currently, available HPV vaccines include Gardasil quadrivalent, which prevents infection with HPV types 6, 11, 16, and 18; Gardasil 9-valent, which prevents infection with HPV types 6, 11, 16, 18, 31, 33, 45, 52, and 58, and Gervarix bivalent, produced by GlaxoSmithKline, which primarily prevents infection with HPV types 16 and 18 (17, 18). In 2019, the first domestically produced, bivalent HPV vaccine was approved (19). With the widespread availability of HPV vaccines in China, various healthcare institutions, including hospitals and community health service centers, can provide vaccination services to women. This greatly enhances the accessibility for preventing cervical cancer, which has clear pathological processes and considerable real-world implications. In this study, 72.8% of college students had heard of the HPV vaccine, a higher rate than in the study by Shi et al. (12). This difference may be because of the growing awareness regarding cervical cancer prevention in recent years. Many college students are gaining knowledge about HPV vaccines through mobile phones, TV, lectures, and science education videos, which have improved their understanding.

TABLE 3 Univariate analysis for the awareness of HPV vaccine among college students[(n)%].

Variable	Categories	Have you heard of HPV vaccine?		χ^2	P-value
		Yes	No		
Gender	Male	58(56.9)	44(43.1)	15.448	<0.001
	Female	415(75.7)	133(24.3)		
Major	Medical	260(78.3)	72(21.7)	10.526	0.001
	Non-medical	213(67.0)	105(33.0)		
Grade	Freshman	100(50.5)	98(49.5)	74.767	<0.001
	Sophomore	133(78.2)	37(21.8)		
	Junior	141(82.9)	29(17.1)		
	Senior	99(88.4)	13(11.6)		
Place of household registration	Rural	293(69.6)	128(30.4)	6.072	0.014
	Urban	180(78.6)	49(21.4)		
Education level	College and below	194(69.8)	84(30.2)	2.184	0.139
	Undergraduate and above	279(75.0)	93(25.0)		
Mean monthly consumption level (yuan/month)	<1,000	106(61.6)	66(38.4)	21.610	<0.001
	1,000 ~ 1,999	305(74.6)	104(25.4)		
	>2,000	62(89.9)	7(10.1)		
Cancer history of family members or friends	Yes	96(79.3)	25(20.7)	3.238	0.072
	No	377(71.3)	152(28.7)		
Sexual history	Yes	89(87.3)	13(12.7)	12.812	<0.001
	No	384(70.1)	164(29.9)		
Mother's participation in cervical cancer screening	Never	129(84.9)	23(15.1)	54.843	<0.001
	Occasional	80(89.9)	9(10.1)		
	Regular	42(89.4)	5(10.6)		
	Unclear	222(61.3)	140(38.7)		

TABLE 4 Logistic regression with multiple covariates for the awareness of HPV vaccine among college students.

Variable	Categories	B	P-value	OR	95%CI
Gender	Female	1.221	<0.001	3.390	(1.978–5.811)
Major	Non-medical	−0.957	<0.001	0.384	(0.250–0.591)
Grade	Sophomore	1.401	<0.001	4.058	(2.423–6.794)
	Junior	1.505	<0.001	4.506	(2.621–7.746)
	Senior	2.042	<0.001	7.708	(3.783–15.702)
Mean monthly consumption level (yuan/month)	1,000 ~ 1999	0.750	0.002	2.024	(1.297–3.157)
	>2000	1.755	<0.001	5.785	(2.251–14.866)
Sexual history	No	−0.966	0.007	0.381	(0.188–0.772)
Mother's participation in cervical cancer screening	Occasional	1.009	0.029	2.742	(1.109–6.779)
	Regular	0.383	0.500	1.466	(0.482–4.461)
	Unclear	−0.737	0.008	0.479	(0.277–0.828)

This study highlights several key findings related to HPV vaccination awareness. Women, students with more education, and higher mean monthly consumption levels are more aware of the HPV vaccine. Medical students have a higher level of awareness about HPV vaccines than nonmedical students. Students with a history of sexual activity are more knowledgeable about the HPV vaccine than those without such a history. These findings are consistent with most studies (10, 12). College students with a sexual history are sensitively aware of the HPV vaccine in their daily lives and studies. For those whose mothers regularly participate in cervical cancer screenings, this acts

TABLE 5 Ways to learn about the HPV vaccine among college students.

Ways to learn about the HPV vaccine	Frequency (n)	Percent (%)
On-site classroom lectures	370	56.9
Online courses	348	53.5
Brochures	398	61.2
WeChat, Weibo	404	62.2
Short videos	363	55.8
Consultation with medical personnel	360	55.4
Other methods	46	7.1

as a positive factor in HPV vaccine awareness, which is likely linked to the family environment. Mothers play a crucial role in families, and their education, awareness, health beliefs, and practices significantly impact their children's health behaviors and awareness. Acceptance of the HPV vaccine is influenced more by a mother's perception of risks and benefits than by the child's willingness (20). Future research should focus on males, nonmedical majors, and those with lower education levels and implement various health education models to improve their understanding of the HPV vaccine.

4.3 HPV vaccination status among college students

Receiving the HPV vaccine can prevent infection for at least 10 years and potentially provide even longer protection. In this study, only 4.2% of college students in Zhengzhou were vaccinated against HPV, a rate significantly lower than that in developed countries such as the United States and the United Kingdom (21–23). Denmark included the HPV vaccine in its national immunization program for children in 2009, which has proven to be highly effective in preventing cervical cancer. A nationwide study published in 2021 reported that women vaccinated before the age of 17 years had an incidence rate of 14%. In contrast, those vaccinated between 17 and 20 years had an incidence rate of 32% compared with unvaccinated women (24). The United Kingdom also introduced a government-funded school vaccination program. Before the 2019 coronavirus pandemic, HPV vaccination coverage was 80%. The pandemic disrupted school-based vaccination owing to decreased school attendance. Despite recent improvements, coverage rates have not yet returned to pre-pandemic levels (21). In the United States, HPV vaccines are primarily provided in primary care and healthcare facilities. Although the vaccination rate has reached 75% (22), considerable disparities in coverage exist because of racial, ethnic, and socioeconomic differences (23). Many low- and middle-income countries face financial and infrastructural constraints preventing the inclusion of HPV vaccines in their national immunization programs.

The Outline for Women's Development in China (2021–2030) proposes important goals such as increasing cervical cancer screening rates and promoting HPV vaccination among eligible women (25). Although the vaccination rate among college students was low in this

study, 63.2% expressed a willingness to receive the HPV vaccine and were eager to learn more through channels such as WeChat, Weibo, and brochures. Some researchers have pointed out that concerns regarding vaccine side effects and an insufficient understanding of HPV vaccines or HPV-related diseases are noteworthy barriers to vaccination (26). The World Health Organization has coined the term “vaccine hesitancy,” referring to the phenomenon in which people delay or refuse vaccination despite the availability of vaccination services (27). Therefore, future studies should focus on enhancing students' knowledge of HPV vaccines, improving public awareness of HPV and its vaccines, and conducting multichannel educational campaigns. This will help to establish college students' health awareness and improve the vaccination rate, ultimately working toward eliminating cervical cancer.

5 Conclusion

Awareness of HPV and HPV vaccine among college students in Zhengzhou needs to be improved. Differences in gender, major, grade, mean monthly consumption level, sexual history, and mothers' participation in cervical cancer screening can influence college students' awareness of HPV vaccine. Although the vaccination rate among college students in Zhengzhou is relatively low, more than half are willing to receive the vaccine. In future studies, hospitals and community health service centers should focus on diversified health education models and provide personalized services according to the characteristics of different groups. By leveraging traditional media, new media, and offline activities, these organizations should actively promote cervical cancer prevention knowledge to advance the vaccination process.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study protocol was reviewed and approved by the Third Affiliated Hospital of Zhengzhou University Committee for the Protection of Human Subjects (approval no. 2021-032-01). The participants provided informed consent before enrollment in the study. All study aspects, including voluntary participation, withdrawal, study risks, confidentiality, and secured data storage, were explained.

Author contributions

ML: Conceptualization, Project administration, Writing – original draft, Writing – review & editing. FZ: Data curation, Formal analysis, Investigation, Writing – review & editing. YS: Conceptualization, Writing – original draft. KS: Data curation, Formal analysis, Investigation, Writing – review & editing. XL: Data curation, Formal

analysis, Investigation, Writing – review & editing. HB: Conceptualization, Project administration, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work was supported by the Medical Science and Technology Research Project of Henan Province, China (LHGJ20190335).

Acknowledgments

The authors deeply appreciate all of the participants and the ethical approval authorities for their contributions to this study.

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Conflict of interest

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RECEIVED 19 May 2024

ACCEPTED 06 September 2024

PUBLISHED 20 September 2024

CITATION

Smith S, Marquez E, Haboush-Deloye A, Tu T, Goodie A and Perez D (2024) Role of community engagement in advancing vaccine equity.

Front. Public Health 12:1435231.

doi: 10.3389/fpubh.2024.1435231

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Role of community engagement in advancing vaccine equity

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The COVID-19 pandemic exacerbated existing health disparities among historically and currently underserved, underresourced, and marginalized communities worldwide. These communities faced disproportionate COVID-19 morbidity and mortality and were generally less likely to receive a COVID-19 vaccine once it became widely available to the public. Community engagement is an approach that can help bridge these inequities. This community case study adapted and implemented an existing community engagement framework to tailor a statewide vaccine equity effort that addresses community-specific priorities during a public health emergency. The adapted framework includes the following key phases: (1) creating an environment for community engagement; (2) making the work relevant; (3) narrowing the focus; (4) planning and conducting the work; and (5) evaluating the work. All of these supported the successful establishment of a statewide collaboration that consisted of various partners from various sectors who shared a collective commitment to increase COVID-19 vaccine confidence and address barriers to vaccination among the diverse communities in Nevada. Ultimately, a community engagement framework can provide a roadmap to navigate the dynamic and multifaceted nature of equity-related work by paving the way for meaningful interventions to mitigate health disparities.

KEYWORDS

community-engaged, vaccine equity, partnerships, community collaborations, vaccine confidence, COVID-19, conceptual framework

1 Introduction

Historically and currently underserved, under-resourced, and marginalized communities suffer from poorer overall health outcomes; these disparities have been further demonstrated by the health impacts of the COVID-19 pandemic (1, 2). Throughout the pandemic, racial and ethnic communities, including African American/Black, Hispanic/Latino, American Indian and Alaskan Native individuals, carried a disproportionately higher burden of infections, hospitalizations, and deaths compared to non-Hispanic White individuals (1, 3–5). Many of these communities encounter social and economic challenges as a result of systemic and structural racism that hinder access to resources that support their health and well-being which contributes to an increased risk of adverse health outcomes. However, despite these inequities and injustices, many community groups, nonprofits, and local agencies across the nation have collaborated to develop and implement community-driven efforts that successfully address the specific systemic or structural challenges they face.

With the COVID-19 pandemic, it was particularly imperative to address the ever prevalent and deeply persistent health disparities, especially in light of the United States' growing diversity (6, 7), with community-driven efforts that are culturally and locally-based. As the COVID-19 vaccines became available in the United States in late 2020 and early 2021, many of the communities that experienced disproportionately higher rates of COVID-19 morbidities and mortality tended to have lower vaccine coverage compared to other racial and ethnic groups (8, 9). By the end of April 2021, Hispanic, non-Hispanic African American/Black, and American Indian and Alaskan Native individuals across the United States had lower rates of at least one dose of COVID-19 vaccine coverage (47.3, 46.3, and 38.7%, respectively) compared to Asians (69.6%) and non-Hispanic White individuals (59.0%) (8). Numerous community groups, nonprofits, and state and local governments, including the state of Nevada, responded to the concerning data on COVID-19 vaccine coverage by launching community-engaged efforts aimed at ameliorating these coverage gaps.

Community engagement (CE) is the process of collaborating with groups of people to address issues that impact their health and well-being, and is an essential component of public health that can bridge gaps and advance health equity (10, 11). CE tailors interventions around the diversity of communities to address the unique factors that contribute to inequities in their health outcomes by building trust and new resources, improving communication, and advancing public health action (10, 12). Despite structural inequities, community-driven groups and community-academic partnerships sprung into action to mitigate the impacts of COVID-19 in their communities. Unidos en Salud, an academic/community partnership, is just one example that demonstrates how a local and culturally based CE approach can help overcome barriers to vaccination in the local community (13). In February 2021, in response to the disproportionate distribution of COVID-19 vaccines in Nevada, Governor Steve Sisolak called for an intentional effort for equity and fairness among those who have been disproportionately impacted by COVID-19 (14). As a result, Immunize Nevada and the Nevada Minority Health and Equity Coalition, two organizations with histories of instituting CE across the state, formed the Nevada Vaccine Equity Collaborative (NVEC) to support statewide COVID-19 vaccine equity efforts. CE was central to NVEC's focus and commitment to working with Nevada communities that have been historically underserved, under-resourced, and marginalized.

Given the challenges of the COVID-19 pandemic and the probability of future public health emergencies, preparation to implement contextually and culturally informed responses that ensure fair access to resources, programs, and services to safeguard the well-being of all communities is critical. There is a growing body of work that supports CE efforts to address community priorities and the social determinants of health that lead to inequitable health outcomes. This community case study draws upon an established CE model and adapts it to illustrate how to utilize and implement a CE framework to address community priorities during a public health emergency.

2 Background of the NVEC

Nevada is the sixth fastest-growing and among the top 10 most racially and ethnically diverse states in the United States (7, 15).

Similar to patterns seen across the nation, Nevadan communities of color and populations historically excluded experienced disproportionate COVID-19 morbidities and mortality (16). Once the COVID-19 vaccines became available, data reports revealed inequities in the vaccine distribution process. More specifically, communities disproportionately impacted by the pandemic were the least likely to vaccinate in early 2021 (5, 14). As a result, Immunize Nevada and the Nevada Minority Health and Equity Coalition co-created NVEC to support COVID-19 vaccine equity efforts by increasing vaccine confidence and addressing barriers to vaccination among Nevada's diverse communities. NVEC committed to applying a CE approach and identified three key aims to support their efforts: (1) to create a hub to facilitate statewide collaboration on COVID-19 vaccine efforts by optimizing partnerships, resources, and opportunities; (2) to provide data-driven recommendations about where to prioritize COVID-19 vaccine distribution based on the CDC/ATSDR Social Vulnerability Index (CDC-SVI) and vaccine coverage rates by zip code tabulation area (ZCTA); and (3) to create culturally and linguistically responsive COVID-19-related educational materials that were relevant to Nevada's diverse communities to increase vaccine confidence and uptake.

3 Framework for community engagement and its application

CE can foster health equity by creating a space for communities to have a "seat at the table" to voice their concerns on matters impacting their overall health and well-being. Implementing CE can result in tailored initiatives or interventions that appropriately reflect the diversity and needs of a community. Several CE frameworks provide a structure and set of principles to help guide the interactions and methods of collaboration between diverse partnerships. Given the many available frameworks, it is evident CE is not a simple nor linear process; it is both a science and art, which can take on many structures depending on the context and dynamics of the groups that are working together (10). CE functions on a continuum based on the level of participation from the community and can take on the form of a partnership, collaboration, or coalition (10). Regardless of the structure, a common component for all forms of CE is participation from diverse groups and disciplines.

The *Community Engagement in Interventions: Conceptual Framework* outlines several components necessary for an effective, sustainable, and appropriate public health initiative that uses CE, which are ways of defining communities and health needs; initial motivations for CE; types of participation; conditions and actions necessary for engagement; and potential issues influencing impact" (16). This framework encourages a fit-for-purpose approach to assist public health professionals, researchers, and community members in examining the philosophical underpinnings of interventions they employ. In turn, NVEC utilized and adapted components of this CE framework into a new and unique conceptual framework to guide its vaccine equity efforts (Figure 1).

This community case study walks through each phase of the adapted CE framework, providing an overview of each phase and its application within NVEC.

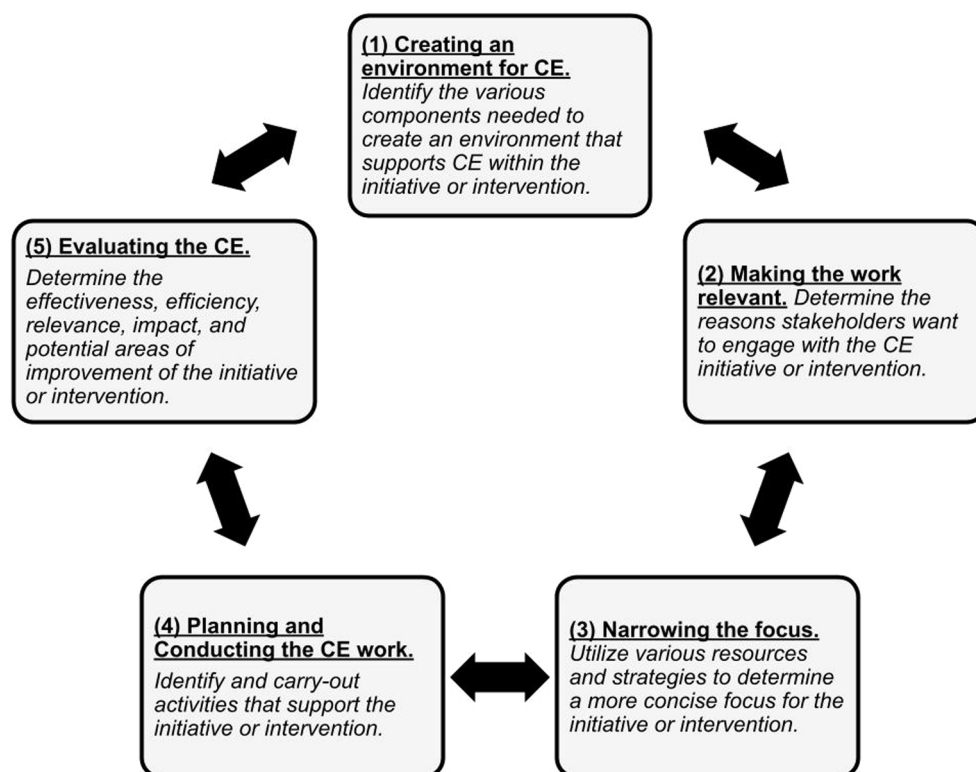


FIGURE 1
Conceptual CE framework for NVEC.

3.1 Creating an environment for CE

The first phase in the adapted framework is to determine the various components needed to create the structure and an environment that supports CE within the initiative or intervention. These components could include staffing, funding, partnerships, skills, expertise, shared values, training, supplies, and physical space.

Within the first 2 weeks of February 2021, Immunize Nevada and the Nevada Minority Health and Equity Coalition formed an NVEC leadership team composed of staff members from each organization to handle the internal operations of the collaborative. Their responsibilities included facilitating regularly scheduled statewide meetings, recruiting partners to join the collaborative, producing vaccine maps, and coordinating pop-up vaccine clinics. The team held meetings via Zoom to allow statewide participation while adhering to state-recommended social distancing guidelines. Lastly, both lead organizations were able to secure funding that supported their and community partner organizations' vaccine equity activities.

Then, the leadership team developed a set of core values and principles to guide NVEC's CE efforts, which derived from input and feedback from coalition members of the Nevada Minority Health and Equity Coalition (Table 1). These values and principles are fundamentally rooted in coalition-building work and created a framework to build trust, guide decision-making, promote transparency and accountability, facilitate effective communication, and promote cultural sensitivity within NVEC. To implement these values and principles, the leadership team recruited over 200 partners from various sectors and disciplines who have diverse expertise, skills,

and a shared goal of promoting equitable distribution of COVID-19 resources and vaccines throughout Nevada. NVEC's diverse partners included community-based organizations, faith-based leaders, healthcare providers, county and local health district representatives, state legislators, pharmaceutical representatives, public health researchers, community health workers, students, and community members.

To create an environment that upholds NVEC's values and principles, the leadership team hosted meetings that were a hub for partners to receive COVID-19-related updates, build interdisciplinary relationships, and collaborate on the development of educational messaging materials and vaccine strategies. These meetings included time for open and honest discussions, where partners could share successes, challenges, and opportunities related to their COVID-19 vaccine efforts within communities across the state. Meetings also served as a way to collectively brainstorm solutions to identified challenges and collaborate on upcoming events. Beyond the meetings, the NVEC leadership team was always available to partners to provide technical as well as general support for their specific vaccine equity efforts. NVEC leadership recognized a commitment to providing ongoing support, especially during the first year of vaccine roll-out, was critical and would occasionally require availability outside of regular work hours and week. Ultimately, NVEC structured its approach to continuously foster CE opportunities where partners could collaborate and engage at a level they found most comfortable. For instance, some partners preferred a less involved role by only attending meetings to receive COVID-19-related updates and resources. In contrast, other partners took on more involved roles by

TABLE 1 NVEC core values and principles.

Value	Principles
Equity	• Share decision-making and leadership • Adapt support strategies as necessary to ensure fair treatment and outcomes • Treat participants with integrity and respect
Inclusivity	• Provide equal access to opportunities and resources • Strive for community representation and inclusion of groups often underrepresented • Create a space in which communities feel valued and welcomed
Diversity	• Engage community members with different backgrounds, beliefs, and experiences, such as race/ethnicity, citizenship status, religious beliefs, socioeconomic status, language, geographical origin, gender and/or sexual orientation • Recognize differences are assets to learning and innovation
Cultural humility	• Maintain awareness of power imbalances and biases, respect other's values, and do not set personal expectations to memorize all aspects of another culture • Understand how personal biases may impact your work • Continuous self-reflection to examine own beliefs and cultural identities
Accountability	• Build processes that are responsive to feedback from community partners • Willingness to change, pivot, and adapt throughout the process
Transparency	• Communicate openly about motives, resources, power dynamics, and decision-making processes • Openly acknowledge challenges and limitations in order to maintain trust
Sustainability	• Continually reflect, assess, and communicate to maintain and deepen relationships for long-term action • Allocate adequate resources to maintain relationships with communities
Capacity building	• Support existing community leaders and develop new leaders • Increase community involvement, impact, trust, and communication by improving coordination, enhancing existing services, advocating for policy change and learning through pilots

Adapted from the New York City Department of Health and Mental Hygiene (17). Race to Justice: Community Engagement Framework. NYC Health.

providing recommendations on messaging materials or offering their location as a pop-up vaccination site.

3.2 Making the work relevant

The second phase of the CE framework is about making the work relevant. In other words, it relates to the motivations or reasons community members, partners, organizations, or other key stakeholders would want to start a new initiative or intervention and engage with it. These motivations can be intrinsic (e.g., wanting to develop a skill, gain knowledge, or improve personal health and

well-being) or extrinsic (e.g., wanting to achieve a common goal, address a shared priority, advance scientific knowledge, improve the community environment on a physical, social, or economic level, or access funding that is currently available).

For NVEC, four key factors drove its development and necessity: (1) the COVID-19 pandemic amplified existing health disparities and inequities throughout the state, (2) data revealed that communities disproportionately impacted by the pandemic were the least likely to get vaccinated once the COVID-19 vaccines were available, (3) the Nevada state governor called-to-action a task force to work toward COVID-19 vaccine equity, and (4) there was funding readily available to support this type of effort. The combination of these factors suggested the need for an effective statewide response to reach communities that were underserved and under-resourced during the pandemic, which required community input and interdisciplinary expertise.

The establishment of NVEC was both timely and relevant to the work of various stakeholders in Nevada. A combination of motivations drove these stakeholders to join NVEC. For example, community members and organizations highly embedded in the communities they live and work in drove to reduce the impacts of COVID-19. At the same time, some, who may not be as well connected, wanted to offer their skills, expertise, assets, and resources to positively impact those communities. Others were interested in bridging gaps in access to COVID-19 resources and services, establishing new partnerships with other organizations and individuals, staying up-to-date on pandemic-related information, learning best practices for delivering COVID-19 resources and services to diverse communities, and supporting efforts to determine where to prioritize efforts. While each partner's individual motivations to sit at the table and join NVEC may have differed, the concept of COVID-19 vaccine equity was shared among all partners.

3.3 Narrowing the focus

The next phase in the adapted framework is narrowing the focus of the initiative or intervention. There are a variety of techniques to narrow the focus of the work, such as reviewing current scientific literature and available data, conducting a survey, or engaging in community conversations. A combination of these strategies is needed to determine which communities are impacted most, their priorities, and the related social determinants. It is also particularly important to consider individual and collective capacities at this phase since the availability of resources will likely drive the direction of the effort.

There are two parts to this phase. The initial step is identifying communities that find this work relevant to their community needs and those that are impacted the most. Communities are defined as groups that share at least one common attribute, such as geographic location, culture, interest, value, and social or economic characteristics (18). The second step in this phase is determining the priority issues of the impacted communities and the associated determinants. Priority issues describe a concern that impacts the health of the community, while the associated determinants describe conditions that influence those health impacts. Issues and determinants can be identified by the community itself, observations from external parties, a review of currently available data, or comparisons with similar communities (18). Ultimately, clearly defining the communities, issues, and determinants related to the initiative or

intervention will narrow the focus and allow the group to develop actionable steps and a clear path to achieve its expected impacts.

NVEC first identified communities most impacted by the pandemic by reviewing available data on COVID-19 infection and vaccination rates at the time. NVEC used two methods to identify priority communities. First, empirical data using COVID-19 infection and vaccination rates paired with the CDC-SVI to determine the location of the most impacted communities (e.g., those with low vaccination and high social vulnerability) at a given time. Second, NVEC relied on community partner input to provide information that may not have been captured by the available data. More specifically, NVEC was able to offer some funding through sub-grants to support community partners' efforts and also maintained flexible communication channels (i.e., Zoom meetings or phone calls outside of regular business hours or in-person meetings at convenient community locations) where community partners could share their on-the-ground insights about factors driving higher rates of infection and lower rates of vaccination in their communities. For instance, in some communities, culturally and linguistically relevant resources communicating COVID-19-related information was scarce. In other communities, it was a matter of access to a COVID-19 vaccination site that met their needs (e.g., at a familiar location in the community, staff that reflected their community, materials that were readily available in their language, and no specific ID requirements). These two methods were employed to determine the priority issues and associated determinants driving the disproportionate COVID-19 impacts within these communities.

3.4 Planning and conducting CE work

The next phase in the framework is to plan and then conduct the CE activities. These activities will involve the community and address previously identified priorities and associated determinants. The first part of this phase is to plan the CE activities based on the desired changes or impacts (Table 2). For example, one of the community's priorities could suggest improving an existing community-based system or the physical environment. Thus, the plan should include the resources needed, activities that should be undertaken to accomplish the desired change or impact within the system or environment, how to measure the change, and who is responsible for each step. Ultimately, the plan is to ensure fidelity, flexibility, and functionality within the proposed CE activities. After establishing a plan, the next step is to carry out and implement it.

The planning of NVEC included many activities, which were informed either by COVID-19 data, input from on-the-ground partners, discussions with members from the impacted communities, or various combinations of each of these modes. NVEC's activities included providing sub-grants to community partners to support their on-the-ground vaccine equity efforts, developing a communication and dissemination model that could guide statewide vaccine equity efforts called *Approaches to Vaccine Equity*, providing data- and community-informed recommendations to organizations that are leading COVID mitigation and vaccination efforts across the state, developing culturally and linguistically responsive COVID-19 resources, conducting outreach and education within impacted communities, addressing policies that created barriers to access vaccines, and planning pop-up vaccine clinics in impacted communities. Additionally, NVEC provided a forum to gain new

TABLE 2 Strategies to affect change.

Category	Strategy
<i>Advancement in Science</i>	- Increasing the understanding of the root causes of health disparities - Improving approaches to address health disparities - Setting the stage for future research.
<i>Environment</i>	Improving elements in the physical, social, and economic environment.
<i>Policy</i>	- Implementing a new policy, which could be a formal or informal law, ordinance resolution, mandate, or regulation. - Revising an existing policy. - Advocating for a new policy or the revision of an existing policy.
<i>Practices</i>	- Improving existing practices within an organization or community, such as day-to-day procedures or standards of operation. - Establishing a new practice within an organization or community.
<i>Systems</i>	- Developing a new program or service to address health disparities in the community. - Improving an existing program or service which could include increasing capacity, staffing, and financial resources.

insights, strategies, and skills that supported building the capacity of partners and their respective organizations to address COVID-19-related disparities and inequities.

3.4.1 Example of a policy change driven by CE

A funded community partner who works with migrants who may be undocumented was interested in hosting a pop-up clinic but expressed concerns to NVEC leadership about the enforcement of an ID requirement to receive COVID-19 vaccines at clinics across the state, including pharmacies and larger federal- or state-run sites. More specifically, members from this community were concerned about identifying themselves at a federal- or state-government-run clinic. NVEC leadership shared these concerns directly with state leadership and was able to modify this requirement for community partner-led pop-up clinics where they did not have to enforce it. Subsequently, NVEC's community partner hosted a pop-up clinic at their trusted location in the community that was primarily staffed by volunteers who reflect and speak the language of the community. This policy change drove the success of this clinic, and future community pop-up clinics across the state, by addressing a community-specific barrier, providing a vaccination opportunity for those who were ready-and-willing, and resulting in several same-day word-of-mouth referrals.

3.5 Evaluating CE work

The last phase of this framework is to evaluate the CE efforts. Evaluation is a systematic way to determine the effectiveness, efficiency, relevance, and impact, as well as identify potential areas for improvement of a particular effort (19, 20). It can occur during development (formative evaluation) and implementation (summative evaluation) (19, 20). To conduct an effective and meaningful evaluation,

it is highly recommended to establish a combination of clear goals, objectives, measures, and baselines to serve as a point of comparison.

After establishing NVEC in February 2021, internal staff periodically conducted a process evaluation to determine whether activities were implemented as intended. The team tracked the number of partners, meetings, meeting attendees, newsletters, data reports with maps, materials, and resources created and delivered, NVEC-hosted events, and other pertinent metrics to show who was reached, what was done, and when it happened. Since the NVEC's establishment in February 2021 to March 2024, it has hosted 34 statewide meetings, distributed 28 newsletters, developed 49 vaccine data reports with CDC-SVI maps, created a vaccine equity toolkit, hosted six telephone town halls, and presented four breakout sessions and one poster session at professional conferences. Ongoing evaluation allowed NVEC staff to assess whether there were any particular barriers or facilitators related to these activities, allowing the team and partners to strategize on how to effectively meet our goals. For example, NVEC initially hosted a general meeting and two separate workgroup meetings on a regular basis. However, once the vaccines were more readily available to the general public, the individual workgroup meetings became less productive and were not as well attended as the general meetings. Therefore, NVEC staff integrated the activities of the two workgroups into the general meeting and dissipated the workgroups.

In addition to the process evaluation, NVEC staff conducted an ongoing outcome evaluation to determine its effects on increasing COVID-19 vaccine access and acceptance among communities that were disproportionately impacted by the pandemic. NVEC evaluated this outcome based on the number of vaccination clinics held in zip codes with high CDC-SVI and low vaccine uptake and the percentage of completed COVID-19 vaccination series among populations living in high CDC-SVI zip codes. In collaboration with community partners, more than 300 vaccine pop-up clinics were hosted in high CDC-SVI and low vaccine coverage areas throughout 2021. In March 2021, about 9% of the population living in high CDC-SVI zip codes had completed a COVID-19 vaccination series, compared to the 15 and 19% in moderate and low CDC-SVI zip codes, respectively. Each month, roughly 40% of the completed vaccinations occurred in high CDC-SVI zip codes. By the end of December 2021, nearly 51% of the population living in high CDC-SVI zip codes completed a COVID-19 vaccination series. Overall, the vaccine pop-up clinics contributed to the nearly 467% increase in completed COVID-19 vaccine series in high CDC-SVI zip codes in 2021, whereas the moderate and low CDC-SVI zip codes had only a 270 and 227%, respectively, increase in completed vaccinations.

4 Discussion

As health disparities and inequities continue persisting and widening among communities that are economically and socially marginalized, there is a need to adopt CE approaches when guiding health equity efforts. CE frameworks provide a dynamic roadmap for navigating the multifaceted nature of health equity work and addressing systemic and structural issues at their root cause. This community case study demonstrated how leveraging and

implementing a CE framework helps tailor a health equity effort amid a public health emergency to yield effective and relevant strategies and measurable outcomes (21–26).

Consistent with the literature (27–29), NVEC highlights the importance of community-driven efforts to address community-specific priorities during a public health emergency. NVEC's strategic partnerships increased the availability of culturally relevant, fact-based, and responsive information related to COVID-19 and addressed barriers to COVID-19 vaccinations among communities most impacted by the pandemic. The collaborative also showed outcomes that were not as easily quantified. For instance, the present initiative created a “seat at the table” for community partners who did not regularly interact with local, state, and federal governments and vice versa. Creating an environment for CE produced opportunities to develop new partnerships and collaborations beyond vaccine equity work. This community case study is consistent with the existing literature that supports the notion that CE work offers opportunities to engage, sustain, and maintain authentic relationships that support community buy-in when the community is integrated into the Decision-making process about what and how things should be done (21, 27–32). Vaccinations are one of the most cost-effective interventions that can be employed to prevent and mitigate the impact of communicable diseases. A meta-analysis examining the impact of CE interventions to improve childhood immunizations in low- and middle-income countries found that CE has “a small but significant positive effect on all primary immunization outcomes related to coverage and timeliness” (33). Another study found implementation of community-informed communication strategies increased childhood immunizations from 45% at baseline to 82% over a 4-year period (34). Although community-engaged work is effective in improving health, there is no one-size-fits-all model (35).

As with any approach, the implementation process provides valuable insights and lessons learned. Some key takeaways from NVEC when engaging in CE work involve relationship building, context, collaborative decision-making, flexibility and adaptability, and impact and action. *Relationship building* is essential to effective CE and requires building trust between partners, which takes significant time, effort, and genuine engagement. An emergency response during a pandemic may not seem like the most conducive time to undertake CE work. However, NVEC served as a hub to support interdisciplinary partnerships across the state to strengthen the pandemic response. Many of the partnerships within NVEC were formed as part of the emergency response, while others were partners brought into the initiative from past collaborations. Despite the challenging time to build trust among new partnerships, the relevance of the issue, NVEC's sincere commitment to integrate the community into the response (e.g., creating a seat at the table), and the ability to fund partners for their time and effort forged the foundation to build new partnerships. Additionally, when “creating a space” for partners, it is more than a metaphoric analogy. It means being prepared to have tough conversations that may challenge what one would consider evidence-based practices and adopt out-of-the-box strategies. It goes without mentioning that building relationships sometimes entails conversations, texts, and emails outside traditional business hours.

As researchers and community members, a commitment to integrating *context* into the development of intervention strategies is

important because each community will have a unique social, cultural, economic, and political system in which they live, work, play, and worship. Thus, it is imperative to develop and implement interventions that are respectful and sensitive to these dynamics. A one-size-fits-all model does not integrate the principles of CE. This requires listening to the unique challenges and needs of the community. In this case study, it meant adapting communication strategies for communities based on real-time concerns and questions. *Collaborative decision-making* is integral. Therefore, it is important to be aware of and think about how to navigate power dynamics. Power imbalances do not foster collaborative and inclusive environments. Creating a “seat at the table” entails respect for local knowledge and the valuable contributions and expertise that knowledge brings to understanding the inequities and the determinants that continue to plague health outcomes in these communities. Input from on-the-ground community partners and members provided insights into the realities and challenges of vaccine implementation. For instance, some partners revealed acute awareness of vaccination challenges and hesitations among our undocumented communities under initial implementation strategies. If it were not for the knowledge they brought to the table and the potential solutions, there likely would have been fewer undocumented community members vaccinated.

Flexibility and adaptability are core principles of CE work. Part of the nature of CE, especially in the face of a pandemic, calls for flexibility and adaptability amongst a variety of methods that are contextually appropriate. No single solution will work in every scenario, and out-of-the-box thinking was highly encouraged as dissemination and vaccination efforts were pushed through communities. As the landscape of the pandemic evolved, maintaining a willingness to learn and adapt based on the changing circumstances fostered an environment for NVEC to maintain effective and diverse methods of CE. This also required being reflexive to community input and adapting actions tailored to that input. Actions vary depending on contextual factors and other elements unique to each community. Multiple methods for CE were employed as well, such as participation in community outreach events with NVEC partners. The *impact and action* of CE work fosters solutions and sustains relationships. Public health efforts must carefully develop and integrate CE work while capturing and tracking both process and outcome measures to assess the work's impact and guide the informed development and actionable strategies. It is crucial to evaluate efforts on an ongoing basis during implementation. It allows for the re-prioritization of efforts based on the current data and the identification of barriers and facilitators to reaching intended outcomes. CE is fluid, and a successful practice may see that the needs and priorities of partnerships evolve throughout the process.

Community-engaged approaches have been used in various fields of work to solve complex problems (36). CE has been instrumental in bringing meaningful and impactful change in communities (30). NVEC's work toward vaccine equity in the face of COVID-19 highlights tremendous value in CE among Nevada's at-risk populations, those being communities who face socio-economic barriers and are historically marginalized and, therefore, are at greater risk of adverse health outcomes. Vaccine equity is only one facet of health equity. Health equity is dynamic, with many

components to consider when working among communities with unique perspectives, experiences, and concerns. Future public health research and interventions in community-based settings should develop actions that put community priorities and culture at the forefront of decision-making to bridge gaps in health equity. Endeavors should not merely focus on health equity as an outcome but as part of the process of CE. Community-engaged approaches centered around equity will ensure meaningful responses when working with those burdened by health disparities.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. EM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. AH-D: Investigation, Project administration, Writing – review & editing. TT: Investigation, Project administration, Writing – review & editing. AG: Investigation, Project administration, Writing – review & editing. DP: Investigation, Project administration, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the Centers for Disease Control and Prevention (# 6 NH23IP922609-02-07). The funder did not take part in writing this manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 17 July 2024

ACCEPTED 19 September 2024

PUBLISHED 09 October 2024

CITATION

Rahman FN, Iwuagwu AO, Ngwu CN,
Kalu ME, Kasherwa A, Chowdhury MRK and
Kader M (2024) Connecting the experiences
of persons with disabilities and social workers
in Nigerian care institutions regarding
COVID-19 vaccine uptake: a qualitative
descriptive-interpretive design.
Front. Public Health 12:1466313.
doi: 10.3389/fpubh.2024.1466313

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Connecting the experiences of persons with disabilities and social workers in Nigerian care institutions regarding COVID-19 vaccine uptake: a qualitative descriptive-interpretive design

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Background: During the COVID-19 pandemic, persons with disabilities (PWDs) have faced additional disadvantages that have exacerbated their physical and mental health challenges. In Nigeria, where cultural, religious, and informational barriers persist, understanding these factors is critical for improving health interventions, including vaccine uptake among PWDs.

Methods: This study employed a qualitative descriptive-interpretive design to explore the perceptions of PWDs regarding the COVID-19 pandemic and the vaccine, alongside social workers' views on their roles in facilitating vaccine uptake. We conducted in-depth semi-structured telephone interviews with 20 participants, comprising 16 PWDs and four social workers in Nigerian rehabilitation homes. Data were analyzed using critical thematic analysis to identify key themes influencing attitudes toward the pandemic and vaccine uptake.

Results: The study uncovered significant barriers to COVID-19 vaccine uptake among PWDs, primarily driven by mistrust in government initiatives, widespread conspiracy theories, and deeply held cultural and religious beliefs. Additionally, while social workers played crucial roles as community surveillance officers, in-house educators, and community referral agents, their interventions lacked specific strategies aimed at increasing vaccine uptake among PWDs. Their efforts were more focused on addressing the psychological impacts of the pandemic rather than fostering behavioral changes toward vaccine acceptance.

Conclusion: To enhance COVID-19 vaccine uptake among PWDs in Nigerian rehabilitation homes, targeted interventions that address the identified barriers are essential. These should include trust-building measures, culturally and religiously sensitive communication strategies, and tailored educational programs by social workers. Moreover, training social workers in specific,

evidence-based strategies to increase vaccine uptake is crucial for mitigating the pandemic's impact on this vulnerable population.

KEYWORDS

disability, rehabilitation homes, social work, COVID-19, vaccine knowledge, Nigeria

1 Introduction

Globally, over 1 billion people live with disabilities [PWD] (1). Persons with disabilities (PWD) include individuals with long-term physical, mental, intellectual, or sensory impairments that interact with various barriers hindering their full and effective participation in society on an equal basis with others (2). PWD is far less inclined to access quality health care and is more likely to experience severe health needs, discriminatory practices, and prejudice (3). The 2019 Coronavirus [COVID-19] pandemic is expected to compound the already existing inability to access quality healthcare because many of the health and social services provided for people with disabilities have been interrupted (1). PWDs are further disadvantaged, leading to poor physical and mental health (4, 5). In Nigeria, PWDs already have limited access to health and social care services, and the COVID-19 prevention strategies, e.g., the lockdown, have further made access to these services difficult.

In Nigeria, over 29 million persons live with various types of disabilities (5). The five most prevalent disabilities in Nigeria (in descending order) are visual impairments, auditory impairments, physical impairments, intellectual impairments, and communication impairments (6). About 7% of household members over the age of 5 (and 9 percent of those 60 and older) have some challenges in a minimum of one functional domain, such as seeing, hearing, communication, cognition, walking, or self-care; and 1 percent have severe difficulty or are unable to work in at least one domain (7). In Nigeria, PWDs are partially ignored and are treated as a welfare or charity case (8). Therefore, programs to empower and socially include PWDs are limited in Nigeria, resulting in PWDs seeking ways to empower themselves, including panhandling (asking people on the street for food or money) on Nigeria's streets. Traditionally in Nigeria, PWDs live at home with their relative (9). Some are admitted into a rehabilitation home, either temporarily or permanently. Those admitted permanently are often those whose relatives have abandoned or do not have relatives who can support them, whereas those admitted temporarily usually require professional social and physical rehabilitation services. Nevertheless, PWDs in Nigeria account for the highest percentage of individuals living below the poverty line, placing them at the lowest socioeconomic strata (5, 10). These accumulated disadvantages put them at the risk of contracting coronavirus.

COVID-19 is a novel virus that was first identified in Wuhan, China. The transmission of COVID-19 from one person to another was rapid, as World Health Organization declared the virus a pandemic just after 3 months of its first transmission. The spread of the COVID-19 virus continues but slower, maybe because people have started observing the safety measures and vaccine administration. While other countries' vaccine administration began in early Jan. 2021, Nigeria's vaccine administration started in late March 2021. According to the African Union Center for Disease Control and

prevention, the priority group is healthcare workers (11); this puts older adults and PWDs in an unfortunate situation as they are at high risk of contracting, developing complications, and dying from COVID-19. PWDs are more likely to get infected because of the underlying medical conditions, congregated living settings, systemic health, and social inequities (12). Besides, PWDs, especially with intellectual disabilities, may have trouble understanding information or practicing prevention measures and difficulty communicating symptoms of COVID-19 (13). COVID-19 strategies to prevent transmission may be reinforced again in the Nigerian context as vulnerable groups, including older adults and PWDs, have refused to take the vaccine (14–16).

Globally, several studies have explored the PWD's perception of COVID-19 on their wellbeing, access to information concerning the COVID-19 during the lockdown. Most of the studies are either quantitative or reviews and focused on the developed countries, with few opinion papers in developing countries, e.g., Nigeria. For instance, Lebrasseur et al. (17) conducted a rapid review that explored the impact of the COVID-19 pandemic on PWDs. They included 11 articles that reported decreased access to health/social service and social and lifestyle changes, including mood changes and decreased physical activities among PWDs. Similarly, in an online survey report, PWDs residing in the Netherlands reported unstable emotions such as fear and anxiety during COVID-19 lockdown (18). In Spain, Amor and colleagues' (19) surveyed 582 people living with intellectual disability and reported that lockdown harmed participants' emotional wellbeing, occupations, and access to information concerning COVID-19 was good. In Nigeria, evidence on the impact of COVID-19 on PWDs is limited and mostly on opinion papers (20, 21) with no empirical data. We found a cross-sectional study investigating demographic factors, attitudes, and knowledge of persons with special needs during COVID-19 in Nigeria (22). They reported that persons with special needs have high knowledge about the symptoms, prevention, and control of COVID-19, and 52.8 and 55.6% of the participants reported that it is hard to get palliatives or financial support from others and feeling frustrated by the uncaring attitude of the government toward them during the COVID-19 lockdown. While this study's findings highlighted the level of knowledge and attitude of COVID-19 characteristics and lockdown perception among persons with special needs, their study population included a wide variety of PWDs regardless of residential settings. PWDs in congregated settings present unique health and social inequities that may differentiate them from those living at home with relatives. Therefore, a qualitative method is needed to explore the perceptions of the COVID-19 pandemic and vaccines among PWDs residing in rehabilitation homes.

Social workers, through their competency skills, are recognized as front-line workers in the fight of COVID-19. However, their roles in providing and advocating for PWDs are rarely highlighted in Nigeria. Besides, social workers are trained to be resilient and provide care or

relief services during disasters, such as pandemics (23). Interestingly, the International Federation of Social Workers [IFSW] recommended specific roles social workers should play during the COVID-19 pandemic, including ensuring that the most vulnerable (e.g., PWDs) are actively involved in planning and response across various communities, providing alternatives to care for vulnerable individuals while facilitating observance of the COVID-19 prevention measures and vaccine uptake (24). While Ajibo et al.'s (25) study has explored the role of social workers in cushioning the effect of COVID-19 in Nigeria, no study explored social workers' role in increasing vaccine uptake among PWDs in rehabilitation homes. Our study aimed to understand social workers' role in increasing vaccine uptake among PWDs residing in rehabilitation homes.

Given COVID-19 lethality and the different susceptibility of PWDs, it is crucial to explore their experiences and recognize the concerns that are deemed more critical during the lockdown in a low resource country like Nigeria. Besides, since communication and supports are pivotal in preserving public health and equally crucial to preventing the spread of the disease, understanding social workers' responses to increasing vaccine uptake among PWDs in rehabilitation homes is also helpful. Therefore, the primary aim of this study was to explore how PWDs' perceptions of the COVID-19 pandemic informed vaccine uptake in Nigeria. The secondary aim was to explore the social workers' perception of increasing vaccine uptake among PWDs in rehabilitation homes.

2 Materials and methods

We employed a qualitative descriptive-interpretive design to guide the data collection and analysis (26). This design allowed us to interpret participants' perceptions on COVID-19 and COVID-19 vaccines uptake by identifying the prominence of ideologies, power relations, and status-based hierarchies. Descriptive-interpretive design emphasizes detailed descriptions and interpretation of participants' experiences, allowing for nuanced understanding of complex phenomena like vaccine acceptance within a specific cultural context. Given the multifaceted nature of disability and its intersection with healthcare access and social support, this approach facilitates capturing the diverse perspectives and lived experiences of both persons with disabilities and social workers. Unlike other qualitative methods like phenomenology or grounded theory, which may focus on abstract concepts or theoretical frameworks, the descriptive-interpretive design prioritizes rich, contextualized data collection and analysis, making it well-suited for exploring the unique challenges and facilitators influencing vaccine attitudes and uptake in this population in Nigeria. Additionally, its flexibility in data collection methods, such as interviews and observations, aligns well with the need for inclusive and participatory research approaches when working with persons with disabilities and their support networks.

Data collection involved semi-structured interviews with PWD and social workers in three rehabilitation homes. Ethical approval was obtained from the Health Research Ethics Committee, University of Nigeria Teaching Hospital Ituku-Ozalla (NHREC-1RB00002323). This approval ensures that the research adheres to established ethical guidelines, safeguarding the rights and well-being of all participants involved. Prior to their involvement, participants were fully informed about the study's objectives,

procedures, and potential risks, and they provided voluntary informed written consent. Additionally, anonymity and confidentiality of the participants were maintained throughout the data collection, analysis, and scientific writing procedure. We followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) (27) in reporting this study.

2.1 Study setting/recruitment

We conducted this study in three rehabilitation homes located in the Anambra, Enugu, and Taraba States. These three rehabilitation homes are private care institutions in Nigeria where persons living with disabilities are accommodated, provided for, and receive physical and social rehabilitation, including physical and occupational therapy, vocational training, counseling, re-integration training programs. The homes accommodate residents with physical disabilities only, and among them residents with visual impairments have targeted support and services for their different needs than others. At the time of this study, there were 104 residents and eight social workers in the three homes. Participants were recruited through snowballing, where participants who participated in the study informed someone eligible to participate. Initial contacts were established through trusted relationships developed with some residents during previous voluntary work by some of the research team members at these homes. Participants were encouraged to refer others by explaining the importance of the study and how additional insights would enhance the understanding of vaccine acceptance among their community. To ensure a diverse and representative sample, efforts were made to include participants with various types of disabilities and different backgrounds (age, gender, education, and religion), ensuring perspectives from both residents and social workers across the three states were represented in the study.

2.2 Sampling

We employed criterion-based purposive sampling in selecting our participants. PWD participants were included if they are (a) 18 years or older, (b) able to consent and communicate in English, Nigerian Pidgin English, Hausa, and Igbo language (which are dominant languages in the states the PWD were recruited from), (c) self-identified as having a disability, and (d) resides in the center. Social worker's participants were included if they have (a) at least a post-graduate degree in social work and practicing and (b) 3 years' experience in working with PWD residing in these homes.

The United Nations Convention on the Rights of Persons with Disabilities (CRPD) provides a broad, inclusive definition of disability, focusing on a human rights perspective. It defines persons with disabilities as those with long-term physical, mental, intellectual, or sensory impairments that, when combined with societal barriers, may limit their full participation in society (28). These impairments include physical (affecting mobility, coordination, or bodily functions), mental (impacting cognitive or psychological health), intellectual (affecting cognitive development), and sensory (affecting hearing or vision) (28). For our study, we included participants with physical impairments or vision-related sensory impairments, considering the feasibility of conducting in-depth telephone interviews.

By selecting individuals who met specific criteria, the study ensured that the participants were most suitable for understanding the study concepts, relating to the questions, and effectively expressing their opinions. Additionally, purposive sampling enabled us to employ a targeted approach to identifying and gathering relevant data from those whose insights were most meaningful for the study. Because data collection and analysis were done concurrently, we stopped interviewing after reaching data saturation and sufficiency, explaining why a smaller proportion of PWDs was interviewed (29). The final number of included participants show a balanced representation of residents with physical disabilities (PD) and visual impairments (VI), ensuring that the study captures varied challenges and attitudes toward the COVID-19 vaccine. The inclusion of both male and female participants, a range of ages (from 18 to 48), and individuals from different educational backgrounds further enhances the diversity of perspectives. Additionally, the representation of participants from various religious backgrounds (Christianity and Islam) and ethnicities (Igbo and Hausa) across different states (Enugu, Taraba, and Anambra) adds depth to the understanding of cultural and regional influences on vaccine acceptance. This diverse sample allows for a comprehensive exploration of how different disability types and socio-demographic factors affect experiences with COVID-19 and vaccination within the PWD community.

2.3 Data collection

We invited each participant to a single, semi-structured telephone interview. Telephone interview was appropriate as it allowed us to obey the social distancing policies during the COVID-19 pandemic. Participants were informed of the study aim, the risks, and benefits of participating in the study, confidentiality, anonymity, and the right to withdraw at any time. All participants provided written and oral consent. We conducted a pilot telephone interview with two PWDs to reflect on the wordings in the questions, reflect how sensitive questions asked would be, and determine appropriate timing for the interviews (data from this pilot were not included in the analysis). The telephone interviews lasting between 40 and 45 min were audio-recorded and conducted in English, or Nigerian Pidgin English by a trained researcher using a semi-structured interview guide developed based on the study aim (see Table 1). The interview guide was self-developed based on the study aim. Only five interviews were conducted in Nigerian Pidgin. We kept reflective and field observation notes throughout the study to enhanced rigor in our study. We identify our “Subjective I’s”—the assumptions and the beliefs the research brought into the research (30) and record in our reflexive notes detailing how these assumptions may influence our data collection analysis. For instance, some of the authors are social workers with a strong passion for professional growth in Nigeria. They wrote their assumption on the role of social workers during the pandemic in Nigeria, consciously returned to this assumption, and reflected how it influences the data collection and analysis.

2.4 Data analysis

Data collection and analysis were done simultaneously; this allowed us to use complete variance sampling and ensured data

sufficiency (informational redundancy) (31). The translation process from Nigerian Pidgin to English was handled by two researchers (AI, CN) with expertise in both the language and culture, as well as post-graduate degrees in social work and extensive experience in qualitative research. They independently transcribed and translated the interviews into English, then met to compare and reconcile the translations, ensuring accuracy and cultural sensitivity (32). We utilized critical thematic analysis (CTA, Lawless and Chen) (29), an extension of Braun and Clarke (32), in analyzing our data. CTA has two major analytical steps: open coding and closed coding. In open coding, two coders (AI, FNR) independently read the transcript of three PWD and two social workers to have a general sense of the data. Both coders independently re-read the transcript to create early codes and categories based on the three concepts of CTA: recurrence, repetition, and forcefulness (33). For instance, coders independently identify statements that provide similar meaning but are described differently by the participants (recurrence) or words used frequently (repetition). Coders also highlight forcefulness by identifying the tone, volume, and emphasis participants lay on statements. Both coders meet to merge the codes and categories to derive a codebook. Any disagreement was resolved in team meetings. We used the codebook to analyze other transcripts; any new codes and categories that emerged were added to the codebook and documented in the audit trail notes. Themes were developed using closed coding processes. All authors meet three times to interlink the categories with dominant societal questions, such as the misconceptions regarding COVID-19 while paying close attention to the discriminatory and non-inclusive practices nested in power relations in Nigeria (see Table 1). The data was managed in NVivo® Software.

2.5 Trustworthiness

We employed several techniques to improve the rigor process in this study. First, we maintain reflexivity by identifying our “Subjective I”—the assumptions we carry into the research during the data collection and analysis (30). Second, we increased this study’s credibility by using double coders at each stage of our analysis. Double coders were selected based on their relevant experience, with one coder being from Nigeria with previous experience working in the home, and the other from outside Nigeria, providing fresh, independent perspectives. We also employed peer-member checking—four independent scholars experienced in CTA analysis examined and provided feedback on the themes, which was incorporated into the final analysis to enhance the study’s credibility (32).

3 Results

Twenty participants (16 PWDs and four social workers) participated in this study; see Table 2 for participants’ demographics. Summarily, three themes: mistrust of government, conspiracy theories perpetuated by the media, and participants’ culture and religious beliefs influence poor compliance of COVID-19 prevention strategies, leading to increased doubt over COVID-19 vaccine

TABLE 1 Open coding subthemes and closed coding themes.

Coding phase	Open coding	Closed coding
Findings/interpretations	What was repeated, recurrent and forceful in the transcripts? • Corrupt government • Increasing number of COVID-19 cases to attract international aid • No objective implementation of palliatives • COVID-19 affects only “sinners”—those who do not believe in God. • Those who believe in God are immune • COVID-19 is the sickness of the “elites”—rich • COVID-19 is a strategy to make developing countries poorer • COVID-19 linked to 5G network • Hand washing is regular in our centers • Distancing and lockdown increase our problems • Perceived impact of COVID-19 lockdown on persons with disability • May not take the vaccine • Neglected roles of Nigerian social workers to PWD during COVID-19 pandemic	What ideologies are recurring, repeated, and forceful? • Mistrust on government • Religious and cultural standpoints • Conspiracy theories perpetuated by the media • Poor compliance with COVID-19 because of mistrust of the government • Increased hunger and delayed spiritual and physical healing when obeying social distancing and lockdown • Increased doubt over COVID-19 vaccine uptake • Increased volunteering role play

uptake among PWDs in rehabilitation homes in Nigeria (see Figure 1).

3.1 Mistrust of the government

The concept of trust and mistrust emerged throughout the participant’s statements. As described by the participants that contribute to their mistrust, several factors include a high level of corruption in the government, historically, government lack of concern for citizen welfare, especially PWD, lack of social inclusion, and the non-implementation of Disability act in most Nigerian states. The participants did not trust the government because of their belief that government is corrupt, and the COVID-19 pandemic creates another avenue for the government to enrich itself. Others believed that the COVID-19 lockdown by the government was only a political game to attract international relief funds. Below are narratives from participants to illustrate this theme.

“Our government is corrupt and would do anything to attract funds from world health organizations and other international agencies. I believe that the government orchestrates the lockdown in Nigeria and the increasing number of recorded cases of Coronavirus to attract foreign sympathy and supports.” (Female, PWD-7, 20 years old).

PWD believed that historically, the government does not support her citizen’s welfare, specifically PWD. Hence, they believe that the palliative received by the international agencies will not reach its citizens.

“To clarify that the government does not have our interest at heart, they locked down places and forgot that people like me and other persons with disabilities in institutions need to be provided for in such homes. Palliatives from the government have been more on paper without an objective implementation.” (Female, PWD-6, 27 years old).

PWDs and social workers were skeptical concerning the proposed COVID-19 palliatives because Nigeria Disability Act 2018 has only been implemented in 6 out of the 36 states since its introduction by the Nigerian Federal government. This further increases their mistrust of the government.

“The Nigerian federal government has enacted the Nigerian Disability Act; however, only about 6 out of 36 states in Nigeria have partially implemented it. The lack of implementation (even partially) of this Act continues to raise questions and doubts over the governments.” (Female, Social worker-17, 35 years).

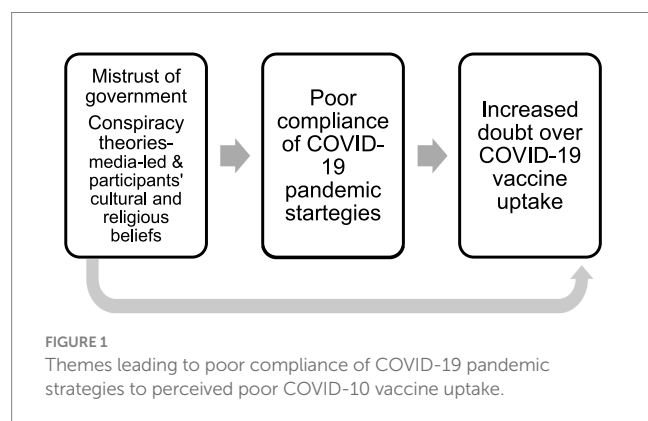
The mistrust of the government appears to contribute to the non-adherence of the COVID-19-pandemic strategies, especially lockdown, as it has more negative impact than positive on their health and wellbeing.

“Mistrust for the government cuts across persons with a disability like myself. If we do not trust the government, how then should

TABLE 2 Demographic information of participants.

S/N	Age (years)	Gender	Highest level of education	Religion	Location (State)	Ethnicity	Disability type
1	21	Female	FSLC	Christianity	Enugu	Igbo	PD
2	27	Male	WASSCE	Islam	Taraba	Hausa	PD
3	25	Male	WASSCE	Christianity	Anambra	Igbo	VI
4	24	Female	WASSCE	Islam	Taraba	Hausa	PD
5	24	Male	WASSCE	Christianity	Anambra	Igbo	PD
6	27	Female	B.Sc	Christianity	Enugu	Igbo	VI
7	20	Female	WASSCE	Islam	Anambra	Igbo	PD
8	18	Female	WASSCE	Christianity	Taraba	Hausa	VI
9	22	Female	FSLC	Christianity	Enugu	Igbo	VI
10	21	Female	FSLC	Christianity	Enugu	Igbo	PD
11	23	Male	FSLC	Christianity	Anambra	Igbo	VI
12	21	Female	WASSCE	Christianity	Enugu	Igbo	PD
13	19	Male	FSLC	Christianity	Taraba	Hausa	PD
14	26	Female	FSLC	Islam	Anambra	Igbo	PD
15	31	Female	WASSCE	Islam	Taraba	Hausa	PD
16	24	Female	FSLC	Christianity	Enugu	Igbo	VI
17	35	Female	M.SW	Christianity	Enugu	Igbo	ND
18	29	Male	M.SW	Christianity	Enugu	Igbo	PD
19	48	Female	M.SW	Christianity	Enugu	Igbo	ND
20	42	Female	M.SW	Christianity	Anambra	Igbo	ND

S/N 1–16 were persons with disability, and S/N 17–20 were social workers; FSLC, First School Leaving Certificate (certificate issued after completing 6 years of primary education); WASSCE, West African Senior Secondary Certificate Examination (certificate issued after completing 6 years of secondary school); M. SW, Master of Social Work; B.Sc., Bachelor of Science degree; PD, Physical disability; VI, Visual impairment; ND, No disability.



we believe them that COVID-19 is actually in Nigeria? we need to have that trust and belief to be able to accept and obey the preventive measures by the government.” (Female, PWD-9, 22 years old).

“Nigerians generally and PWD specifically have many reasons for their mistrust of the Nigerian government, and this is one of the reasons I feel they have not taken the COVID-19 prevention warnings of the government seriously.” (Male Social worker-18, 29 years old).

3.2 Conspiracy theories perpetuated by the media and religious and cultural beliefs

All PWDs believed that Nigerians are immune to the virus and berated the Nigerian government for the lockdown. More worrisome is the assumption among participants that COVID-19 is a sickness of the elites and bourgeoisie with abroad travel histories.

“...have you seen any media report about a poor man with COVID-19? All reports of COVID-19 cases I have heard of are of the rich and influential persons in Abuja and Lagos who have the resources to travel worldwide.” (Female, PWD, P14, 26 years old).

One of the social workers collaborated on this assumption held by the PWDs.

“Up to a month after the outbreak of COVID-19 in China, almost none of my patients believed that the virus was real more especially as a lesser number of cases are reported in Nigeria. Even with the record of COVID-19 cases in Nigeria and associated deaths, most of my patients continue to believe that the virus is not real and at best believe it is a virus for the rich because of their penchant to travel to foreign countries for business, medical, leisure or politics.” (Female, Social worker-19, 48 years old).

Some participants believed that COVID-19 is a weapon (5G network) developed by the devil to affect God's children.

"...Coronavirus cannot affect the children of God and those it affects are evil people who are facing punishment from the Supreme Being." (Female, PWD-7, 20 years old).

"I believe COVID-19 is a punishment for those whose ways are sinful and not pleasing to Allah. I have also watched a video where a Christian pastor called Chris Oyakhilome said a similar thing and attributed the virus to technological development such as the 5G network." (Male, PWD-3, 25 years old).

We asked the social worker to describe their experience regarding their role in correcting the misconception held by the PWDs. Two social workers stated:

"It is disconcerting that in this our dispensation of advanced science, people even some enlightened ones continue to think that the introduction of 5G network causes coronavirus. This is absurd, and to worsen the case, vaccine intake has been reportedly low among PWLD because they do not trust vaccines because of the misconceptions and beliefs." (Social worker-18, 29 years old).

"Our first job is to correct the wrong assumptions people living with disability have. When I engaged this population, I noticed that they already have some image in their head about Coronavirus, and most of the information they hold are wrong perceptions..." (Female, Social Worker-20, 42 years old).

3.3 Mistrust of government leading to poor compliance with COVID-19 preventive measures

Mixed reactions were observed on the compliance of COVID-19 safety measures. While respondents acknowledge the efforts of government and non-governmental agencies to enlighten the public on the safety measures to prevent the spread of COVID-19, they, however, were not comfortable with such rules. Most of the non-compliance stems from the non-belief that COVID-19 exists.

"I do not believe that this virus exists, so why should I suffocate myself with a face mask in the name of compliance with government directives?" (Male, PWD-3, 25 years old).

3.3.1 Obeying some of the rules to please doctors and family members

Most participants stated that they obeyed some of the rules for COVID-19 prevention measures either to please their doctor or family members.

"... After the ease of the first phase of the lockdown, I used a face mask not because I believed in the existence of the virus or its ability to prevent the spread of the virus. I only used it to satisfy the doctors who would not come close to treating patients or check on their

wellbeing if they were not wearing masks. They usually stayed away from patients and asked us to put on our masks." (Female PWD-4, 24 years old).

Further, some participants stated that culturally in Nigeria, distancing oneself from another is not ideal. Most of them socialized with friends and families by seeking opportunities to attend social events (e.g., parties and church services).

"How can we live or survive in isolation or without the company of others..... how possible is it for us to stay away from each other or fully maintain the two meters' distance? Parties and church services are the easiest way for us to forget the hardship in this country... asking us to stay apart, even though we are yet to believe this COVID-19 exists is very difficult." (Male PWD-3, 25 years old).

3.3.2 Hand washing and sanitizing is the routine practice in the homes

Amongst all preventive measures, participants were more likely to engage in handwashing and hand sanitation. However, this measure is seen as a routine practice in the rehabilitation home rather than COVID-19 prevention compliance.

"... The management of this home is particular about compliance with the COVID-19 preventive measures, and they provided all the necessary facilities to ensure compliance, for instance, the solar energy-powered hand washing machine and sanitizer dispenser. However, if I must be frank with you, most people here wash their hands and use sanitizer because we are used to it and not necessarily because of the virus prevention. After all, before Coronavirus came, we do wash our hands when we feel like they are dirty." (Female PWD-8, 18 years old).

3.3.3 Increased doubt over COVID-19 vaccine uptake

Participants remain unsure about the uptake of the COVID-19 vaccine for fears such as its efficacy and possible complications. Participants reported that lack of trust in the government is the major issue that could prevent them from taking the vaccine. They do not know what is in the vaccine and what the government is planning.

"The Government has not shown serious care about us. Why then should we believe their supposed care now? I have an underlining condition already, and I should be even more careful with what I take into my system-I mean the COVID-19 vaccine. Because I do not trust the intention of the Government regarding COVID-19 in Nigeria, I seriously doubt I will take the vaccine when available." (Female, PWD-8 18 years old)

Other factors that may hinder PWDs from taking the vaccine may include proximity to the vaccine centers.

"We expect the vaccine to be brought to us in our residential facility, but we doubt if that will happen in Nigeria where our welfare is not

fully prioritized, and this will add to the reasons I may personally not take the COVID-19 vaccine...” (Male, PWD-13, 19 years).

The participants believed that some of them had not been adequately educated on the advantages and disadvantages of taking the vaccine. They believed that there could be complications, especially for people with other health conditions or low immunity.

“I cannot take the vaccine because I have no symptom of COVID-19, and there is a rumor that some older people who have taken it are having some complications. I cannot attempt to add salt to my injury. I have health issues I am battling with already, and I cannot complicate things for myself until the vaccine is proven tasted and trusted.” (Male, PWD-2, 27 years).

3.4 Pandemic restrictions slowed healing and subsequent limited access to healthcare and vaccination

3.4.1 Delayed physical healing contributes to accessibility barrier in healthcare and vaccination

PWDs in Nigeria faced significant challenges during the COVID-19 pandemic, particularly due to lockdown restrictions. These measures not only exacerbated hunger and socioeconomic hardship but also delayed access to healthcare services, including vaccination. The closure of businesses and charitable organizations, a primary source of support for many PWD, made basic survival difficult. As a result, financial constraints further delayed their access to essential medical care and rehabilitation, impeding physical recovery.

For example, one participant shared how the lockdown affected their access to surgery-related follow-up care due to a lack of funds:

“My orthopedic amputation surgery was successful, and I was healing well. But my parents couldn’t pay the medical bills because their business was shut down during the lockdown. Not only healthcare, even feeding became a struggle; and with the uncertainty of the pandemic, those who could help were also hesitant.” (Male PWD, 23 years old).

This lack of financial resources and mobility restricted access to healthcare services and, subsequently, COVID-19 vaccines. Many PWDs were unable to travel to healthcare facilities due to reduced income and movement restrictions, further limiting vaccination uptake.

For many PWDs, physical impairments already posed significant barriers to accessing healthcare, and the pandemic further complicated these challenges. The inability of medical personnel to provide hands-on care due to social distancing requirements left many PWDs without the necessary support for their recovery. One participant described the struggle:

“Even before the pandemic, moving around for medical care was difficult due to my condition. Now, with the restrictions, medical

staffs maintain more distance, it feels like getting the help I need has become almost impossible.” (Female PWD, 18 years old).

3.4.2 Reduced spiritual support impacts mental well-being and subsequent health-seeking

In addition to physical challenges, many PWDs experienced a delay in their perceived spiritual and emotional healing due to the closure of religious institutions. For individuals who rely on faith for healing, the lack of access to religious gatherings created a sense of spiritual isolation, impacting their overall well-being and health management. This added emotional burden, combined with physical pain, limited their ability to actively seek out healthcare and vaccination services.

One participant highlighted the role of religious support in their healing process:

“..... not being able to visit or have my pastor visit me for prayers could be part of the reasons I continue to feel some physical pains. I continue to be worried; I don’t feel like doing anything else for my health...” (Female PWD, 21 years old).

Overall, the pandemic’s restrictions created a cycle of delayed recovery, worsened living conditions, and limited access to healthcare including vaccines, as many PWDs found it difficult to overcome both physical and logistical barriers during this period.

3.5 Roles of social workers in supporting PWDs and increasing COVID-19 vaccination uptake during the pandemic

The COVID-19 pandemic not only exposed existing vulnerabilities among persons with disabilities (PWDs) but also provided an opportunity for social workers, especially those in medical and disability services, to step up and expand their roles. Their involvement, both voluntary and professional, addressed critical gaps in healthcare access, psychosocial health, and overall well-being, which became more acute during the pandemic. Merging their experiences from the in-depth interviews, revealed the multi-dimensional impact of social worker interventions, and provided a deeper insight into the value they bring and the systemic changes needed to better support PWDs.

Analyzing the role of social workers for people with disabilities (PWDs) during the pandemic has revealed four key dimensions of their work, as presented in [Table 3](#). These dimensions are discussed below.

3.5.1 Adaptation and flexibility of social workers

One key dimension that emerged during the pandemic was the adaptability of social workers to the unprecedented challenges PWDs faced. As traditional support systems were disrupted due to lockdowns and physical distancing measures, social workers had to rapidly adjust, adopting new roles and responsibilities to ensure that PWDs received the necessary support.

“COVID-19 pandemic and lockdown gave some of us the ample opportunity to sell ourselves and show our expertise as social

TABLE 3 Roles of social workers in supporting persons with disabilities during the COVID-19 pandemic: dimensions and key tasks.

Dimensions	Tasks
Adaptation and flexibility	Expanded on new roles, volunteered on weekends
Psychosocial support	Provided counseling, offered psychotherapy, worked toward reducing vaccine-related fear
Advocacy for systemic change	Lobbied for funding and better healthcare including vaccination access, called for inclusive policies
Building resilience and trust	Educated on vaccines and virus spread, promoted preventive practices

workers.... Colleagues who embraced this new opportunity during the pandemic are mostly those who are medical or disability specialists. Some of us even went as far as volunteering for other agencies and rehabilitation homes on weekends. I must tell you that the relatively few people we worked with have come to appreciate what we do as social workers.” (Female Social worker-17, 35 years old).

Specific job roles identified by social workers that they engaged in to assist people living with a disability included, but were not limited to Community Surveillance Officers, In-house Educators, Community Referral Officers, and Engagement Officers. As part of these roles, they contributed in monitoring PWDs for COVID-19 symptoms, educating PWDs about vaccine efficacy and debunking myths, facilitating referrals to COVID-19 vaccination facilities, and ensuring equitable distribution of healthcare resources including vaccines. Notably, the social workers created these roles in the rehabilitation homes to demonstrate the social worker’s role during the COVID-19 pandemic.

The volunteering efforts of social workers went beyond the call of duty, highlighting the profession’s inherent flexibility and dedication to human welfare. The creation of these new roles exemplified how social workers adapted to meet the needs of their communities in real-time, showcasing a holistic approach to disability support.

“All of us have our day jobs; we just volunteer most evenings and weekends on these roles” (Male Social worker-18, 29 years old).

3.5.2 Psychosocial support for PWDs

Another critical dimension is the psychosocial impact of the pandemic on PWDs. Many PWDs experienced heightened psychosocial health challenges due to isolation, uncertainty, and economic hardship. Social workers stepped in to provide essential counseling and psychotherapy services, addressing issues such as depression, anxiety, and trauma induced by the pandemic.

“Generally, social workers are focused on human wellbeing, which has different biological, psychological, and social wellbeing dimensions. Therefore, our job role is quite vast, to sum up. For the sake of specificity, in some of the job roles I did to support PWD during the lockdown with counseling and psychotherapy.” (Female Social worker, 20 years old).

This dimension reveals the role of social workers extended beyond direct physical care to encompass psychosocial support, demonstrating social workers engagement in addressing the full spectrum of well-being, including psychological resilience toward fear of vaccine.

3.5.3 Advocacy for systemic change

Social workers also informed about their advocacy roles, particularly in pushing for systemic changes that benefit PWDs. They lobbied to attract funds and palliative care to various institutions they worked with during the pandemic. Additionally, they used their platforms to call for disability-inclusive policies and programs, both at the governmental and institutional levels. Their advocacy efforts included call for better vaccination and healthcare access, financial assistance, and targeted vaccinations and interventions for PWDs during the pandemic.

“Our advocacy works included but not limited to lobbying for funds and palliatives, ensuring equitable distribution of vaccines and other resources across institutions and among residents where available. I also advocate for the wellbeing of persons with disabilities in such time through the call for disability-inclusive policies and programs by the government and sensitization programs in different disability institutions” (Female Social worker-20, 42 years old).

3.5.4 Building community resilience and trust

In addition to providing direct services, social workers played a crucial role in building community resilience and trust among PWDs and their families. By serving as reliable sources of information and education, social workers were engaged in efforts to alleviate fears about the vaccine and the virus itself, and promoting preventive behaviors.

“We created this role to help the PWD during this pandemic and educate them on COVID-19 vaccine. We took session in disability institutions on how Coronavirus spread and how to apply preventive measures in line with the World Health Organization.” (Male Social worker, 29 years old).

This dimension reveals the key role of social workers in building community trust through their long-standing relationships with PWDs.

3.5.5 Long-term implications and sustaining social worker engagement

Lastly, the pandemic’s impact on the social work profession itself is an important dimension to consider. The expanded roles and increased visibility expressed by the social workers during the crisis have demonstrated the critical importance of their work in times of emergency. However, their views also highlighted the need for better institutional support and recognition of social workers, who often operate in underfunded and understaffed environments.

"We hope that the home will see the need of social workers and sustain the roles they play even after the COVID-pandemic" (Male Social Worker, 29 years old).

"Social workers are essential, especially in disability care, and our profession needs more support and resources." (Female Social Worker, 42 years old).

This dimension underscores the long-term implications for the profession include the need for formal recognition of expanded roles and improved funding for social work services. A concerted opinion of the social workers was that the pandemic has shown their value in supporting vulnerable populations, and this should be reflected in policies and funding structures moving forward.

4 Discussion

This study explored how PWDs' perceptions of the COVID-19 pandemic informed vaccine uptake in Nigerian care institutions and the social workers' perception of their role in increasing vaccine uptake among PWDs in rehabilitation homes. Our study noted that participants' mistrust of government, conspiracy theories perpetuated by the media, and participants' culture and religious beliefs influence their poor compliance with COVID-19 prevention strategies, leading to increased doubt over COVID-19 vaccine uptake.

PWDs' perceptions were guided by the public perception of conspiracy theories that influence their beliefs on the COVID-19 pandemic and vaccine uptake. The belief in conspiracy theories (e.g., the 5G network conspiracy theory) is associated with negative public health behavior, such as the unwillingness to social distance and vaccinate against the virus (34). Furthermore, some religious doctrines in Nigeria emphasize faith healing over medical intervention, leading to skepticism about vaccines. Additionally, there are infrequent but deep-rooted cultural norms that value traditional medicine and distrust Western medical practices, which contribute to vaccine hesitancy. The exposure of PWDs to various cultural and religious beliefs regarding their physical conditions may further compound their mistrust in the COVID-19 vaccine, as these beliefs often intersect with broader societal skepticism and conspiracy theories perpetuated by the media. Although not among PWD, Romer and Jameison (35) conducted a national survey and reported that belief in three COVID-19 Related conspiracy theories was inversely related to the perceived threat of a pandemic, taking preventive actions (e.g., wearing a face mask), perceived safety of vaccination and intention to be vaccinated against COVID-19. Global studies have also highlighted comparable challenges regarding vaccine uptake among PWDs. Although there has been limited research among this population, studies in diverse settings have identified low vaccine uptake and high vaccine hesitancy among PWDs compared to the general population (36, 37), with lack of vaccine education and misconceptions playing a vital part (37–39). Additionally, global evidence has underscored the influence of socioeconomic factors and accessibility barriers on vaccine hesitancy among PWDs, emphasizing the need to strengthen the roles of caregivers and social workers (40, 41). These findings suggest that while specific cultural and social practices influences may vary locally, the broader trend of these factors contributing to vaccine hesitancy among PWDs is pervasive globally, necessitating context-specific strategies to enhance vaccine acceptance.

Since belief in conspiracy theories is a strong predictor for vaccine uptake, we argued that re-educating the PWDs with global evidence on the causes and the importance of the COVID-19 vaccine should be prioritized in the Nigerian context. This education can be achieved with social workers who have created volunteer positions (e.g., community surveillance officer, in-house educator) in the rehabilitation homes.

PWDs perceived that the COVID-19 lockdown impacted their general wellbeing as their religious and socioeconomic life suffered. PWDs depend on social and religious gatherings to socialize outside the rehabilitation home (42, 43). These social and religious gatherings were shut down because of the nationwide lockdown. Most PWDs depend on other people such as caregivers, family, friends, philanthropists for their livelihood and daily survival. This finding agrees with McKibbin and Fernando's (44) and Guerrieri et al.'s (45) findings that COVID-19 lockdown has affected the developed economies and has brought untold economic hardship among people, especially those who live on daily wages. This economic hardship is worst for PWDs in developing countries, as strategies or processes to provide palliatives and government subsidies or emergency funds are either lacking or poorly managed (46). PWDs depend on international, national, and individual donations in Nigeria and some developing countries (47). However, these donations, especially individual's donations, are affected by the Lockdown, thereby increasing the hardship experienced by PWDs in the rehabilitation homes.

Although PWDs often do not comply with all the COVID-19 preventive measures, they stated that hand washing and the use of sanitizer is not new in their rehabilitation homes, as it has been standard practice in their home even before the arrival of COVID-19. Generally, PWDs' compliance to COVID-19 preventive measures is low, as it can be linked to their mistrust in government and misconception about COVID-19, including that COVID-19, does not exist. This low compliance to COVID-19 safety measures is not peculiar to PWD (48, 49), but it is concerning as they [PWD] are at higher risk of contracting COVID-19. Interestingly, social workers in our study reported that one of their roles since the pandemic is to educate PWD on the importance of obeying COVID-19 prevention strategies, as evidence has shown that targeted education is promising to increase compliance (50, 51). Our respondents were unsure about taking the COVID-19 vaccine, given reasons for mistrust of the government and the proximity of vaccine uptake centers, and some fears regarding the vaccine's efficacy.

Our study's secondary aim was to explore the social workers' perception of their role in increasing vaccine uptake among PWDs in rehabilitation homes in Nigerian. Social workers have been continually active since the COVID-19 pandemic, including the lockdown period in Nigeria. Social workers specializing in medical and disability fields have seized the opportunity to establish their professional roles with PWD residents in health and social care institutions. Prior to COVID-19, Nigerian social workers' roles were overtly ignored or not acknowledged by the government or the citizens (52). Social workers who participated in our studies created innovative positions in the rehabilitation homes to educate the PWDs on the COVID-19 pandemic, its strategies, and the importance of vaccine uptake. Our study's social workers' roles were volunteered grassroots roles, e.g., community sensitization officer that works directly with PWD. These roles lessen the negative impact of lockdown on PWD, as most social workers' role is for psychological readjustment and strengthening PWD's ability to

cope with the 'new normal' (53). However, our findings did not provide evidence on the social workers' role in education to increase the COVID-19 vaccine. There could be several reasons for this. The study interview was conducted when the lockdown was in place, social workers emphasized promoting mental health among PWDs, and the COVID-19 vaccine was at the development stage. Regardless, these active roles describe by our social worker participants are congruent with previous findings that social workers also provide counseling and referral services to clients and advocate for providing essential services for their wellbeing (48). The findings of other studies are not different from this present study on the place of social workers during the lockdown. For example, the International Federation of Social Workers [IFSW] (25) confirmed that social workers render essential services necessary during social upheavals like this present pandemic and lockdown. Brindle (54) further found that social workers are currently creating safety measures for vulnerable communities such as PWD to manage COVID-19 and avoid its further spread.

4.1 Study limitations and strengths

Although our study has provided insights into PWDs' perception of COVID-19 and vaccine uptake, we must acknowledge some limitations. We did not perform participants' member checking, as this approach would have increased the strength of our study findings. Since the current study was conducted among PWDs in institutions using a qualitative interview format, the sample size involved may be considered small; hence we caution the generalization of our findings to the general population of PWDs. Future research can enhance the understanding and generalizability of findings by employing a mixed methods approach that combines representative quantitative surveys with alternative qualitative components like focus group discussions (FGDs). In a mixed-methods approach, quantitative surveys could capture broad trends and demographics influencing vaccine uptake, while FGDs could delve deeper into nuanced perspectives and community-specific concerns regarding COVID-19 vaccine among PWDs. Furthermore, utilizing a representative sample of PWDs from both the community and institutional settings would provide a more comprehensive understanding of vaccine perceptions. Moreover, future studies can consider exploring the differences in the perception of the COVID-19 vaccine across different PWDs, for instance, people living with physical disabilities and people with intellectual disabilities.

As for strengths, our study employed peer member checking, we maintained reflexivity by identifying our "Subjective I" to enhance rigor, and we increased this study's credibility by using double coders at each stage of our analysis.

5 Conclusion

Participants' mistrust of government, conspiracy theories perpetuated by the media, and participants' culture and religious beliefs influence their poor compliance with COVID-19 prevention strategies, leading to increased doubt over COVID-19 vaccine uptake. PWDs residing in three rehabilitation homes in Nigeria believe that COVID-19 does not exist mainly due to mistrust in government; thus, they would not comply with the evidence-based preventive measures.

Interestingly, hand washing, and hand sanitizer were practiced because it is the rehabilitation home culture, but not as the other COVID-19 measure, including social distancing. Amid the lack of institutionalization of the social work profession in Nigeria, social workers have continued to show their relevance to the Nigerian community during COVID-19, especially among PWD. Social workers created grassroots volunteer positions that allow them to work directly with PWD in their rehabilitation homes.

Based on our study findings, we recommend that government and NGOs employ targeted communication strategies to address the cultural and religious beliefs contributing to vaccine hesitancy among PWDs, involving trusted community leaders. Educational programs providing clear, factual information about COVID-19 and vaccines should counteract misinformation and conspiracy theories, using formats such as workshops, leaflets, and digital content. To enhance the role of social workers, the government should devise structured pathways for their support to PWDs in both institutional and community settings during pandemics. Future implementation research should explore the best strategies and practices for their integration and impact on health outcomes for PWDs. Future research and policy advocacy should focus on generating robust evidence on the role of social workers and establishing educational and paid support systems for them, promoting their institutionalization in Nigeria and similar contexts during pandemic-like crises.

Data availability statement

Transcripts of the interviews will be available upon reasonable request from the corresponding author.

Ethics statement

The studies involving humans were approved by The Health Research Ethics Committee, University of Nigeria Teaching Hospital Ituku-Ozalla (NHREC-1RB00002323). Written informed consent was obtained from the [individual(s) AND/OR minor(s)' legal guardian/next of kin] for the publication of any potentially identifiable images or data included in this article. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

FR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. AI: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. CN: Data curation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. ME: Data curation, Methodology, Project administration, Validation, Writing – original draft, Writing – review

& editing. AK: Methodology, Writing – original draft, Writing – review & editing. MC: Methodology, Validation, Writing – original draft, Writing – review & editing. MK: Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. Open access publication fees were covered by Dalarna University, Sweden, and received by the corresponding author, MK. The funders had no role in the study design, conduct, manuscript preparation, review, or approval process.

Acknowledgments

The authors acknowledge Department of Social Work, University of Nigeria for the technical and logistical support for this research.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1466313/full#supplementary-material>

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RECEIVED 07 February 2024

ACCEPTED 30 September 2024

PUBLISHED 11 October 2024

CITATION

Zhao P, Xu W, Wang J, Liang P, Li H and
Wang C (2024) Uptake and correlates of
influenza vaccine among older adults residing
in rural regions of south China: a
cross-sectional study.
Front. Public Health 12:1383293.
doi: 10.3389/fpubh.2024.1383293

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Uptake and correlates of influenza vaccine among older adults residing in rural regions of south China: a cross-sectional study

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Background: Seasonal influenza continues to pose a substantial public health challenge for older adults residing in rural areas worldwide. Vaccination remains the most efficacious means of preventing influenza. This study aimed to investigate the extent of influenza vaccine coverage and identify the factors influencing vaccine uptake among older adults in rural regions of south China.

Methods: A cross-sectional study utilizing convenience sampling was conducted in two rural sites in Guangdong Province. Individuals needed to meet specific inclusion criteria: (1) attainment of 60 years of age or older; (2) originating from rural households; (3) demonstrating a voluntary desire to partake in the survey, either through written or verbal informed consent. Data encompassed variables such as socio-demographic information, influenza infection and vaccination history, knowledge and attitudes toward influenza vaccination, and perceived beliefs regarding the influenza vaccine. Univariate and multivariable logistic regression analyses were employed to ascertain the factors associated with influenza vaccine utilization. In the multivariable model, adjustments were made for gender, age, legal marital status, highest educational attainment, and monthly income.

Results: A total of 423 participants were ultimately included in this study, with the majority falling within the age range of 60–75 years (81.3%). Only one-third of the participants had received an influenza vaccine in the past year (30.0%). Notably, nearly half of the older adults exhibited hesitancy toward influenza vaccination (45.1%). The multivariable analysis revealed that rural older people with a robust understanding of influenza vaccines and a positive attitude toward them (adjusted odds ratio [aOR] = 2.60, 95% confidence interval [CI]: 1.41–4.81), along with a high level of trust in vaccination service providers (aOR = 2.58, 95% CI: 1.01–6.63), were positively associated with receiving influenza vaccination in the past year.

Conclusion: This study reveals a low rate of influenza vaccine uptake among older adults residing in rural areas of south China. Given the limited adoption of influenza vaccination and the significant threat it poses, there is an urgent imperative to devise precise interventions aimed at enhancing the effectiveness of influenza vaccination programs.

KEYWORDS

influenza vaccine, aged, rural population, factor, China

Introduction

Seasonal influenza imposes a significant global health burden, annually resulting in a substantial toll of morbidity and mortality. Recent estimates indicate an alarming prevalence of severe illness, encompassing 3–5 million cases, alongside a staggering 290,000–650,000 annual respiratory-related fatalities (1). While influenza can affect individuals across all age groups, it is imperative to recognize that older adults, aged 60 and above, face a heightened susceptibility to hospitalization and mortality upon infection (2). This vulnerability stems from a weakened immune system compounded by the presence of chronic diseases (3). A study conducted in China, utilizing data from national influenza surveillance and cause-of-death surveillance, unveiled a disconcerting annual average of 88,100 excess deaths attributed to influenza-associated respiratory diseases during the seasons spanning from 2010–2011 to 2014–2015. Strikingly, older people accounted for a significant 80% of these fatalities (4).

Immunization is the paramount strategy for influenza prevention, substantially mitigating the risk of influenza-related hospitalization among older adults by an average of 40% (5). The World Health Organization (WHO) and the technical guidelines for influenza vaccination in China (2019–2020) both endorse prioritizing individuals aged 60 and above for influenza vaccination (6). Meanwhile, a review indicated that influenza vaccination in the old adult is also cost-effective from a societal perspective (7–9). Regrettably, influenza vaccine uptake in China remains distressingly low, standing at a mere 3.8%, in stark contrast to the United States (ranging from 59.6 to 75.2%) and Europe (35.5%) (10–12). Meanwhile, a study in Florida did not find an association between influenza vaccine use among rural and urban residence (13). Significantly, the influenza vaccine is not integrated into China's national immunization program and is available only upon request, incurring out-of-pocket expenses for vaccination, typically around \$21. Exceptions to this financial burden exist in the form of local government-subsidized influenza vaccine initiatives, which are limited to select metropolitan areas (14, 15). Consequently, accessibility to vaccines may be markedly restricted for older adults residing in remote or rural regions, particularly those who possess limited knowledge about influenza and are economically disadvantaged. Paying special attention to the older adults living in rural areas is of great significance to promote health equality. Although there were studies focused on the influenza vaccine coverage among older adults, most of them did research on the developed areas (such as Beijing, Shanghai, etc.) or only focused on urban populations and lacked the analysis of the overall status of the older adults in rural China (16–19).

In light of this knowledge gap, our study aimed to scrutinize the prevalence of influenza vaccine coverage and to elucidate the influencing factors that govern vaccination uptake among older adults inhabiting rural areas of south China.

Methods

Study sites

Guangdong, a subtropical province in southern China, serves as a vital hub for both domestic and international trade. With a population exceeding 120 million, the province faces year-round influenza prevalence. Guangdong is composed of 21 prefecture-level cities, each with distinct economic conditions and population profiles. At its center lies the Pearl River Delta, a cluster of nine highly developed cities that contribute 80% of the province's gross domestic product. In contrast, the other 12 municipalities, which are less developed and resource-constrained, are spread across four cities in the east, four in the west, and four in the north.

Participants

A cross-sectional study was carried out in October 2023 at two rural sites, namely Yangcheng and Zhongluotan, both situated in Guangdong Province, China. Each site featured a single clinic that engaged in the recruitment of research participants. The choice of these clinics stemmed from their ample representation of older adults and medical personnel, including nurses and doctors, well-versed in influenza vaccination procedures. These clinics, serving as primary care facilities, catered to the healthcare needs of local residents, offering a spectrum of primary medical services. These services encompassed vaccinations, complimentary health check-ups for older people, and the dissemination of health-related information. The range of essential primary care services provided was consistent between the two clinics, encompassing the management of common medical conditions, chronic diseases, vaccination services, and other preventive public health initiatives. It is noteworthy that the majority of the study participants were regular visitors to these clinics.

To qualify for participation in the study, individuals needed to meet specific inclusion criteria: (1) attainment of 60 years of age or older; (2) originating from rural households; (3) demonstrating a voluntary desire to partake in the survey, either through written or verbal informed consent.

Data collection

Data collection for this study employed paper questionnaires, which were crafted in consultation with the study group, influenza vaccine experts, and personnel from the local Centers for Disease Control and Prevention (CDC). In order to ensure the survey's validity, a pilot test was administered to 10 older adults to assess the questionnaire items. It is pertinent to note that the data obtained during the pilot phase were not integrated into the final analysis. Face-to-face survey interviews were administered by local medical staff or members of the research team to all eligible participants in the clinic setting. The survey required approximately 10 min to be completed in its entirety. It is imperative to emphasize that all survey data were treated with utmost anonymity and confidentiality, with written or verbal consent being procured prior to the initiation of the survey process. To express our gratitude for

Abbreviations: WHO, World Health Organization; CDC, Centers for Disease Control and Prevention; aOR, Adjusted odds ratio; CI, Confidence interval.

their participation, participants were provided with a moisturizing cream valued at 2 United States dollars upon concluding their involvement in the study.

Measurements

Social-demographic factors

The socio-demographic information gathered in this study included a range of variables such as age, gender, marital status, education, household size (including family members residing in the same home), and insurance status.

History of influenza infection and vaccination

The assessment of a participant's history of influenza infection involved the use of two binary (yes/no) questions: 'Have you experienced influenza or flu-like symptoms in the past year?' and 'Have you been hospitalized due to influenza or flu-like symptoms?' The history of receiving the influenza vaccine was evaluated through the following question: 'Did you receive the seasonal influenza vaccine in the previous year?'

Knowledge and attitudes toward the influenza vaccine

The assessment of knowledge and attitudes toward the influenza vaccine involved the utilization of five items, each rated on a Likert-type scale ranging from 1 (completely agree) to 5 (completely disagree). These items covered areas related to the perceived importance, safety, and effectiveness of the vaccination. The total scores ranged from 5 to 25 with 3 categories: low (5–10), moderate (11–20), and high (21–25). The Cronbach's α of knowledge and attitudes toward the influenza vaccine scale in this study was 0.869.

Perceived beliefs regarding the influenza vaccine

Participants' perceived beliefs regarding the influenza vaccine encompassed several key aspects, namely their trust in healthcare providers' guidance, self-perceived risk of infection, attitudes toward vaccination cost, and vaccine hesitancy.

Trust in healthcare providers' advice was gauged through the employment of four items, self-perceived infection risk through four items, attitudes regarding vaccination cost through three items, and vaccine hesitancy through one item. Each of these items was rated on a Likert-type scale, spanning from 1 (completely agree/very hesitant) to 5 (completely disagree/not at all hesitant). All questionnaire items were adapted from a prior study on vaccine hesitancy among Chinese adults. Trust in healthcare providers' advice ranged from 4 to 20 with 3 categories: low (4–12), moderate (13–15), and high (16–20). In a similar manner, self-perceived infection risk produced a total score ranging from 4 to 20, thus allowing for categorization as low (4–10), moderate (11–15), and high (16–20). Finally, attitudes toward vaccination costs generated a total score within the range of 3–15, with 3 categories: low (3–5), moderate (6–12), and high (13–15). The Cronbach's α of trust in healthcare providers' guidance scale was 0.877. The Cronbach's α of self-perceived infection risk scale was 0.778. The Cronbach's α of attitudes toward vaccination scale was 0.732.

Statistical analysis

A descriptive analysis was undertaken to furnish an overview of the sociodemographic attributes and the prevalence of influenza vaccine uptake. For comparing categorical variables, the χ^2 test was employed. The differences in knowledge and attitudes between the subgroup of individuals who had received the influenza vaccine and those who had not in China were assessed using the *t*-test. To scrutinize the factors linked to the utilization of the influenza vaccine, univariate and multivariable logistic regression analyses were conducted. In the multivariable model, adjustments were made for gender, age, legal marital status, highest educational attainment, and monthly income. All data analyses were executed utilizing SAS 9.2 (SAS Institute Inc., Cary, NC).

Results

In its entirety, the survey encompassed 435 older individuals. Among this group, 9 participants were excluded due to being below 60 years of age, while 3 older people were ineligible for inclusion as they had not provided their consent. Consequently, a total of 423 (97.2%) participants were ultimately included in this study.

Sociodemographic characteristics

Among the 423 participants, the majority fell within the age range of 60–75 years (81.3%), were predominantly female (59.1%), married (86.5%), possessed an educational background of junior high school or below (85.8%), reported a monthly income of less than 700 US dollars (83.2%), resided with their children (68.3%), held local household registrations (93.4%), and nearly two-fifths of them had chronic non-communicable diseases (42.6%). Additionally, more than half of the participants had previous knowledge of influenza (57.4%), over one-fourth had experienced influenza or flu-like symptoms in the past year (27.0%), and less than one-tenth had a history of hospitalization due to influenza or flu-like symptoms (6.6%) (Table 1).

Vaccine characteristics

A mere one-third of the participants had received an influenza vaccine in the previous year (30.0%), while nearly half of the older adults exhibited hesitancy toward influenza vaccination (45.1%). Furthermore, more than half of the participants were already familiar with the concept of the influenza vaccine (58.2%). Additionally, a significant majority of the older population expressed willingness to accept free influenza vaccines donated by their peers (83.9%), as evidenced in Table 1.

The analysis revealed that participants who had received an influenza vaccination in the past year were more likely to fall within the age bracket of 66 to 75 (41.6%), have a monthly income exceeding 700 dollars (52.1%), possess prior knowledge of influenza (38.3%), have experienced influenza or flu-like symptoms in the past year (41.2%), have a history of hospitalization due to influenza or flu-like symptoms (60.7%), possess knowledge of the influenza vaccine (47.2%), exhibit a

TABLE 1 Social demographic and influenza characteristics among Chinese older, 2023 (n = 423).

Characteristic	Total, <i>n</i> (%)	Influenza vaccination in the past year, <i>n</i> (%)		<i>P</i>
		Yes	No	
	423	127(30.0)	296(70.0)	
Age (years)				
60–65	98(23.2)	12(9.4)	86(29.1)	<0.001
66–70	150(35.5)	57(44.9)	93(31.4)	
71–75	96(22.7)	37(29.1)	59(19.9)	
>75	79(18.7)	21(16.5)	58(19.6)	
Gender				
Male	173(40.9)	53(41.7)	120(40.5)	0.904
Female	250(59.1)	74(58.3)	176(59.5)	
Highest educational attainment				
Junior high school or below	363(85.8)	106(83.5)	257(86.8)	0.506
Senior high school or above	60(15.1)	21(16.5)	39(13.2)	
Legal marital status				
Married	366(86.5)	109(85.8)	257(86.8)	0.904
Unmarried/divorced/widowed	57(13.5)	18(14.2)	39(13.2)	
Monthly income (Dollar)				
<\$150	110(26.0)	25(19.7)	85(66.9)	<0.001
\$150 ~ 400	144(34.0)	34(26.8)	110(86.6)	
\$401 ~ 700	98(23.2)	31(24.4)	67(52.8)	
>\$700	71(16.8)	37(29.1)	34(26.8)	
Family situation				
Living alone	36(8.5)	10(7.9)	26(8.8)	0.373
Living with spouse	98(23.2)	35(27.6)	63(21.3)	
Living with children	289(68.3)	82(64.6)	207(69.9)	
Household registration				
Local	395(93.4)	123(96.9)	272(91.9)	0.096
Migration	28(6.6)	4(3.1)	24(8.1)	
Medical insurance				
Medical insurance for urban workers	71(16.8)	19(15.0)	52(17.6)	0.237
New Rural Cooperative Medical Care	286(67.6)	93(73.2)	193(65.2)	
Other	66(15.8)	15(11.8)	51(17.2)	
Have chronic non-communicable diseases				
Yes	180(42.6)	55(43.3)	125(42.2)	0.922
No	243(57.4)	72(56.7)	171(57.8)	
Ever heard of influenza				
Yes	243(57.4)	93(73.2)	150(50.7)	<0.001
No	180(42.6)	34(26.8)	146(49.3)	
Had influenza or flu-like symptoms				
Yes	114(27.0)	47(37.0)	67(22.6)	0.002
No	309(73.0)	80(63.0)	229(77.4)	
Ever hospitalization for influenza or flu-like symptoms				
Yes	28(6.6)	17(13.4)	11(3.7)	<0.001

(Continued)

TABLE 1 (Continued)

Characteristic	Total, <i>n</i> (%)	Influenza vaccination in the past year, <i>n</i> (%)		<i>P</i>
		Yes	No	
No	395(93.4)	110(86.6)	285(96.3)	
Ever heard of influenza vaccine				
Yes	246(58.2)	116(91.3)	130(43.9)	<0.001
No	177(41.8)	11(8.7)	166(56.1)	

The bold values meant “*p* < 0.05”.

TABLE 2 Influenza vaccine knowledge, attitude, vaccination service provider trust, influenza risk perception, perceived cost of vaccination, and influenza vaccination hesitancy among Chinese older, 2023 (*n* = 423).

Characteristic	Total n (%)	Influenza vaccination in the past year, <i>n</i> (%)		<i>P</i>
		Yes	No	
Influenza vaccine knowledge attitude				
Low	68(16.1)	13(10.2)	55(18.6)	0.004
Moderate	251(59.3)	74(58.3)	177(59.8)	
High	104(24.6)	40(31.5)	64(21.6)	
Mean ± SD	12.6 ± 3.0	13.32 ± 3.1	12.22 ± 2.9	0.001
Vaccination service provider trust				
Low	12(2.8)	3(2.4)	9(3.0)	0.094
Moderate	26(6.1)	3(2.4)	23(7.8)	
High	385(91.1)	121(95.3)	264(89.2)	
Mean ± SD	18.1 ± 2.3	18.66 ± 2.0	17.84 ± 2.4	<0.001
Influenza risk perception				
Low	201(47.5)	53(41.7)	148(50.0)	0.006
Moderate	194(45.9)	58(45.7)	136(45.9)	
High	28(6.6)	16(12.6)	12(4.1)	
Mean ± SD	10.9 ± 3.1	11.62 ± 3.4	10.66 ± 2.95	0.004
Perceived cost of vaccination				
Low	96(22.7)	45(35.4)	51(17.2)	<0.001
Moderate	299(70.7)	79(62.2)	220(74.3)	
High	28(6.6)	3(2.4)	25(8.4)	
Mean ± SD	7.2 ± 2.2	6.5 ± 2.1	7.5 ± 2.2	<0.001
Influenza vaccination hesitancy				
Very hesitant	17(4.0)	6(4.7)	11(3.7)	<0.001
Hesitant	68(16.1)	9(7.1)	59(19.9)	
Neutral	106(25.1)	20(15.7)	86(29.1)	
No hesitation	123(29.1)	37(29.1)	86(29.1)	
Not at all hesitant	109(25.8)	55(43.3)	54(18.2)	

Due to numerical rounding, some totals may not add up to 100%.
The bold values meant “*p* < 0.05”.

high level of influenza vaccine knowledge and positive attitudes (38.5%), exhibit a high level of influenza risk (57.1%), perceive the cost of vaccination as low (46.9%), and have no hesitations whatsoever

regarding influenza vaccination (50.5%). These associations were found to be statistically significant (*p* < 0.05), as elucidated in [Tables 1, 2](#).

Factors correlated with receiving the influenza vaccine

In the multivariable model, adjusted for age, marital status, highest educational attainment, annual income, and gender, several factors were found to be significantly associated with influenza vaccination in the past year. Three factors demonstrated a positive correlation with influenza vaccination uptake: possessing high influenza vaccine knowledge and a positive attitude (adjusted odds ratio [aOR] = 2.60, 95% confidence interval [CI]: 1.41–4.81), having a high level of trust in vaccination service providers (aOR = 2.58, 95% CI: 1.01–6.63) and having a high level of influenza risk perception (aOR = 4.36, 95% CI: 1.77–10.71).

Conversely, five factors exhibited a negative correlation with influenza vaccination in the past year: never having heard of influenza (aOR = 0.32, 95% CI: 0.19–0.53), not experiencing flu-like symptoms in the past year (aOR = 0.50, 95% CI: 0.31–0.81), no history of hospitalization due to influenza or flu-like symptoms (aOR = 0.25, 95% CI: 0.11–0.58), never having heard of the influenza vaccine (aOR = 0.05, 95% CI: 0.02–0.10), and perceiving a high cost associated with vaccination (aOR = 0.35, 95% CI: 0.21–0.59). Refer to [Table 3](#) for further details.

Discussion

Influenza remains a formidable global public health challenge. The most effective preventive measure against influenza is vaccination, with the older people being prioritized for such vaccination. Studies have indicated that influenza vaccination for the old adult is cost-effective (7–9). Our study reveals a notable deficiency in influenza vaccine coverage among older people in rural China. By focusing on this demographic, monitoring prevalence, and probing into the associated factors affecting vaccine coverage, our study contributes to the existing body of literature. The insights gleaned from this study hold the potential to bolster vaccination rates among the older people in China.

Our findings indicate a low rate of influenza vaccine uptake among rural older people in China, a trend that aligns with similar observations in previous Chinese studies, but is lower than vaccination rates in the United States and Canada (12, 20). However, the rate is higher than the COVID-19 vaccination rate in most high-income

TABLE 3 Factors correlated with influenza vaccination among Chinese older, 2023 ($n = 423$).

Characteristic	cOR (95% CI)	<i>P</i>	aOR ^a (95% CI)	<i>P</i>
Age (years)				
61–65	Ref		–	–
66–70	4.39(2.21–8.74)	<0.001	–	–
71–75	4.49(2.16–9.33)	<0.001	–	–
>75	2.59(1.19–5.68)	0.017	–	–
Gender				
Male	Ref		–	–
Female	0.95(0.62–1.45)	0.819	–	–
Highest educational attainment				
Junior high school or below	Ref		–	–
Senior high school or above	1.31(0.73–2.32)	0.365	–	–
Legal marital status				
Married	Ref		–	–
Unmarried/divorced/widowed	1.09(0.6–1.99)	0.783	–	–
Monthly income (Dollar)				
<\$150	Ref		–	–
\$150 ~ 400	2.20(1.15–4.19)	0.017	–	–
\$401 ~ 700	2.22(1.24–3.99)	0.007	–	–
>\$700	2.7(1.57–4.64)	<0.001	–	–
Family situation				
Living alone	Ref		Ref	
Living with spouse	1.44(0.62–3.34)	0.390	1.42(0.53–3.78)	0.481
Living with children	1.03(0.48–2.23)	0.940	1.3(0.53–3.17)	0.566
Household registration				
Local	Ref		Ref	
Migration	0.37(0.13–1.08)	0.070	0.51(0.16–1.62)	0.255
Medical insurance				
Medical insurance for urban workers	Ref		Ref	
New rural cooperative medical Care	1.32(0.74–2.36)	0.350	0.96(0.48–1.92)	0.915
Other	0.8(0.37–1.75)	0.585	0.83(0.36–1.93)	0.664
Have chronic non-communicable diseases				
Yes	Ref		Ref	
No	0.96(0.63–1.46)	0.837	1.22(0.78–1.91)	0.391
Ever heard of influenza				
Yes	Ref		Ref	
No	0.38(0.24–0.59)	<0.001	0.32(0.19–0.53)	<0.001
Had the flu or flu-like symptoms in the past year				
Yes	Ref		Ref	
No	0.50(0.32–0.78)	0.002	0.50(0.31–0.81)	0.005
Ever hospitalization for influenza or flu-like symptoms				
Yes	Ref		Ref	
No	0.25(0.11–0.55)	0.001	0.25(0.11–0.58)	0.001
Ever heard of influenza vaccine				
Yes	Ref		Ref	

(Continued)

TABLE 3 (Continued)

Characteristic	cOR (95% CI)	<i>P</i>	aOR ^a (95% CI)	<i>P</i>
No	0.07(0.04–0.14)	<0.001	0.05(0.02–0.10)	<0.001
Influenza vaccination hesitancy				
Very hesitant	Ref		Ref	
Hesitant	0.28(0.08–0.94)	0.040	0.26(0.07–0.92)	0.037
Neutral	0.43(0.14–1.29)	0.131	0.41(0.13–1.29)	0.127
No hesitation	0.79(0.27–2.29)	0.663	0.79(0.26–2.41)	0.674
Not at all hesitant	1.87(0.64–5.41)	0.250	1.71(0.55–5.28)	0.353
Influenza vaccine knowledge attitude				
Low	Ref		Ref	
Moderate	2.48(1.39–4.46)	0.002	2.72(1.47–5.04)	0.001
High	2.37(1.34–4.20)	0.003	2.60(1.41–4.81)	0.002
Vaccination service provider trust				
Low and moderate	Ref		Ref	
High	2.44(0.99–6.00)	0.051	2.58(1.01–6.63)	0.049
Influenza risk perception				
Low	Ref		Ref	
Moderate	1.19(0.77–1.85)	0.436	1.31(0.81–2.12)	0.270
High	3.72(1.65–8.38)	0.001	4.36(1.77–10.71)	0.001
Perceived cost of vaccination				
Low	Ref		Ref	
Moderate and high	0.39(0.24–0.62)	<0.001	0.35(0.21–0.59)	<0.001

^aAdjusted for gender, age, legal marital status, highest educational attainment, and monthly income.
The bold values mean $p < 0.05$.

countries from a scoping review about COVID-19 vaccine hesitancy (21). Several factors may underlie this suboptimal vaccination rate. First and foremost, rural older people exhibit limited awareness of the influenza vaccine. Such low awareness, coupled with perceived disease risk, serves as a deterrent to vaccination. Additionally, older adults in rural areas of China encounter significant challenges in accessing influenza vaccination services, including geographic barriers, limited healthcare resources (22). Finally, the variation in vaccination programs and public health policy might contribute to the differences in vaccination rates. A review also clearly indicated gaps for evidence on system-based level or political strategies to improve vaccination uptake among older adults (23). Currently, only a few areas with budget surpluses in China are trying to integrate influenza vaccination into government financial subsidies or medical insurance reimbursement schemes, providing free vaccination for the older people. In contrast, in most regions, the older people must bear the cost of vaccination. Given the high cost-effectiveness of influenza vaccination for the old adult (7), developed countries such as the United States, the United Kingdom, and Australia have already incorporated influenza vaccination into national immunization programs, offering free vaccines to the older people (12, 24, 25). Considering the low coverage of influenza vaccination among the older people and the serious health threats posed by influenza, China urgently needs to devise effective strategies to promote vaccine uptake for older adults, such as expanding national immunization programs to include free vaccinations,

establishing mobile vaccination units to reach older adults who have limited access to healthcare facilities in rural areas.

We found that approximately three-quarters of the rural older people exhibits a moderate and high level of perceived cost of vaccination. This may be primarily attributed to lower income levels among older people in rural areas (26). Our study found that approximately one-quarter of older people in rural areas have a monthly income below \$150. However, previous studies and our findings have shown that older people with a higher level of perceived cost of vaccination are less likely to be vaccinated (26, 27). In the context of influenza vaccines being currently categorized as self-paid vaccines in China, many studies are exploring novel economic interventions to promote vaccine uptake among older people, such as “pay it forward” initiatives (16, 28, 29), offering financial or social incentives to encourage older adults to get vaccinated and local free government influenza vaccination policy. Additionally, previous studies also suggest that launching public awareness campaigns to highlight the long-term cost benefits of flu vaccination, emphasizing potential savings on medical expenses, sick days, and productivity losses, can mitigate perceived cost risks associated with vaccination (30, 31). Hence, developing national-level public health campaigns to raise awareness about the benefits of influenza vaccination is necessary for older populations who are at higher risk of complications.

We found a low level of knowledge, attitude, and risk perception regarding influenza vaccine among older people, only one quarter of

the older people possesses a high level of knowledge, attitude, and risk perception. We also found that older people with heightened knowledge and a greater perception of the risk associated with flu vaccines exhibit higher vaccination rates, which was consistent with other studies (32, 33). This finding was also similar with other studies about COVID-19, SARS and MERS pandemics (34). This phenomenon is primarily attributable to the fact that increased knowledge and heightened risk perception empower individuals to make proactive decisions to protect themselves and their communities against influenza, consequently leading to increased vaccination rates. Given the low level of influenza vaccine knowledge, it is imperative to initiate public health campaigns aimed at educating the older people on the significance of vaccinations and the potential risks associated with abstaining from vaccination. A combination of traditional and digital media channels, including television, radio, newspapers, social media, and online platforms, can be leveraged to reach a wide-ranging audience. Collaborations with local healthcare providers, community leaders, and influential figures can further facilitate the dissemination of information regarding vaccination's importance (35).

It is important to acknowledge the limitations of our study. First, the data regarding influenza vaccine uptake were gathered via voluntary self-reporting, introducing the potential for information bias. Second, as this was a cross-sectional study, the observed correlations between influenza vaccine uptake and knowledge and attitudes should be interpreted as associations rather than causation. Third, while our study examined older adults in rural areas, the findings may not necessarily extrapolate to older adults in urban settings in China or those residing outside of China.

Conclusion

In this study, we found a low influenza vaccine uptake among older people residing in rural China. Notably, influenza vaccine utilization is positively associated with factors such as knowledge about influenza, positive attitudes toward vaccination, and an increased perception of the risks associated with the influenza virus. In light of the suboptimal vaccination rate and the considerable health risks posed by influenza, it is crucial to devise targeted interventions aimed at augmenting influenza vaccine coverage.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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Ethics statement

The studies involving humans were approved by Dermatology Hospital of Southern Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

PZ: Conceptualization, Writing – original draft. WX: Writing – original draft. JW: Data curation, Writing – review & editing. PL: Writing – review & editing. HL: Writing – review & editing. CW: Conceptualization, Project administration, Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This publication was supported by Medical Scientific Research Foundation of Guangdong Province (B2022139).

Acknowledgments

We are very grateful to all the participants who participated in this study. We wish to acknowledge Yangcheng Town Health Service Center and Zhongluotan Town Health Service Center.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 16 August 2024

ACCEPTED 25 October 2024

PUBLISHED 22 November 2024

CITATION

Wrenger J, Berger B, Martin DD and
Jenetzky E (2024) Information needed for
optimal immunization related to medical
advice: an observational prospective cohort
study protocol (INFORMed).
Front. Public Health 12:1481942.
doi: 10.3389/fpubh.2024.1481942

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Information needed for optimal immunization related to medical advice: an observational prospective cohort study protocol (INFORMed)

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Introduction: Today, accessing information on health issues is easier than ever. However, the flood of information can make decision-making difficult. Information can influence the intention for an action, yet the action often remains unpredictable. It is unclear if there is a relationship between the intention behavior gap and the wish for medical advice in parents of newborns as they have to deal with a number of vaccinations more than any other group of people. According to survey data, vaccine-hesitant people have less interest in vaccine advice.

Methods and design: This study aimed to validate and elaborate this finding in a specific population and in a prospective observational manner. This study protocol was registered: <https://drks.de/search/en/trial/DRKS00030716>, DRKS00030716. The specific objectives include a primary endpoint focused on the wish for advice among hesitant and non-hesitant parents. Secondary endpoints involve comparing parents in terms of their respective information needs, which will be assessed based on: (a) vaccination attitudes at 6 weeks, (b) actual action taken at 12 weeks, and (c) the consistency of their attitudes and decisions. Parents of infants up to 6-week-old will be recruited and asked before the first recommended vaccination period and thereafter when the infant is 12 weeks old. Participants will receive an online questionnaire focusing on the information and advice they would like to receive and have received. Vaccination attitudes will be assessed using the C7C questionnaire at 6 weeks and the actual action of taking the first vaccine at 12 weeks.

Discussion: INFORMed will provide data on information needs and wishes of young parents depending on their attitude toward vaccination. Based on the results, health literacy in parents can be improved and information strategies can be adapted.

KEYWORDS

vaccination, infants, informed choice, shared decision-making, advice, health literacy

Introduction

It has never been easier to access information on any topic than it is today. Social media, in particular, offers many avenues for finding information, which can either undermine or reinforce one's opinions. Evaluating the correctness of this information can be difficult, leading to uncertainty and confusion, especially in medical contexts. Patient preference is, next to expert clinical experience and current state of research, one of the three pillars of evidence-based medicine, but evidence for information strategies is very low and often focused on the view of healthcare experts. Many patients do wish to participate in the decision-making process (1, 2), yet information (3) and evidence show that especially hesitant patients tend to need individualized participatory formats (4). The decision process and way of education are based on different influencing factors and experiences.

Different strategies of participative decision-making have been developed over the years, which have in common that they can be time-consuming (5). Physicians are often working under time constraints, a factor that can contribute to limiting the extent to which they practice shared decision-making (6).

On the parents' side, personal experiences influence their decision. As highly effective drugs, vaccines also have the potential to produce negative side effects that, although presumed to be rare (7), can be classified as threatening by parents (8). In this context, a lack of information seems to have a particular influence on decision-making to the effect that healthcare workers who provide more information are experienced, as being more trustworthy, resulting in a higher rate of vaccination (9). In some contexts, hesitant parents seem to wish less for information than non-hesitant parents (1). Good communication, which includes parents feeling understood (10), is then all the more important to answer open questions and to explain the current state of research (11). Even though there is research on shared decision-making and other forms of patient participation, it generally focuses on large population groups (1, 12) and seldom measures actual vaccine uptake (13, 14). Another difficulty with research in this area is that communication about vaccines cannot be compared between different vaccines as they cause different degrees of hesitancy (15).

The timing of the consultation could also play an important role, particularly in connection with childhood vaccinations. As immunization of infants is recommended as early as possible (16), one of the first decisions parents must take for their children after birth is whether they want to vaccinate as recommended or not, especially given that different countries have different recommendations. At no other time of life do humans face so many immunizations against as many pathogens as in the newborn phase and first year of life, on top of many other decisions, that this phase of family life requires. Hence, parents have to deal with much information at this time, and the vulnerable postpartum period can pose an extra strain on decision-making (16). Vaccinations are applied multiple times, but the most important is the first initial application, because parental experience of the first vaccinations may influence all following actions for their child (17). It is therefore particularly important to consider this phase of the first vaccination decision and make it as smooth as possible for the parents.

Considering these aspects, the study aims to ask new parents who they trust and what they need to make an informed and satisfying decision for their newborns. To improve research in vaccine

promotion, parental attitudes must be investigated before and after the actual action of the initial vaccination consultation, which consists of two parts: the immunization advice and the initial vaccination itself. Hence, the immunization advice will be investigated in this study from the parental perspective. Furthermore, it is unclear what factors influence actions deviating from the parental vaccination attitude. Vaccine promotion has often the primary intention to persuade hesitant parents/patients and not the main aim to answer the expressed information needs of parents/patients. This implicit intention of each counseling session must be considered in analyses. This study is the first to distinguish these two intentions (persuasion and information satisfaction) in order to evaluate success in terms of the desire for counseling and actual vaccination. Therefore, parents will be asked before their first advisory and vaccination appointment about their needs and their attitude and after the first recommended time for vaccination about their experience, their action, and their suggestions for improvements. Since time management plays a major role in medical offices, one part of this study also deals with the search for information channels other than medical ones. The results may allow us to develop the underlying framework and promotion initiatives.

Strengths of the study

- Exclusive focus on the population with the highest vaccination rate
- Prospective and longitudinal
- Differentiation between attitude and action
- Differentiating between vaccination education in principle and information content
- Information content checklist developed based on qualitative preliminary work (2)
- Neutrally observing and not intervening, thus also reaching hesitant parents (4)
- Theoretical framework examined in detail.

Methods and analysis

This protocol is built in accordance with the STROBE guidelines (18) because it is a purely observational study.

Study design

In contrast to most cross-sectional surveys with various ages, this investigation is planned (a) very early after the birth of the child and (b) as a prospective longitudinal study before and after the first vaccination. This purely observational study will exclusively focus on the parental view and does not entail a specific intervention. It is intended to assess requirements and needs for information and optimal vaccination intervention.

To minimize the stress associated with becoming a parent and expectation bias in the parent–pediatrician interaction, the study is designed as an online case report form, so that parents can easily answer the questions independently. This study is parent-based because the parents' view is crucial for their decision.

Sample selection

Physicians, midwives, social workers, and other professionals working with parents and parents-to-be register on the study website. For external validation, multipliers answer a case report form that includes information necessary for the shipping of flyers, the profession of the multiplier, and an adapted version of the 7C questionnaire to assess their attitude to vaccines.

Multipliers hand out flyers to possible study participants and draw attention to the study. Depending on the professions of the multipliers, flyers can be handed out to families with newborns younger than 6 weeks, for example, at the appointment for the U3 (a routine preventive medical checkup in Germany at the age of 4 to 6 weeks) or to expectant parents, for example, during preventive pregnancy checkups. Further advertising can take the form of posters, newsletters, or websites of multipliers. If this way of recruitment does not result in sufficient participants, the use of less validated methods such as the distribution of the study website via social media could be discussed.

Inclusion and exclusion criteria

As expectant and new parents get informed electronically via the study website, register and consent electronically in a separate REDCap database (19, 20), and participate via email, study participation is only possible for parents who have access to a digital device and have an email address. To guarantee consistent conditions, all participants need an affiliation with the German healthcare system. Furthermore, sufficient knowledge of the German language is needed.

Infants that are older than 8 weeks or families with one child already participating in the study will be excluded.

Data collection

The registration process and consent to participation for parents should end before the infant gets its first immunization, which is according to the immunization schedule as soon as the infant is 6 weeks old. Registration must take place before the child has passed the age of 8 weeks, as this is the recommended time frame of the six-fold vaccination, which is sometimes given together with the rotavirus vaccine, which is recommended from 6 weeks on.

After registration, parents receive emails with further information depending on the age of the infant. Parents of unborn babies indicate the expected date of birth. They receive an email asking them to state the actual date of birth 3 weeks after this date. Parents of babies already born get invited to answer the first questionnaire as soon as their baby is 6 weeks old. The electronic case report forms will be stored in the Research Electronic Data Capture (REDCap) system (19, 20). Before the first question, parents get informed about the use and security of their data and their option to withdraw their consent to the use of their data. The first questionnaire in which parents get asked for their personal data, such as names and addresses, is kept in a database that is separate from the child's health questions. A link between both databases is only possible via record linkage, with the email address being essential for sending invitation emails.

TABLE 1 Invitation and visit schedule of INFORMed study.

Separate visits	(V-1)	(V0)	V1	V2
Age of observed child (months)	Unborn*	<1 ½*	1 ½*	3
Informed consent	X	X	X	
True date of birth		X		
Attitude toward vaccination (C7C), demographic data, health status of the parents and siblings, and their vaccination			X	
Type of information, source of vaccination information, influencing factors, and trustworthiness of information sources			X	X
Details about vaccination advice and vaccination status				X

*Registration possible.

Parents will be interviewed via online case report forms at two time points. The first is before the first recommended vaccination, as mentioned before. The second time point occurs when the infant is 12 weeks old, as this is the time when the recommended time slot for the first immunization is over (Table 1). By this time, parents will have made decisions regarding whether and how to immunize their infant. If parents do not answer a questionnaire, they receive up to five reminder emails, which are sent every 5 days.

Quality control

The electronic capture allows logical consistency tests and in case of incomplete or unclear responses recognized during statistical monitoring, direct clarification with parents is undertaken.

Patient and public involvement

The questions of the case report forms are based on a qualitative study with young parents. However, the wishes of young parents are not only considered in protocol development, but are a fundamental focus of this investigation, because the information needs are evaluated not from physicians, but from parents' perspective.

In addition, participating parents are invited to regular meetings during the study to report on their experience with the study and to offer suggestions.

Measurements

The main question of this study is if vaccine-hesitant parents with negative attitudes wish less vaccine advice, as reported. To elaborate this further, we evaluate if and what kind of vaccination advice has been given to the parents and what was missing in their opinion. To analyze the type of vaccination advice, the case report form at the first visit includes questions about:

- The attitude toward vaccination will be assessed at the first visit using the C7C Scale (21). At the same time, confounding factors such as demographic data, health status of the parents and siblings, their vaccination status, and experience with vaccination will be assessed.
- Type of information based on a qualitative study (2) (e.g., effect and side effects, incidence and severity of the disease being vaccinated against, and information on divergent strategies)
- Source of vaccine information (Internet, books, circle of friends, midwife, and non-medical practitioner)
- Previous concrete understanding of the vaccination advice and strategy
- Influence of professionals and of the social environment
- Trust in professionals, social environment, and possible counseling centers

The second case report form at the age of 12 weeks (visit 2) contains the same questions, except the attitude toward vaccination but supplemented by information on:

- The professional who gave the advice (e.g., pediatrician, general doctor, and additional or other specialties)
- Details about vaccination advice (separate appointment/in the context of prevention examination/only at the vaccination procedure/information by a counseling interview/in writing; which brochures were delivered, duration of vaccination advice, fulfillment of the parental expectations, change of vaccination decision by the advice given and in what way, and influence of vaccination decision on further medical care)
- Other sources of information (e.g., Internet, books, circle of friends, midwife, and non-medical practitioner)
- The actual action: vaccination status at 12 weeks.

Primary study endpoint

The primary study endpoint is the wish for vaccine advice before the first recommended period of vaccination, which is related to the initial attitude/hesitancy toward vaccinations.

Secondary study endpoints

Secondary endpoints are the description of the scope of vaccination advice (such as advice received on the vaccination date, self-informed, informed by a doctor during a checkup, or at a special appointment); the perceived direction of the advice (e.g., non-hesitant or hesitant or undefined regarding vaccination); and the identification of influencing factors and suggestions for

improvement. In addition, the need for information among four groups of parents will be described, along with the information content (Figure 1):

- (a) Non-hesitant to vaccination and immunized child at 12 weeks of age
- (b) Non-hesitant to vaccination but not immunized child at 12 weeks of age
- (c) Hesitant to vaccination and not immunized child at 12 weeks of age
- (d) Hesitant to vaccination but immunized child at 12 weeks of age.

Sample size calculation

The sample size calculation is based on the data from the Federal Center for Health Education (BZgA) (22) in Germany. According to a cross-sectional survey conducted by the BZgA involving parents with children of various ages ($n = 1.153$), parents who (tend to) reject vaccinations want less often more information (4%) than parents who (tend to) support vaccinations (25%), which corresponds to an odds ratio of 8. The survey reports that 7% of parents are hesitant and tend to reject vaccination.

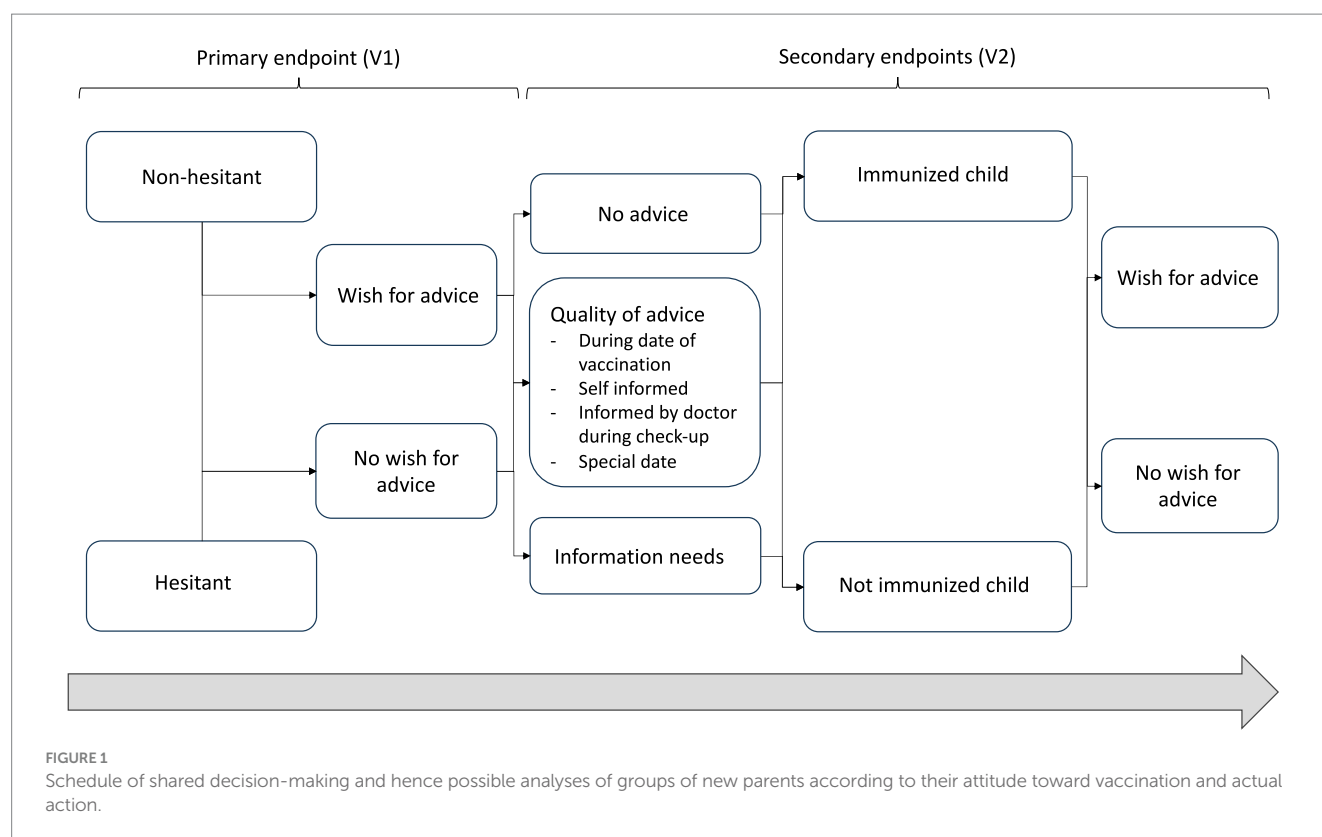
Based on these assumptions, and calculated using a Fisher's exact test with a power of 80% and a two-tailed significance level of 5%, a minimum of 378 parents is needed, with 28 (7%) of them identified as hesitant. Considering the possibility that some surveys could be incomplete, at least 400 parents are needed.

Study duration

The recruiting period for key persons and families is set for 2 years until the end of 2025 but may be extended depending on the success of the recruitment strategies of this group, which can be difficult to reach because of their vulnerable life stage.

Analysis plan

After sample size completion, two groups (hesitant versus non-hesitant) will be made based on their initial attitude toward vaccination assessed using the C7C questionnaire. Using a chi-square test, the primary research question, as to whether hesitant people have a lesser proportion of wish for vaccine advice, can be answered in a confirmatory and prospective way for new parents. All other secondary analyses are explorative. With regression analyses, we will try to explore the various attitudes and reasons for both vaccination and vaccine advice. Further secondary endpoints such as results of information content, trustworthiness of information of different professions, the perceived influence, and suggestions for improvement will be reported as descriptive statistics and divided by the four groups (hesitant and not vaccinated, hesitant and vaccinated, non-hesitant and not vaccinated, and non-hesitant and vaccinated) as described above. All details are defined in a statistical analysis plan prior to the analyses.



Dealing with bias and limitations

In contrast to existing surveys regarding vaccination attitudes, this study prospectively investigates attitude, change of attitude, and actual implementation of vaccination in the most important age group for this topic, namely, parents of newborns. As the first vaccination is recommended within a few weeks after birth, the examination of new parents poses some difficulties. For example, parents may not be willing to take part in a study during the probably stressful period following a birth. Furthermore, one group of parents (e.g., vaccine-hesitant or non-vaccine-hesitant) could participate more. Therefore, we assess the vaccination attitude of the parents in the beginning to adjust the group size if necessary.

Based on the chosen study period, attrition bias is possible if families do not answer the second questionnaire after vaccination. Nevertheless, the intentions and wishes they offered in the first questionnaire will be mentioned in the analysis of the primary outcome. Parents are only included if they have answered the first survey completely. Drop-out rates can be evaluated exploratorily according to the parents' intentions.

To reduce detection bias, the groups and the statisticians will be blinded toward the outcomes as described before.

One limitation of the study is the exclusive view of the parents without considering the influence of the physicians. This may be a strength, too, because parents could be more open, but further studies that address physicians' viewpoints will be necessary. This study does, however, also assess the attitudes of the participating

physicians using a modified version of the 7C questionnaire (23). Depending on the findings of this exclusively observational design, further studies that include interventions may follow. The exclusively observational design reduces self-reporting bias because only the parents' viewpoints are considered. Vaccination uptake will be reported by the parents, and this carries a risk of bias. This risk will be reduced by the detailed query of vaccinations, which asks for the date, vaccine name, and diseases against which vaccinations are given.

Furthermore, the parents may feel under pressure to answer the questionnaires and may answer incorrectly. This risk of bias primarily affects the secondary endpoints and can be addressed by including the timing of responses in the analysis. As in this first stage of life, many vaccination dates are recommended, and rapid response from the parents is necessary. However, parents may forget to answer because of lack of sleep or other difficulties associated with the first months of an infant's life, so reminding can be helpful to keep the participation rate high.

As some parents may visit different offices and physicians with different attitudes toward vaccination, the study may have to deal with performance bias. To enhance external validity in this context, physicians are requested to register their offices, while parents are asked to document their treating physicians.

In addition to the parental attitudes, this study also investigates the vaccine advice received, from the parental perspective, and the actual vaccinations given. Therefore, unconsidered covariates could be investigated.

Discussion

This study addresses a very important population by clarifying whether vaccine-hesitant parents are generally less interested in vaccine advice (1). Furthermore, it can provide useful insight into the information wishes and needs of new parents. It is characterized not only by the fact that it deals with the population group most likely to come into contact with vaccinations, but also by the fact that it takes into account the three pillars of evidence-based medicine - science, patient and doctor - and their interactions, in this case from the parents' perspective. These results can enhance information strategies, especially for new parents, and may give information on the different needs of vaccine-hesitant and non-hesitant parents.

However, this study has to deal with some difficulties, too. As research into vaccines continues to progress, the recommendations for childhood vaccinations are also constantly changing. This leads to parents being confronted with changing information, which may influence the comparability of the data. Particularly, the current recommendation for respiratory syncytial virus (RSV) vaccination in German newborns could influence the results, as the prospective study design cannot be realized for this vaccine if 3-day-old newborns receive vaccinations in the hospital before their first visit to a pediatrician (24). As the recommendation for those vaccinations depends on the month of birth, it may be necessary to include more families to be able to compare their strategies. On the other hand, there are legal and economic uncertainties with regard to the practical implementation of this recommendation, meaning that precise planning is not possible at the present time.

Another difficulty is finding participants for the study. Recruitment started in August 2023. Up to now, 42 parents have completed the second visit, the recruitment per month is far lower than expected, and the number of participating vaccine-hesitant parents is much higher than the non-hesitant parents. Therefore, the number of participating offices must be expanded, and the recruitment of non-hesitant parents needs to be optimized. By now, promotion strategies seem mostly to address vaccine-hesitant parents. Consequently, the wording and appearance of the flyer and other promotion materials will be designed with feedback from hesitant and non-hesitant parents. Other strategies could include multipliers that give parents the possibility to register during their contact with the multiplier or focusing on obstetric clinics as multipliers. However, the current recruitment delay is due to initial organizational difficulties. We are currently working on eliminating these difficulties and developing advertisement strategies. We welcome further supporting offices, which is one of the reasons for submitting this protocol for publication.

Previous research has shown that balanced leaflets help to improve decision-making in parents and do not influence their decision (25). A more detailed understanding of the shared decision process, considering both the *a priori* and *a posteriori* wish for advice, the experienced advice, and vaccine administration as a common intervention, may help reduce vaccine hesitancy and improve public healthcare outcomes. Based on the findings of this study, an intervention that addresses parents' needs for advice can be designed and tested. Furthermore,

the results may help to secure resources in pediatric settings and improve vaccine acceptance if parents get the information they need. The findings about attitudes, interventions, and subsequent actions can be extrapolated to other medical settings such as medication, inpatient stays, or surgeries.

Ethics statement

The ethical correctness of this study was examined and approved by the ethics committee of University Witten/Herdecke (no. 113/2022). The authors aim to maintain a high level of transparency while also ensuring the protection of personal data. Anonymized data will be made public via peer-reviewed publications and reasonable research requests. Participating parents and physicians' offices are invited to submit and discuss research questions. Information on the course of the study will be provided in German on a regular basis.

Author contributions

JW: Data curation, Investigation, Visualization, Writing – original draft, Writing – review & editing. BB: Conceptualization, Writing – review & editing. DM: Funding acquisition, Supervision, Writing – review & editing. EJ: Formal analysis, Methodology, Supervision, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. JW is a research associate at the registered association 'physicians for individual vaccination decision' (Ärztinnen und Ärzte für individuelle Impfentscheidung e.V.) and participant of the 'Interprofessional Graduate College Integrative Medicine and Health Sciences' (IGIM) of the Witten/Herdecke University. Currently, the study is supported by the Gerhard Kienle Chair's own funds from the non-profit Software AG foundation grant for 2023–2027 and volunteer efforts as part of a thesis.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 18 July 2024

ACCEPTED 07 November 2024

PUBLISHED 04 December 2024

CITATION

Xu J, Guo D, Wu J and Xu J (2024) Can social media promote vaccination? Strategies and effectiveness of COVID-19 vaccine popularization on Chinese Weibo. *Front. Public Health* 12:1436632. doi: 10.3389/fpubh.2024.1436632

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Can social media promote vaccination? Strategies and effectiveness of COVID-19 vaccine popularization on Chinese Weibo

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Background: The COVID-19 pandemic has shown a high severity in terms of mortality, and to mitigate the impact of the COVID-19 pandemic, a great deal of reliance has been placed on vaccines with defensive effects. In the context of the transmission of hazardous Omicron variant strains, vaccine popularization and acceptance are very important to ensure world health security. Social media can spread information and increase public confidence in and acceptance of vaccines.

Method: In this study, weibos related to “vaccine science popularization” during the COVID-19 pandemic in China were collected, and Weibo publishers were divided into Individuals, Organizations, Media, Government, and Scientists. The communication strategies were analyzed with content analysis from the four dimensions of Issue, Topic, Frame, and Position. SnowNLP was used to mine the audience comments and to assess their emotional tendencies. Finally, hierarchical regression was used to verify the causal relationship between vaccine science popularization strategies and audiences’ emotions.

Results: We found that the higher the scientific authority of the weibo publisher, the more positive the emotional tendency of the audience toward the weibo. Issues that are scientific, authoritative, and positive topics that positively present the advantages of the COVID-19 vaccine, and frames with detailed narratives, scientific arguments, diversified forms of presentations, and positions in support of the COVID-19 vaccine, positively affect the effect of vaccine popularization.

Discussion: Based on the experience of COVID-19 vaccine promotion in China, the results may serve as a reference for promoting innovative vaccines and handling public health affairs around the world.

KEYWORDS

vaccines, COVID-19, vaccine acceptance, sentiment, social media, outreach strategy

1 Introduction

COVID-19 is highly transmissible, placing a high strain on public health systems worldwide. Due to the lack of specific drugs, many countries have adopted defensive measures to address the COVID-19 pandemic (1), and these include vaccine development, nucleic acid testing, social distancing control, etc. Vaccination against COVID-19 is one of the most successful prevention strategies (2). At the end of 2021, Omicron, a mutated strain of COVID-19, spread widely around the world. Omicron was assessed by the World Health Organization as a very high-risk strain, further stimulating efforts by countries to ramp up COVID-19

vaccination (3). China is the most populous country in the world, and the acceptance of the COVID-19 vaccine among Chinese people is significant for world health security. COVID-19 is the first pandemic spreading widely in the age of social media, big data, and artificial intelligence (4). Many studies have shown that social media can provide new information about vaccines and may influence users' vaccine acceptance behavior (5). In China, citizens' information reception is highly dependent on social media, the most important of which is Weibo (due to its large number of users and its role as a public information platform) (6). In this context, it is essential for vaccine promotion and public health security to investigate how popularizing information on social media affects people's vaccine attitudes and behaviors.

Fisher et al. (7) found that public confidence in and acceptance of COVID-19 vaccines are often in flux, requiring a clear and direct way for science educators to explain vaccine characteristics to the public. During the COVID-19 pandemic, several scholars have linked the government (8, 9), organizations (10, 11), media (8), actors (12), etc., as disseminators of health information and studied their communication activities, strategies, and effects on social media. For example, Salmon et al. (13) focused on government vaccination communication strategies for different groups. Azer and Alexander (14) identified and conceptualized patterns of public vaccination behavior, starting with the communication and interaction about vaccines between the World Health Organization and the public. In addition, scholars also paid attention to the interaction between individuals and official media (10). Previous studies have shown that different types of communicators directly affect public engagement and emotional evaluation. For example, the public is more likely to trust weibos published by healthcare professionals than health media (15). Therefore, based on previous research and the current social media in China, public health experts, medical workers, government, media, health organizations, and individuals were selected as the subjects of vaccine information dissemination.

On social media platforms, the issue is an essential aspect of shaping public conversations about vaccination, providing context for what to highlight, emphasize, and exclude as a strategy for health communication (16). Harris (17) studied the theme of widespread science reporting from three stages: before, during, and after the crisis. Weaver et al. (18) proposed four themes of progress, regulation, conflict, and risk, which inspired the thematic classification of science communication. Mutua and Oloo (19) conducted content analysis and concluded that the main framework of global media on COVID-19 vaccination is conflict and responsibility, which can influence whether netizens support or reject vaccines. Some studies related to issue showed that in news communication, the different choices of issues will affect the public's views and attitudes toward news events (20, 21), and the more relevant an issue is to users (22), the more it can promote their positive views. Therefore, the study of issues in vaccine transmission plays a vital role in how disseminators, including journalists and governments, use different issues to form and disseminate content that promotes the public's positive attitude toward vaccine evaluation. Based on existing academic research and Weibo's dissemination, the sample issues in this study are divided into progress, regulation, science, international news, and risk (23).

Most studies discussed vaccines on social platforms during pandemics and categorized them by topic (24–26). Vaccine information on social media can be divided into two major topics:

pro-vaccine and anti-vaccine communication (27). Different issues may receive different degrees of emphasis in the popular science content of social media (28), and the choice of popular science topics will also affect the public's acceptance of vaccines. The issues supporting vaccines are divided into the availability of vaccines, the role of vaccines in life, the increase in pandemic cases, etc. The more information about the advantages of vaccines that is disseminated, the more people can vigorously promote vaccination (29). Most anti-vaccine studies focused on vaccine hesitancy, vaccine misinformation, and the use of risk transmission. We divide the topics into five categories in the coding table: side effects, infection control effects, vaccine development, vaccine promotion, and vaccination rates.

The frame is an essential aspect in forming the public topic of vaccination. In vaccine science, it refers to highlighting, emphasizing, and excluding specific vaccine information through appropriate expressions. The vaccine science popularization frame is essential in media content analysis (30, 31). How to share health-related behaviors and participate in topic discussions is an essential theme for media content analysis in academia (31), and framing analysis as a way to organize and present information on social issues and controversies enables us to understand the dynamic public sentiment toward vaccines on the internet. Narratives and statements are often placed at the center of an individual's conversation about health-related issues (32) and become a fundamental paradigm for understanding health communication and personal health-related behavior (33). Scannell et al. (34) studied discourse persuasion techniques such as comparison, story, and narrative frames used in posts. They found that when detailed narrative statements were used as expression methods, the public tended to view vaccines more positively. Based on previous literature, four frames, namely, the informational frame, the emotional frame, the contrasting frame, and the narrative frame, are used in this study to describe the expression of vaccine transmission on Weibo (35, 36).

The spread of positive or negative emotions on social media may influence vaccine acceptance, hesitancy, and even rejection (37). Studies have shown that the experience of vaccination has become an important topic on Weibo, where the public is more likely to express concerns about vaccines after scandalous vaccine-related events (38). Negative public perceptions of vaccines and the vaccine industry expressed in social media may bring about vaccine hesitancy and the need to restore public confidence (39). Vaccine confidence was significantly associated with participants' concerns regarding vaccine safety and efficacy, satisfaction with incident response, and perception of vaccine benefits versus vaccine risks (40). In social media, if the sentiments and opinions of vaccine promoters are examined, objections can be addressed to some extent, and vaccine confidence can be fostered (41). The classification criteria of "positive," "negative," and "neutral" can be used to better evaluate the communication content of social media and are widely used in research on health issues (42). For example, Lyu et al. (43) used the sentiment analysis tool of Python to classify historical posts about vaccination on Twitter as "positive," "negative," and "neutral." While weibo's content contains positive emotions such as hope, happiness, and relief, it reflects the characteristics of more audience participation, and the audience's evaluation attitude toward vaccination in the comment section is generally more positive. To determine the views of different groups on vaccination and thus understand its impact on public opinion, this paper's coding table also employs this classification to evaluate weibos' positions.

In summary, content analysis was used in this paper to extract the vaccine science popularization actors and strategies (including issue, topic, frame, and position) of sample weibos, automated sentiment analysis was employed to investigate the audience's response (emotional tendency), and hierarchical regression analysis was conducted to interpret the impact of different strategies on the audience. Specifically, this study proposes the following research hypotheses:

H1: The higher the scientific authority of the actor is, the more positive the emotional tendency of the audience.

H2: The more relevant the issue's content is to the COVID-19 vaccine, the more positive the audience's emotional tendency is.

H3: The more the topic presents the advantages of COVID-19 vaccines, the more positive the audience's emotional inclination.

H4: The more comprehensive the frame's description of COVID-19 vaccine information is, the more positive the audience's emotional inclination.

H5: The more the position leans toward supporting the COVID-19 vaccine, the more positive the audience's emotional orientation.

2 Materials and methods

2.1 Sample collection

Based on the discussion about the COVID-19 vaccine among Weibo users, weibos containing the keywords "COVID-19 vaccine popularization" and "COVID-19 vaccine" were collected from December 1st 2019 to December 31st 2022. Then, the following weibos were eliminated in the screening process: (1) weibos with most of the content (more than 80%) not related to COVID-19 vaccine and vaccine popularization; (2) weibos mainly focusing on the history or the market of the COVID-19 vaccine (e.g., there is limited information on COVID-19 popularization); (3) weibos' contents being mostly emotions and meaningless texts; (4) weibos mainly focusing on COVID-19 vaccine advertisements instead of COVID-19 vaccine popularization. After the data screening process, 1,058 valid samples were obtained. The study does not involve human participants. The data collected in this study comes from public content on the Internet and does not require ethical approval under Chinese law.

2.2 Content analysis

Based on the research hypothesis, the experience of existing studies, and sample characteristics, we analyze Actors and the weibos they posted, and construct a content-coding table of weibos' COVID-19 vaccine science actors and strategies, including Actor, Issue, Topic, Frame, and Position. In addition, specific coding rules are presented in Table 1 to better quantify the weibo text as the unit of analysis.

Actor refers to the identity of the weibo publisher (44). Weibo accounts are categorized into different weibo publishers, such as

government, media, and individuals. We identify and categorize Actors based on the authentication information of weibos. We follow the categorization basis of existing literature, and we identify them from the authentication information. We set five indicators, Individuals, Organizations, Media, Government, and Scientists, according to the scientific authority of the publisher (from lowest to highest) (8–11, 13).

Issue, Topic, Frame, and Position are all important indicators for measuring the strategy of popular science weibo.

Issue refers to the domain covered by weibo content (45). We set five indicators, risk, international news, science, regulation, and progress, according to the degree of relevance of issues to the COVID-19 vaccine (from low to high) (23).

Topic refers to the specific topic discussed by weibo content (36). We rate the percentage of vaccine benefits included in topics (such as safety, efficacy, accessibility, etc.) from low to high; we set five indicators, side effects, infection control effects, vaccine development, vaccine promotion, and vaccination rates (27).

Frame refers to the expression used by weibo (46). We follow the frame's description of COVID-19 vaccine information as comprehensive (from low to high) and we set four indicators: informational frame, emphatic frame, contrasting frame, and narrative frame (35, 36).

Position refers to weibo's position on COVID-19 (47). We set three indicators, anti-vaccine, neutral, and pro-vaccine, according to the degree of support for the COVID-19 vaccine position (from low to high) (37, 43).

According to the content analysis and coding table rules, two coders pre-coded 10% of the sample. The two coders then independently coded all valid pieces. Inter-coder reliability scores were calculated using Scott's Pi coefficient (π) (48). The scores all exceed 75%, indicating high coding reliability. For the same weibo or indicator, when there was a disagreement among coders, they negotiated and left the most likely coding result.

2.3 Sentiment analysis

When exploring the public's emotional trend and evaluation of vaccine transmission on social media, it is necessary to build scientific and reasonable evaluation criteria. For comment sentiment recognition, we use SnowNLP, a dictionary-based Python database for Chinese sentiment analysis (49). SnowNLP has excellent short-text processing capabilities, and several studies have confirmed that it can identify emotions in weibos or weibo comments and that the accuracy rate is more than 80% (50). For this paper, all comments from a sample of 1,058 weibos, totaling 349,401, are obtained. We use SnowNLP to calculate the emotional value of each comment separately. SnowNLP automatically outputs an emotion number between 0 and 1; the closer the number is to 1, the more positive the emotion tendency is. The closer the number is to 0, the more negative the emotional direction is (51). Then, we average the sentiment values of all comments under a weibo to obtain the overall sentiment of each weibo.

2.4 Regression analysis

Hierarchical regression analysis can be used to detect the relationship between different dissemination subjects, dissemination strategies and dissemination effects (52). Since the Actor involves the

TABLE 1 The dimension and indicators of coding.

Samples	Indicators	Description
Actor	Individuals	Ordinary individual users.
	Organizations	Public health organizations, hospitals, health centers, etc.
	Media	Central media, local media, media companies, etc.
	Government	The central government, local government, government departments, etc.
	Scientists	Public health experts, doctors, medical researchers, etc.
Issue	Risk	It highlights the potential risks, side effects, and complications associated with vaccination against COVID-19.
	International news	It reports on the progress of international COVID-19 vaccination and social response.
	Science	It demonstrates the scientific knowledge of the principles, characteristics, and technologies of COVID-19 vaccines.
	Regulation	It highlights the free vaccination policy of the COVID-19 vaccine and some convenient vaccination conditions.
	Progress	It introduces the progress of COVID-19 vaccination in China, including the number of people vaccinated and the vaccination rate.
Topic	Side effects	Introduces the possible adverse consequences of vaccination against COVID-19.
	Infection control effects	Introduces infection prevention rates after vaccination against COVID-19.
	Vaccine development	Introduces the development of the COVID-19 vaccine.
	Vaccine promotion	Introduces the benefits of the COVID-19 vaccine and the benefits after vaccination.
	Vaccination rates	Introduces the progress of COVID-19 vaccination in China.
Frame	Informational frame	Presents the COVID-19 vaccine information straightforwardly without complex presentation techniques.
	Emphatic frame	Highlights and emphasizes the advantages of COVID-19 vaccines based on the information provided.
	Contrasting frame	Uses contrasting narratives (e.g., comparing different vaccines, countries, populations, etc.) to highlight the benefits of COVID-19 vaccines.
	Narrative frame	Describes and demonstrates the benefits of COVID-19 vaccination in detail by providing extensive background information.
Position	Anti-vaccine	Opposes COVID-19 vaccines or COVID-19 vaccination efforts.
	Neutral	Is neutral on the COVID-19 vaccine or COVID-19 vaccination efforts.
	Pro-vaccine	Supports the COVID-19 vaccine or COVID-19 vaccination efforts.

identity of the publisher behind weibos, Issue, Topic, Frame, and Position extracted from the content of weibos can be categorized as different dissemination strategies. And different vaccine dissemination subjects and strategies bring different dissemination effects (53). Therefore, hierarchical regression is used in this paper to investigate the causal relationship between weibos' COVID-19 vaccine popularization strategy and audience emotion. We convert all the variable values to a perfect score of 5. In the hierarchical regression analysis, we first conduct regression analysis by importing independent variable, actor and dependent variable, audience emotion. Then, we add independent variables (Issue, Topic, Frame, and Position) to conduct regression analysis and output the results.

3 Results

3.1 Actors, Weibo science popularization strategies and public emotions

Table 2 shows the number and proportion of weibos posted by every Actor. From the actor's perspective, media ($N = 396$) has the most significant number of weibos. The leading publishers include China's most influential mainstream media, such as People's Daily and CCTV News, and well-known local media in China, such as The Paper and Caixin. The second largest number belongs to individuals ($N = 358$), most of whom are not identified, who participate

anonymously in COVID-19 vaccine science communication and discussion. The number of Scientists ($N = 113$) comes in third. The scientists active on Weibo are mainly doctors, nurses, and other medical workers, in addition to a few influential public health experts. The number of organizations ($N = 109$) ranks fourth and their weibos are generally short and brief. The number of governments ($N = 82$) is the lowest, and the vaccine popularization information released by the Chinese government has high credibility. It can often cause a specific range of transmission and diffusion.

Concerning Issue, Science ($N = 388$) has the largest number of weibos. This kind of weibos, relatively neutral, aims to reveal the characteristics of COVID-19 vaccines and provides vaccine knowledge to the public. Regulation ($N = 262$) has the second largest number of weibos, improving the convenience of COVID-19 vaccination supplied by the Chinese government and relevant departments and encouraging the public to take vaccination. The number of international news ($N = 286$) ranks third and their weibos describe the characteristics and the progress of foreign vaccines. Progress ($N = 108$), which describes progress in vaccine development and testing, ranks fourth. The number of risks ($N = 14$) is the smallest. This kind of weibos mainly informs the public about the potential risks of COVID-19, which easily induces negative emotions about vaccines.

Regarding the topic, the number of vaccine promotions ($N = 285$) is the largest. This kind of weibos persuades the public to vaccinate, emphasizing the safety and effectiveness of vaccines. The number of

TABLE 2 The number and proportion of weibos posted by actors.

Samples	Indicators	Description	number	proportion
Actor	Media	Central media (e.g., @People's Daily), Local media (eg.@Sichuan Daily), media companies (e.g., @Caixin)	396	37.43%
	Individuals	Individual user (e.g., @Chaitai CT)	358	33.84%
	Scientists	Public health experts (e.g., @Wenhong Zhang), doctor (e.g., @Doctor Weiming Luo), medical researcher (e.g., Zhuangshilihe)	113	10.68%
	Organizations	Public health organization (e.g., @Health China)	109	10.30%
	Government	Central government (e.g., @SASAC), local government (e.g., @Xian Publishing)	82	7.75%

infection control effects ($N = 273$) is the second largest and this kind of weibos does not blindly emphasize the impact of vaccines on preventing COVID-19 infection but highlights the proportion of COVID-19 in preventing severe illness, hospitalization, and death. The number of vaccination rates ($N = 269$) ranks third. These weibos provide psychological stimulation for unvaccinated users by showing vaccination progress. Especially at the later stage of the vaccination campaign, when most people have been vaccinated against COVID-19, it is easy to stimulate the herd mentality of the unvaccinated. The content under the topic of vaccine development ($N = 195$) is mainly related to the progress issue, aiming to point out breakthroughs and progress in vaccine research and development. Side effects ($N = 63$) have the lowest number. Most weibos that describe vaccine side effects include qualifiers such as “For people with severe allergic disease, vaccination against COVID-19 may, in a small probability, cause dangerous consequences such as breathing difficulties or shock.” This emphasizes that the side effects of COVID-19 vaccines are only found in certain groups of people.

In terms of frames, the number of informational frames ($N = 499$) is the largest. Most popular science weibos still maintain the characteristics of short text and simple expression and directly list the popular science information of the COVID-19 vaccine. The number of Emphatic frames ($N = 305$) is the second, and the presentation of microblogging under this framework is similar to that of the Informational structure. Nevertheless, emphasis is given to the critical information by setting the title, adding a new line, adding a topic, and adding pictures or videos. The narrative frame ($N = 171$) ranks third. This kind of weibos is often long, with more detailed descriptions of the knowledge of the effect of the COVID-19 vaccine. Weibos involving vaccine persuasion have an argumentative process. Contrasting frames ($N = 83$) are easy to identify and often involve comparisons between domestic and foreign vaccines, and comparisons between different groups. The aim is often to persuade eligible people to vaccinate as soon as possible.

Regarding Position, the number of pro-vaccines ($N = 786$) is the largest. Most weibos are supportive of COVID-19 vaccines and vaccination efforts. Vaccination against COVID-19 is the most effective way to eliminate the COVID-19 outbreak. The number of neutral ($N = 226$) is the second largest, and this kind of weibos explains the advantages and disadvantages of vaccines and lets the audience decide whether to vaccinate or not. The number of anti-vaccines weibos ($N = 46$) is the smallest and this kind of weibos is mainly related to the safety and effectiveness of vaccines. Some weibos argue that there have been fatal cases of the COVID-19 vaccine and that vulnerable populations need to be careful. A few weibos believe that China's domestic COVID-19 vaccine technology is backward and

has poor performance in infection prevention and that it is unnecessary to vaccinate.

Regarding the emotion of the comments, most comments are neutral ($M = 2.27$, $\sigma = 1.26$). Positive comments usually contain positive words such as “support, belief, trust, great, like,” expressing strong trust in COVID-19 vaccines. Neutral reviews tend to be descriptive and short, making it difficult to distill public opinion about vaccines. Negative comments often contain “rejection, danger, death, allergy, fear” and can be divided into two types: concerns about vaccine safety and expressions of vaccine fear.

3.2 Influence of actor and Weibo science popularization strategies on public sentiment

Table 3 shows the results of the hierarchical logistic regression analysis. Model 1 examines the influence of the Actor on public sentiment. The results show that actors can explain 7.7% of the changes in public opinion, and actors positively affect the public view ($OR = 0.267$, $p < 0.001$). H1 is confirmed.

When the vaccine popularization strategy of the weibos is introduced into the model, the explanatory power of independent variables to comment sentiment is expanded, and 6.1% of the explained variance is observed. In Model 2, the actor and all strategies (Issue, Topic, Frame, Position) positively affect public sentiment. Among them are actor ($OR = 0.199$, $p < 0.001$), issue ($OR = 0.097$, $p < 0.05$), topic ($OR = 0.192$, $p < 0.001$), frame ($OR = 0.062$, $p < 0.05$), and position ($OR = 0.131$, $p < 0.01$). H2-5 are confirmed.

4 Discussion

We get 1,058 effective samples by collecting weibos related to “vaccine popularization” during the COVID-19 pandemic. Based on existing research and sample characteristics, we divide actors into Individuals, Organizations, Media, Government, and Scientists. We conduct content analysis to analyze the communication strategies from the four dimensions of Issue, Topic, Frame, and Position and measure the emotional tendency of audience comments with SnowNLP. Then, we use hierarchical regression to verify the causal relationship between vaccine popularization strategies and audiences' emotions.

Actors can explain 7.7% of changes in public mood, and the higher the scientific authority of actors is, the more positive the audience's emotional tendency. As the main body of information

TABLE 3 Hierarchical regression model of actor and Weibo science popularization strategy.

	Model 1	Model 2
Actor	0.267*** (9.414)	0.199*** (6.489)
Issue		0.097* (2.503)
Topic		0.192*** (7.953)
Frame		0.062* (2.211)
Position		0.131** (3.159)
Sample size	1,058	1,058
R ²	0.077	0.142
Adjusted R ²	0.077	0.138
F	F (1,1056) = 88.626, p = 0.000	F (5,1052) = 34.838, p = 0.000
△R ²	0.077	0.065
△F	F (1,1056) = 88.626, p = 0.000	F (4,1052) = 19.812, p = 0.000

*p < 0.05, **p < 0.01, ***p < 0.001.

dissemination, the media posts the most, followed by individuals. At the same time, scientists (e.g., medical workers, public health experts), public health organizations, and governments publish relatively little information. Since information released by scientists, organizations, and governments is authoritative in science communication, trust in vaccine science information essentially means trust in science, scientists, and governments. As a result, data published by scientists and governments can be widely disseminated. This also inspires public health departments to appropriately increase the amount of information released by scientists, public health organizations, and governments when promoting vaccines on social media. The vaccine information published by these actors contains much professional and authoritative vaccine knowledge, which can improve the public’s understanding of vaccines. When these highly credible sources consistently present the benefits of vaccines to the public, it is easier to promote positive public attitudes toward vaccines.

The more relevant an issue is, the more positive the public’s attitude tends to be. The number of weibos of science, regulation, international news, and progress ranks the top four, meeting the audience’s needs for scientific and authoritative vaccine knowledge popularization and research and development progress, and meeting the public’s high demand for government policy directions and international vaccine situation. Moreover, when the issue is related to the personal health and vital interests of the public and has strong relevance to the public, people affected by the pandemic are more likely to believe that the information described in the communication content (54, 55) can inspire their positive emotions. The smallest number of topics is that of negative vaccine risks, which easily arouses public concerns about the safety and effectiveness of vaccines but has difficulty in encouraging the public’s inclination to vaccinate. Therefore, when disseminating international vaccine information, different actors can promote more topics of public concern and interest and promote positive public acceptance in demonstrating vaccine science and policy support and guarantees. In addition, China’s vaccine science popularizing actors should also pay attention to the accuracy of vaccine risk information, refute false statements

promptly, reduce the negative impact of risk topics, and prevent mass panic caused by the spread of vaccine risk rumors (56).

It has been suggested that when a topic presents more advantages of COVID-19 vaccines, the audience’s emotional tendency is more favorable (42), which has been confirmed by the findings of this study. Vaccine promotion that emphasizes the safety and effectiveness of vaccines has the largest number of weibos, which can effectively alleviate the vaccine fear or vaccine hesitation of the audience to soothe the emotions of the audience (57, 58) so that under the topic of vaccine safety and effectiveness, a large number of users comment with positive emotions. The number of side effects is the lowest because side effects easily cause negative feelings in the audience and even cause them to resist the vaccine (42). Therefore, disseminators of vaccine information can pay more attention to the advantages of vaccines when posting weibos. When the Chinese public receives more information emphasizing the safety, effectiveness, and convenience of COVID-19 vaccines and the convenience measures provided by the government, the Chinese public’s sentiment toward vaccines is also more positive.

The more comprehensively the frame describes the COVID-19 vaccine information, the more positive the public sentiment is. Whether it is a short text, simple Informational frame, or Emphatic frame of text, pictures, or video in various forms of communication, concise or audio-visual rich media expression can attract the attention of the majority of the public to the greatest extent in the age of attention (59). The narrative frame of detailed narration and scientific argumentation is more accurately projected on audiences with a particular cultural level who are willing to learn information on social platforms to enhance users’ positive emotions toward vaccines. Contrasting frames enable the Chinese people to differentiate vaccine research progress, effects, risks, and hazards at home and abroad. The public can easily enhance positive emotions from contrasting frames highlighting vaccine advantages. Therefore, relevant actors need to describe vaccine information as comprehensively as possible and adopt more diversified forms in vaccine promotion. This suggests that when vaccine dissemination actors use multiple ways, such as pictures, videos, and texts, to disseminate vaccine information and set rich, comprehensive, and dialectical information in the content, information dissemination will be more scientific, objective, and lively, reaching audiences with different information needs to the maximum extent and helping the public understand vaccine information. This improves people’s judgment and trust in vaccines to promote vaccination.

The more the weibo’s position leans toward supporting COVID-19 vaccines, the more positive the audience’s emotional response is. A pro-vaccine approach mainly emphasizes support and trust in vaccines and is based on the belief that vaccination is an effective way to prevent and control COVID-19 (60). Kwok et al. (25) found that nearly two-thirds of all tweets on Twitter about COVID-19 vaccines were positive. Hussain et al. (61) found that the overall sentiment in vaccination-related tweets and Facebook posts was positive in the US and UK. This paper also confirms this point. Under the guidance and drive of the dissemination of content supporting vaccines, Weibo users would think that vaccines could achieve low mortality and low infectivity, meet the needs of protecting personal health, and give positive emotional evaluations such as “support” and “thumbs up.” This inspires experts, related institutions, we-media, and other communicators to pay attention to their position in vaccine promotion, provide positive information supporting vaccines, including safety and effectiveness, and at the

same time, appropriately increase pro-vaccines content to convey positive emotions to the audience (62–64).

This paper verifies the feasibility of vaccine popularization on social media. Weibo is an important platform for science communication and information about vaccines can affect vaccine popularization and vaccination. This paper summarizes the advantages and strategies of China's diverse actors for vaccine science popularization on Weibo and proposes specific suggestions for vaccine promotion. The findings elucidate the communication strategy characteristics of Chinese actors such as media, scientists, public health organizations, governments, and individuals. It offers references for other countries to effectively popularize science communication during public health crisis.

This paper has some limitations. First, the selected samples are still limited and do not include all representative samples, and such a sampling method may bias the results. Second, the categorization can still be refined. We explore the promotion strategies and effects of the COVID-19 vaccine during the period from December 1st 2019 to December 31st 2022. It needs to be further verified whether the vaccine popularization strategies and effects of each communication actor during the period of COVID-19 are effectively used for the promotion of other vaccines. In the future, we will expand further on the types of vaccines, such as focusing on influenza, HPV, and other vaccines.

5 Conclusion

This paper examines the COVID-19 vaccine communication activities conducted by individuals, organizations, media, government, scientists, and other diverse actors on Chinese social media (Weibo) (including communication strategies, audiences' feedback, and communication effects). The higher the scientific authority of the actor is, the more positive the emotional tendency of the audience is. Weibos with the following communication strategies had a positive impact on the effect of vaccine popularization: scientific, authoritative, and positive issues; topics that actively presented the advantages of the COVID-19 vaccine; the frames of detailed and diversified descriptions and scientific arguments, and offers to support the position of the COVID-19 vaccine. Based on the experience of COVID-19 vaccine promotion in China, this paper proposes suggestions for vaccine promotion on social media, and the results may provide references for innovative vaccine promotion and public health affairs in countries around the world.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JingX: Conceptualization, Data curation, Funding acquisition, Writing – original draft. DG: Conceptualization, Data curation, Methodology, Software, Writing – original draft, Writing – review & editing. JW: Investigation, Project administration, Supervision, Writing – original draft. JinghX: Conceptualization, Investigation, Supervision, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was financially supported by the Research Initiation Fee Program for High-level Talents of Huaqiao University “A Study of the Image of Women in Social Media” (24SKBS007).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 23 August 2024

ACCEPTED 25 November 2024

PUBLISHED 06 December 2024

CITATION

Schlopsna M and Scheersoi A (2024)
Understanding student engagement in
vaccination education: an interview-based
multi-stakeholder study.
Front. Public Health 12:1485498.
doi: 10.3389/fpubh.2024.1485498

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Understanding student engagement in vaccination education: an interview-based multi-stakeholder study

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The COVID-19 pandemic has underscored the importance of informed decision-making, especially concerning vaccination for disease prevention. This highlights the need for scientific literacy, trust, and understanding of relevant concepts such as pathogens, immune responses, and transmission pathways. Additionally, societal and ethical considerations are integral for a comprehensive approach. While collaborating with medical professionals and fostering argumentation and decision-making skills hold promise for enhancing engagement with these topics in educational settings, understanding students' perspectives is essential for maintaining their motivation to learn and their interest in such complex subjects. Therefore, a qualitative study involving interviews with secondary school students, experienced educators, and vaccination experts familiar with school environments was conducted to identify factors fostering student engagement and interest in immunobiology and vaccines. The findings highlight focal areas of student interest in the topic and the value of involving students in lesson planning. They also underscore the importance of real-world relevance and the need for clear, student-centered communication with medical professionals. Recommendations for educators include integrating interactive learning activities, real-world examples, and case studies.

KEYWORDS

vaccine education, interest, students' perspectives, vaccination experts, socio-scientific issue

1 Introduction

The rapid spread of infectious diseases such as COVID-19 has underscored the critical importance of vaccinations in protecting global health. Vaccinations are widely recognized as one of the most effective tools in combating severe diseases, yet vaccine hesitancy and the global decline in vaccination rates are listed among the top 10 threats to public health (1).

Research highlights the positive impact of comprehensive public education on vaccination (2). While public education initiatives can take place in various settings, a qualitative study by Schott et al. (3) on increasing HPV vaccination rates suggests that school-based vaccine education is the most effective method for reaching a broad audience of students and their parents. This effectiveness is partly attributed to the significant amount of time students spend in school and the instructional expertise of trained educators (4).

When addressing controversial topics such as vaccination, it is crucial that school instruction extends beyond merely presenting facts. Effective education should empower students to contextualize and critically evaluate the information they receive (4, 5).

Interest in a topic is a key factor in determining the depth of student engagement (6, 7), which is particularly relevant for complex topics such as vaccination. Despite the importance

of this factor, there is a significant gap in the research regarding how to foster student interest in vaccination-related topics and how to design effective, student-oriented instructional strategies (2, 4).

To address this gap, this study employs qualitative interviews and qualitative content analysis to explore the aspects of vaccine education that promote student interest. The primary focus of this study is to identify which aspects of the topic of vaccination students find particularly interesting. Additionally, it explores their attitudes toward addressing this complex topic in the classroom and their preferences regarding specific teaching methods. In addition to student perspectives, the study also gathers insights from experienced teachers and medical experts who regularly engage in vaccine education within schools.

The results of this study will not only contribute to improving vaccine education in schools but will also be used to inform an international open schooling project where schools collaborate with science experts. This project aims to create partnerships that enhance students' learning experiences and further engage them in complex topics like vaccination.¹

By analyzing the data from these interviews, this study aims to develop concrete recommendations for designing lessons on vaccination that enhance student interest and engagement. The findings are expected to provide valuable insights for educators, policymakers, and public health initiatives, aiming to improve vaccine education in schools as well as support innovative educational projects that foster contemporary science education.

2 Background

2.1 Interest and learning

As with all other topics, effective teaching on the theme of vaccination benefits from a teacher understanding the students' perspectives and interests and using these insights to shape their instruction (8, 9). Several studies have shown that interest in a topic significantly influences attention and conceptual understanding (10, 11). Interest fosters positive emotions, persistence, and voluntary engagement with learning content, making learning more meaningful and effective (12, 13). Thus, promoting interest—with its emotional, cognitive, and value-related components—is a key responsibility of educational institutions (14). As a result, interest as a motivational construct and its development across learning contexts have become central themes in educational research (15).

Studies in both formal and informal learning contexts have identified numerous factors influencing interest development. These include the satisfaction of basic psychological needs—competence, autonomy, and social relatedness (16–19). Novelty is another influential factor, where encounters with new or unfamiliar situations, especially those involving discrepancy and surprise, promote interest (15, 20). Learning environments that support problem-oriented or inquiry-based approaches also foster interest, particularly when they involve physical and cognitive engagement (21–25).

Moreover, the inherent characteristics of learning topics themselves influence interest. For example, astrophysics tends to attract more interest among young people than geology, while biology topics related to zoology or human biology are generally more engaging than botanical ones (26).

Finally, individual psychological traits such as gender, prior knowledge, and self-efficacy differentially impact interest development and should be considered when designing learning environments (27, 28).

This study focuses on how to stimulate interest in vaccination and maintain it during the exploration of the topic to encourage a thorough engagement with the complex subject matter.

2.2 The topic of vaccination in school education

In school education, the topic of vaccination is often treated as a secondary subject, merely connected to broader topics such as the immune system or genetics (4). For example, the results of a textbook analysis in Germany show that vaccination is only a small part of the topic of the immune system and is not treated as an independent subject (29). The textbooks analyzed contain a limited selection of teaching materials, and the presentation of information usually follows a uniform pattern: details on the specific and innate immune systems are provided, followed by a chapter on active and passive immunization. This chapter is divided into therapeutic and preventive vaccination and includes information on the general effects of vaccination in the human body and the concept of herd immunity. Most books also cover Jenner's historical cowpox experiment for the development of a smallpox vaccine and provide an example of a modern vaccine, such as for measles or tick-borne encephalitis (TBE). The tasks provided are mostly of a reproductive nature, focusing on describing, explaining, or comparing content. Evaluation, assessment, and justification are rarely included in the tasks (29). This leads to a rather superficial treatment of the topic of vaccination, raising questions about whether such an approach, which overlooks emotional and sociocultural issues, is contemporary for science education (30). If teachers want to address the topic of vaccination more thoroughly in the classroom, they must rely on external materials, which can be difficult to find and may vary in quality.

The design of the lesson and the presentation of the subject also heavily depend on the teacher's attitudes and prior knowledge about vaccination. If the teacher is critical of the topic, this will be reflected in their teaching [cf., (31)].

Another barrier is the lack of inclusion in university teacher education—at least in Germany; vaccination education is not part of the teacher training curriculum. Additionally, school conditions, such as the minimal integration of the topic in the core curriculum, pose challenges. The narrow guidelines of the core curriculum often leave no time for a more detailed exploration of the topic. To effectively integrate and address vaccination in the curriculum, it must be firmly incorporated into teacher education and expanded in school core curricula (2).

Given that vaccination is a complex and controversial topic, a sensitive approach to the content is also important in school education (9). Individuals who are critical of the topic are often stigmatized and labeled as poorly informed or selfish. Since students'

¹ <https://multipliers-project.org/>

motivation to engage with a topic also depends on whether they feel socially included, it is crucial to create an atmosphere where even those who are critical of the topic feel respected and taken seriously. This means addressing any concerns and fears associated with this criticism (4).

To foster students' understanding of the "Nature of Science" [e.g., (32, 33)], the topic of vaccination is particularly suitable, as historical case studies or discussions about the effectiveness and use of different vaccines allow students to critically engage with research (4). Sociocultural and ethical questions can also be integrated (e.g., vaccine scarcity and distribution or vaccine mandates) and discussed through role-playing or debates—either as part of science education or through an interdisciplinary approach in the context of geography, history, or philosophy (4).

Comprehensive engagement with the topic of vaccination and examination from a systemic perspective can also be achieved through its inclusion in One Health education, which explicitly focuses on promoting critical thinking (34).

To specifically address students' concerns and uncertainties, schools can invite external experts, such as vaccination doctors [cf., (2)]. They can visit individual classes and answer students' questions. This also includes expertise on current misinformation and conspiracy theories circulating on social media about certain vaccines, such as infertility claims related to COVID-19 vaccines. Misinformation can thus be specifically debunked, and students can be factually informed. In addition to their specialized expertise, the openness of students and the lower level of embarrassment when interacting with individuals outside the school context also support the inclusion of experts (2).

Few studies have explored how to generate interest in vaccination among learners or provided concrete recommendations for designing engaging lessons on this topic [cf., (4)]. This study aims to fill that gap by identifying factors that enhance students' interest in vaccination and offering guidelines for creating lessons that effectively foster this interest.

3 Materials and methods

3.1 Data collection

To gather students' perspectives and measure their interest, both quantitative and qualitative methods can be employed (14). For this study, qualitative data collection was chosen in the form of semi-structured interviews, as it provides the most direct form of interaction with the participants, allowing the interviewer to respond directly to statements. This approach enables follow-up questions and allows participants to elaborate on and explain aspects in detail when necessary (35). Additionally, interview participants can introduce additional aspects that the interviewer can then address with spontaneous questions and prompts (36). The interviews with the students were conducted in small groups (2–4 students) to reduce anxiety and create an atmosphere of casual conversation among peers, where they could freely exchange ideas and express their preferences and interests. This approach typically results in more authentic responses, and the interviewer needs to intervene less, thereby reducing the risk of unintentionally influencing the participants (36).

Niebert and Gropengießer (36) provide recommendations for designing such interviews with students to obtain comprehensive

data. These recommendations were implemented in the context of the interviews with the students in the following manner:

To ease the atmosphere and initiate conversation, the interview began with an open prompt: "When you think about your time in school, what have you enjoyed most in biology class so far?"

To illustrate and support the discussion, to encourage the flow of conversation, and to guide their responses, participants were provided with *material*—topic sheets and custom-made info cards on various vaccines were used.

Additionally, targeted *follow-up interventions* were employed, such as asking further questions to obtain detailed information and more comprehensive explanations, e.g., "Earlier you mentioned XY, could you explain what you meant by that?"

Ad-hoc interventions, in the form of spontaneously generated follow-up questions, prompts, and remarks from the interviewer, were intentionally used to make the participants' statements understandable and clear.

To ensure that no important aspects from the participants' perspectives were overlooked during the interview, they were asked at the end if they had any additional tips or comments or if something relevant to them had been omitted (*final intervention*).

The interview questions initially focused on the students' general assessment of the topic of vaccination in biology class ("Would you find this topic interesting? Would you like to study this in class?") and on their interest for vaccines against specific viruses (measles, COVID, HPV—"Which of these topics interests you the most? Which would you like to cover in class?"). Prior knowledge was briefly addressed ("Do you already know a little about the different vaccinations or viruses?") to then use the information material to establish a common foundation for the rest of the interview ("Read through the fact sheets at your own pace to get an idea of what it's about."). The materials consisted of custom-made, short, and colorful information sheets on the three viruses and vaccinations (Figure 1).

The next interview question addressed specific content that the students would like to explore in class ("If you were to study the topic of vaccination in class, what would interest you the most? What would you like to discuss in class?") to identify areas of interest.

Since addressing the topic of vaccination in class can also include social and ethical questions, the students' views on this aspect were subsequently explored ("Would you be interested in the societal aspect? Like addressing the ethical aspects of vaccination?"). Additionally, the interview specifically inquired about anti-vaccination movements and myths and how the students perceived the potential for conflict in the classroom if these topics were discussed ("Do you think it would be problematic to talk about anti-vaxxers in your class?").

Another set of questions focused on excursions and meetings with experts, particularly reflecting on the students' past experiences and their evaluation of those situations (e.g., "Have you ever gone on excursions and talked to experts in your science classes? Or have experts ever come to your school?").

Finally, the students were asked to provide tips for the methodological design of lessons on vaccination, allowing their preferences to be considered ("What tips would you give us for making the topic of vaccination interesting in class? How would you like to learn about it?").

Due to the complexity of the topic and the integration of vaccination into the school curricula from grade 9 onwards, the study

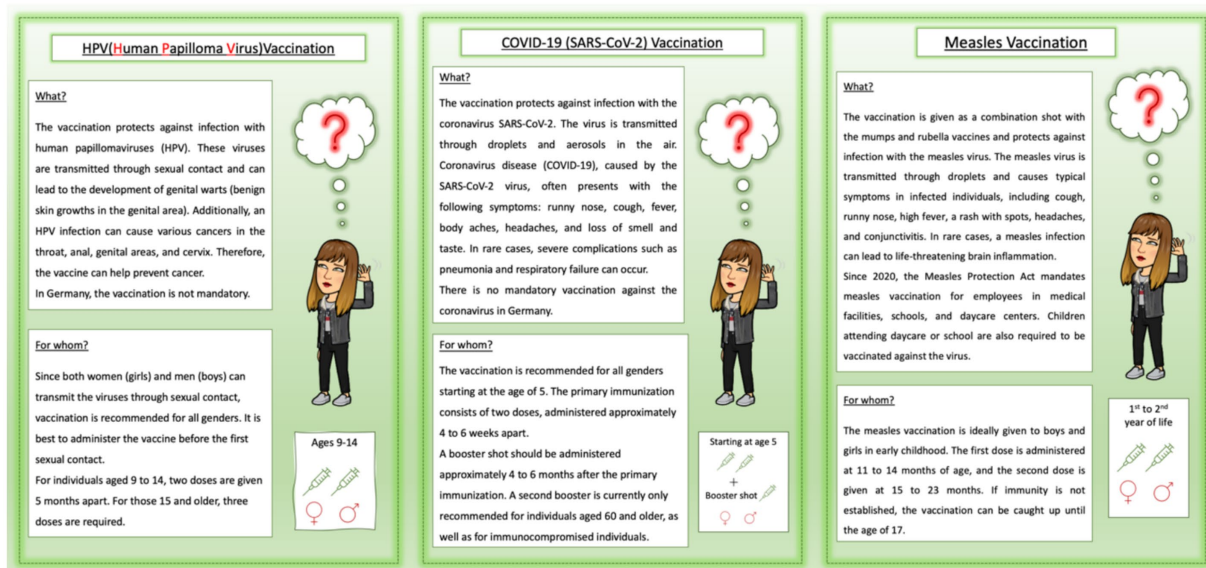


FIGURE 1

Information sheets on viruses and vaccinations (M. Schlopsna; translation from the German original).

focuses on the interest development of secondary school students from grade 9 and above. The sample of interview participants consists of a total of 12 students from two grade levels (14 years old, $N = 7$; 17 years old, $N = 5$). Purposive sampling was employed to select participants who could provide rich, relevant insights into the research topic. Participants were chosen based on their age, as they are at a stage where they should have learned about basic immunobiology (and vaccines) in school, and due to the relevance of the topic to their everyday lives, e.g., HPV vaccines in adolescence. Detailed information about the study's purpose, the importance of their participation, and the potential impact of their responses was communicated to both the students and their parents. Parental consent was obtained for all participants, and students' confidentiality was ensured throughout the process. To ensure credibility and dependability, member checking was employed by sharing key findings with participants for confirmation.

The main objective of this study was to investigate student interest and their perspective on vaccine education. Consequently, the majority of data collection was focused on students. To supplement the data, additional interviews were conducted with biology teachers ($N = 2$) who have previously taught the topic of vaccination and the immune system, as well as with medical experts ($N = 5$) from the volunteer organization "Get vaccinated!" These experts regularly visit schools to provide vaccine education. Teachers and experts served as complementary sources, providing context and a broader understanding of student responses within the framework of educational practices, observed behaviors, and classroom interactions.

The teachers were interviewed individually, while the experts were interviewed as a group due to their availability and time restrictions.

During the data collection, the method of triangulation was employed by revisiting the same aspects across different interviews—from students, teachers and experts [triangulation by data source (37)]. This approach allows for the comparison of participants' statements, which increases the validity of interpreting

similar responses. For example, teachers and experts were asked which topics, based on their experience and observation, the students find most interesting. The interviews with teachers also served to gather their experiences in teaching the subject, as well as the limitations and challenges they face—such as involving experts in the classroom. The group interview with the experts aimed to derive recommendations for designing interest-enhancing lessons on vaccination based on their experiences in classroom settings.

3.2 Data analysis

The interview data were recorded via audio and subsequently transcribed into a text file (38). Additionally, the transcripts were annotated with comments in square brackets to capture non-verbal cues such as facial expressions and gestures, like laughter, fascination, or disbelief (39).

The data were then subjected to qualitative content analysis, where the statements from the transcripts were condensed into thematic units and organized into categories [content-structuring qualitative content analysis according to (40)]. These categories were deductively derived from the research questions, with additional inductive categories created for emerging themes that had not been previously captured.

4 Results

Through data analysis, specific areas of interest and various influencing factors for the development of interest in the topic of vaccination were identified. Additionally, the respondents provided concrete suggestions for structuring lessons, including on the topic of vaccination.

To enhance transparency, the results section includes original interview quotes alongside their categorizations and interpretations (Tables 1–6). This allows readers to critically assess the data interpretation and ensures a clear, traceable link between the raw data and the conclusions. Quotes from students are marked with ‘S’, S1–S7 representing students from grade 9 (14 years old), and S8–S12 representing students from upper secondary school (17 years old). The quotes from the two teachers are marked as T1 and T2, while the expert statements are labeled E1–5.

4.1 Topic-specific interest/content aspects

When asked which topic the students found most interesting in biology class so far, human biology topics were mentioned particularly often. The students described these topics as the most exciting and memorable, citing the personal connection to their own bodies as the main reason for their interest. The tangible nature of the content also contributed to the popularity of human biology.

Half of the respondents reported having no prior knowledge of vaccination, while the other half rated their knowledge as limited, despite having covered the immune system in class. This lack of knowledge was confirmed by experts and teachers. However, the interview data show that the students want to learn more about the topic, seeing its importance both on a societal level and in relation to their own lives, especially in the context of the COVID-19 pandemic. Teachers and experts also confirmed this interest, attributing it to the personal relevance and current significance of the subject.

In summary, all students expressed an interest in studying vaccination in biology class. Their positive emotions are closely linked to the topic’s strong connection to their personal lives and health.

Certain aspects of the topic of vaccination are considered particularly interesting by the students (see Figure 2).

Approximately one-third (34%) of the statements related to interest in the topic of vaccination are connected to how vaccines work in the body. The primary reasons cited include the relevance to personal health and the connection to one’s own body.

Seventeen percent of the statements referred to student interest in vaccine development and research, with the COVID-19 pandemic and the topic’s high relevance to everyday life being the main factors driving this interest.

Social and ethical aspects accounted for a quarter (25%) of the expressions of interest, particularly in relation to misinformation about vaccination and vaccine hesitancy. Students expressed a desire to form their own opinions through better knowledge of vaccination, allowing them to more effectively assess and evaluate misinformation.

The topic of disease symptoms was also frequently mentioned, with 15% of the statements reflecting interest in this area. Experts confirm that students find this aspect especially engaging when symptoms are discussed in detail and supported by visual aids such as images.

Finally, some statements (9%) addressed special functions of the immune system and vaccinations in general.

4.2 Pathogen-specific interest

The students were asked to express their interest in three specific pathogens (Coronavirus, HPV, and Measles virus) and rank them.

The Coronavirus and the topic of the COVID vaccine were rated as the most interesting by all respondents. HPV ranked second, while the Measles virus was rated as interesting by only a quarter of the students.

The reasons for this were particularly the connection to their own bodies and daily life, societal relevance, and their own knowledge—depending on how strongly these factors were present (or not), they either fostered or hindered interest.

4.2.1 COVID-19

Nearly all of the students surveyed indicated a strong interest in the topic of COVID-19. Only one student stated that he/she did not want to learn anything about COVID-19, reasoning that the topic had been repeated and discussed so often that there was hardly anything new to learn about it.

Statements indicating student interest in the topic of COVID-19 and the COVID vaccine were most often associated with relevance to daily life and topicality. The students also mentioned finding the topic interesting because, although they already had some prior knowledge, there were still many aspects they only knew about superficially and would like to learn more about.

The strong interest in learning more about COVID-19 and the COVID vaccine was also confirmed by the teachers.

In connection with COVID, the topic of vaccine development and research was mentioned particularly frequently.

4.2.2 HPV

Regarding the topic of HPV, students reported having little to no knowledge about the consequences of an HPV infection or the vaccine. This observation was corroborated by the teachers, who confirmed that students’ prior knowledge about HPV is limited and often restricted to its association with cervical cancer.

The students mentioned that they all received the vaccination because “that’s just what you do” and because it is recommended. While they frequently observed their peers getting vaccinated against HPV, they did not engage in further discussions about it.

About half of the students expressed interest in HPV, citing personal relevance as their primary reason. The other half initially showed indifference to the topic. However, after reading the fact sheets containing additional information about HPV, the number of students interested in the subject increased.

4.2.3 Measles

Twenty-five percent of all students interviewed expressed an interest in the topic of measles. They mentioned that while they understood the dangers of contracting the measles virus and acknowledged having been vaccinated against it long ago, they had little knowledge about the disease itself. The lack of interest in measles was primarily attributed to its perceived low personal relevance and impact on their lives.

4.2.4 Other pathogens and diseases

Students also expressed a desire to learn more about exotic diseases that require vaccination, particularly those encountered when traveling abroad. One of the teachers interviewed confirmed that her students found the topic of exotic diseases and vaccinations very engaging in class, mainly due to the focus on the symptoms associated with these the diseases.

TABLE 1 Topic-specific interest in biology class (quotes from S=Student, T = Teacher, and E = Expert; the age of the students is indicated in each case).

Theme	Subtheme	Category	Example quotes
Interest in Human Biology	Personal relevance	Understanding one's own body	<i>"I think it's overall about understanding how the body works exactly. And so that I know how I function, so to speak. Because it also has something to do with me."</i> (S2, 14y.)
	Tangible content	Topics easier to visualize	<i>"I can imagine that it's simply because you could picture something, and it wasn't something like cell types or DNA, where you could not really visualize it. It was something you could actually see."</i> (S1, 14y.)
Interest in vaccination	Knowledge gaps	Limited prior knowledge of vaccination	<i>"I think we have already covered it, but not really in-depth. And there's not much that I can remember now."</i> (S9, 17y.) <i>"Usually, it's like you get vaccinated, and your parents send you there. I've been vaccinated many times, and that's it. I did not necessarily know what kind of vaccine it was."</i> (S11, 17y.) <i>"Yeah, for example, I did not know that there are different types of vaccines. I always thought they just put a little bit of the disease into your body and then the body is like, 'Ah, there's a disease.' And then it's ready, I do not know. I did not know there were different types."</i> (S5, 14y.) <i>"And that was always a signal to me that this is something unfamiliar, even though they had heard of the disease, but maybe did not really know what it was. And then they found it really interesting to hear about it."</i> (E5) <i>"It seems that at home, for some, it's not a topic either. There were those who are vaccinated, who also knew about it, especially from home. But those who were not vaccinated looked at me like, 'What's HPV?' And I mean, this was in 9th grade."</i> (T1)
			<i>"Yeah, I think I would find it quite exciting because it's something that affects all of us, because I think everyone has been vaccinated at some point."</i> (S1, 14y.) <i>"We all get vaccinated (...) and you never really knew what was actually happening in the body, so if you then learn about it in school, I think it would be very interesting."</i> (S9, 17y.) <i>"And I think it's also important because vaccinations became more relevant because of COVID. That you learn about it to see what it actually is and how it works? And why it's not necessarily dangerous. And that's why I think it's good to cover it in school."</i> (S8, 17y.) <i>"In general, I think this is always a topic that students are interested in because it directly affects them and is part of their personal environment. So, it's not as abstract as some other topics. I always had positive feedback, and they were happy to work on this topic."</i> (T1) <i>"I think it's also the public fascination with this topic. It's something that affects all of us, and everyone wants to discuss it in some way, and that's clearly reflected in the kids' reactions."</i> (E3)

TABLE 2 Vaccine aspects of particular interest to students (quotes from S = Student and E = Expert).

Theme	Subtheme	Category	Example quotes
Interest in vaccine mechanics	Biological processes	Functioning; mode of operation	<i>"I think 'How does the vaccine work in the body?' is the most interesting (...). The first question I ask myself when I get vaccinated is: 'What does it trigger in my body?'"</i> (S8, 17y.) <i>"I'm also interested in vaccination because you mostly just see the external part, like getting a shot in your arm, but you do not really get an explanation of what happens inside your body."</i> (S4, 14y.)
		Side effects	<i>"Sometimes you also get sick afterwards, or have side effects, and you do not really get an explanation of why you have those side effects or not."</i> (S4, 14y.)
Interest in vaccine development	Research and development	Process of vaccine development	<i>"I'm also interested in how a vaccine is developed. Because first, you have to figure out what it's for. And how long it takes to make a vaccine that might be effective."</i> (S4, 14y.) <i>"And especially with something like COVID, there still aren't any real long-term studies. And that's why I find it interesting how they determine whether a vaccine is worth it or not."</i> (S1, 14y.)
Interest in ethical and social aspects	Misinformation and vaccine debate	Desire to understand and form own opinions	<i>"But because there's a lot of debate about vaccinations (...) I think it's important because everyone needs to form their own opinion on it."</i> (S12, 17y.) <i>"For yourself, I think also, like how information is presented. So that you can think about it on your own."</i> (S11, 17y.) <i>"There are so many different opinions about it on the internet. And it's important to get information so that you can form your own opinion."</i> (S10, 17y.)
Interest in disease symptoms	Symptoms and visuals	Effect of visual aids	<i>"When I used to give school presentations, I always noticed that when I talked about diseases and showed pictures of them, and described what they were like and what the symptoms were, the class often got really quiet. Before, there was some rustling and whispering, but then the students suddenly became very focused and quiet and listened very attentively."</i> (E5) <i>"In our HPV topic, it was quite exciting because we also showed some images of genital warts and things like that, and that was a moment when they were like, 'What exactly is that?'"</i> (E2)
Interest in the immune system	General/basic understanding	Functioning of the immune system	<i>"That was the series on the immune system. The substance was injected so that the body could already develop the antibodies for it. I thought it was good to learn something about the immune system because then you really developed an understanding of it."</i> (S1, 14y.)

TABLE 3 Students' interest in specific pathogens (quotes from S = Student, T = Teacher, and E = Expert).

Theme	Subtheme	Category	Example quotes
Interest in COVID-19	Topicality and daily impact	Relevance of current events and research	"For me, COVID would definitely be included because it's so current." (S6, 14y.) "There's still a lot of research being done on COVID, and that's just interesting." (S2, 14y.) "Afterward, we did a small unit on the current COVID vaccines because it was, of course, exciting and something they wanted to learn about." (T1) "They found it very interesting. I mean, COVID made it even more relevant." (T1)
	Knowledge gaps	Limited knowledge on vaccine mechanics	"You already know what happens when you get COVID, but not really what exactly happens when you get the vaccine or what exactly the vaccine does. Or what causes you to be protected afterward." (S6, 14y.) "The interest was very high. The students also researched on their own and invested time at home, informing themselves about mRNA vaccines. And they also had very specific questions about it." (T2)
		Limited knowledge on vaccine development	"What I never really understood was how they approach it, like how they even come up with vaccines." (S12, 17y.)
	Lack of need	Overexposure leading to disinterest	"I think the Coronavirus has already been discussed so many times, so it's kind of been played out." (S5, 14 y.)
Interest in HPV	Knowledge gaps	Low awareness of consequences or relevance	"Yes, so I was at the gynecologist, and there's a very brief conversation just before. Um, and then an appointment is made. At least that's how it was for me. It was briefly explained that it's a sexually transmitted disease and that it would be very good to be vaccinated against it." (S4, 14y.) "We only talked about it privately. When we got vaccinated. And that it's a sexually transmitted disease." (S3, 14y.) "[fascinated] Yeah, I did not know that HPV also leads to cancer in the throat area." (S1, 14y.)
	Personal relevance	Increased interest after additional information	"Now that I know what it is, I also see the relevance in it. I also generally think that this could be a topic that might be uncomfortable for some. But I still think it's important that it continues to be de-tabooed in schools. I do not know how to say it correctly, but that topics like HPV are normalized. And since it corresponds to the age you are when you attend school, it is relevant. Personally, I did not know about the vaccine at all, and I wasn't aware of it, but now I see that it's actually important to know about it and be educated on it." (S8, 17y.)
		Age-appropriate	"And maybe also HPV, because we are at an age where the vaccine is relevant for our protection." (S1, 14y.) "Because it's very current among teenagers." (S5, 14y.)
Interest in Measles	Knowledge gaps	Little knowledge about the disease's severity and about vaccine mechanics	"Yeah, (...) and maybe also something about measles, because I do not have a clear picture in my mind. Just kids with some red spots." (S1, 14y.) "Why exactly is it mandatory, for example?" (S7, 14y.) "I did not realize that it could become life threatening after a certain period because it can also affect the brain. (...) I cannot really imagine how a vaccine helps with that. So I actually find that quite interesting." (S1, 14y.)
	Lack of personal relevance	Low interest due to perceived outdated relevance	"So, measles, (...) I feel like it's been a while since it was really an issue for us." (S12, 17y.) "It's just mandatory. With optional things, it's more interesting because then you can decide for yourself. If it's mandatory, you just have to do it anyway. And the vaccination does not really affect us much now because we got it a long time ago." (S12, 17y.)
Interest in other Pathogens	Personal relevance	Exotic diseases, e.g., when traveling	"And when it comes to vaccines in general, I would also be interested in which ones (...) because we once planned to fly to Africa and before that, we had to get a lot of vaccinations, like, uh, hepatitis or something? And, um, I would be interested in which diseases or like in different countries because in Germany there aren't that many diseases, but what different diseases are very common in other countries." (S4, 14y.)
	Symptoms	Impact of symptoms	"And I think that was just a topic that really interested them. When they saw, how does yellow fever affect you. Like how dangerous it is." (T1)

TABLE 4 Students' ideas about interest-promoting biology classes (quotes from S = Student).

Theme	Subtheme	Category	Example quotes
Student-centered learning	Station learning	Control over learning	"I think for me, I always found station learning not too bad because we worked through things ourselves step by step and could set our own pace." (S3, 14y.)
	Group work	Social learning	"Usually in biology class, you just get worksheets that you have to work on, and it's usually more fun and engaging when you do group work or work at different stations and talk to each other." (S3, 14y.)
	Student involvement in planning	Personal relevance and purposeful learning	"Yeah, I think it would be good to listen to the students themselves about how they want to learn instead of just strictly sticking to the teacher's own lesson plan [...]. Maybe just take suggestions and ideas from the students." (S1, 14y.) "I also think in general that lessons should be designed to be practical or related to everyday life. So you can better understand what it means for yourself. That makes it more interesting." (S7, 14y.) "Yeah, so you can see the purpose behind why you are learning it." (S4, 14y.)
Teacher-centered instruction	Teacher lecture	Low engagement	"What's sometimes a bit boring is when the teacher stands at the front and talks about something because you cannot necessarily follow along the whole time." (S2, 14y.)
		Overload	"It's way, way too much in class. You cannot keep up (...) I cannot keep up anymore, and then it's not fun anymore." (S12, 17y.)
Visual and experimental learning	(Hands-On) Experiments	Improved understanding	"But when you do experiments together—not anything extreme, but just things that make concepts more tangible, or sometimes even hands-on—that really helps you understand better." (S5, 14y.)

4.3 Designing vaccine education

In the interviews with students, teachers, and experts, insights were shared on how to design lessons that foster interest, including both general methodological-didactic advice and specific suggestions for teaching about vaccination. The experiences and perspectives of students and educators on engaging with experts were also explored, along with the challenges and opportunities of organizing vaccination-related lessons within the school environment.

4.3.1 Designing interest-promoting biology classes in general

Students find their biology classes more motivating when they have opportunities to work in groups and exchange ideas with one another, particularly through group work and station learning. They cited not only enjoyment but also a sense of control over their own learning process and the opportunity for differentiated learning as key reasons for this preference.

Additionally, students feel more competent when the subject matter is well-illustrated and they have ample time to engage with it. They expressed a strong desire to help shape the learning process, including the choice of content covered in class and the methods used to explore it.

Furthermore, students indicated that lessons become more interesting when they are relevant to everyday life, as it helps them see the personal significance of the content.

4.3.2 Designing interest-promoting lessons on vaccination

The topic of immunobiology and vaccination is generally perceived as complex, making the methodological-didactic approach and effective visualization particularly important, according to the interviewees.

Students find case studies especially engaging, as they help illustrate the subject matter and create personal connections to the topic. They also reported feeling more competent when they have opportunities to

apply their knowledge through transfer tasks, allowing them to explore additional aspects of the content independently.

Creative and playful approaches, such as collaborative activities and visual aids, can help simplify the complexity of the topic, fostering a more engaging and interest-driven lesson.

Give the social relevance and controversies surrounding vaccination, respondents stressed the importance of approaching the subject with factual accuracy and sensitivity. Students noted that it is crucial to ensure no one is marginalized or excluded for their views, whether by teachers or peers, when discussing the topic in class. Teachers highlighted the need to equip students with evaluation skills to help them make informed, fact-based decisions.

However, some students expressed reservations about addressing social and ethical aspects in biology class. While they acknowledged the importance of the topic, they felt that ethical debates and discussions of social issues would be better suited to social studies classes, arguing that biology should focus primarily on scientific content.

4.3.3 Opening schools: meetings and interaction with experts

The interviews also explored how interactions with experts on the topic of vaccination can foster student interest in the classroom.

Students noted that while expert presentations often contain valuable biological content, they can sometimes be too complex and not methodically engaging. The frequent use of specialized language was identified a barrier to understanding, leaving students struggling to grasp the content.

Some students also shared experiences where they felt not taken seriously by the experts, which negatively affected their interest and engagement. Conversely, expert interactions were perceived positively and as more engaging when the experts adopted an appropriate approach, making the topics tangible and accessible. This allowed even complex or unfamiliar to become understandable. Students valued these interactions with experts because they offered new perspectives and authentic insights into the subject matter.

TABLE 5 Suggestions for designing interest-promoting lessons on vaccination (quotes from S = Student, T = Teacher, and E = Expert).

Theme	Subtheme	Category	Example quotes
Complexity of vaccination topic	Need for simplification	Reducing complexity of biological content	“So, yeah. Definitely, especially because vaccinations are also like photosynthesis —you hear about it all the time, but you do not really understand it.” (S8, 17y.) “It’s a very complex topic that needs to be didactically reduced (...). So it’s not too abstract and difficult, or the students will lose motivation right away. You cannot go as deep as you might want to because it would be too difficult and also for time reasons.” (T2)
	Appropriate for higher grades	Age-appropriate learning	“It’s already very complex, the topic of immunobiology is not something that I think should be taught before grade 9. With all the different things, whether it’s T-cells, plasma cells, etc., the whole complex.” (T1)
Illustration, visualization	Case studies, personal stories	Making content relatable	“I find it really exciting when you go over old cases. For example, if you now know that there was already a vaccine back then, where everyone had to be vaccinated. And that had big effects.” (S3, 14y.)
		Relating topic to personal life	“When you have cases and deal with people, maybe in a film, who have had experiences with it. (...) Because then you can imagine it much better and relate it to your own life. You have an example in front of you and a certain idea of it.” (S3, 14y.)
Application of knowledge	Transfer tasks	Developing/ exploring knowledge independently	“They did look at something about these vaccines at some point, but when they really know exactly how mRNA is created in genetics, then they can also independently deduce, and I always let them do that. So that they can independently develop ideas about how this vaccine might work and what it actually does. And they always find that quite exciting.” (T1)
	Real-life applications	Linking different concepts	“They found it very interesting because mRNA and genetic engineering were our topics in genetics, and they could then apply that to vaccination.” (T2)
Creative and playful approaches	Quizzes, games	Interactive learning	“Like maybe doing a quiz on it and finding out a bit more about how it works.” (S6, 14y.) “Last time we also incorporated a game with drinking cups, (...) in the end, you could see that the more contacts you have, the higher the probability that you were (...) infected, so to speak. That went over very well.” (E4)
	Comics	Visual/Artistic learning	“They enjoyed creating comics. I know that always sparks great interest because it’s just a nice way to apply knowledge, to visualize it in drawings.” (T1) “(…) that you do more creative stuff. Because many learn better through creative things and visualizations.” (S9, 17y.)
Sensitive and factual approaches	Neutral and pluralistic presentation of content	Avoiding judgment or exclusion	“And you might need to be careful not to pressure them too much or say, ‘You were raised wrong!’ That’s not productive either. (...) but I think continuing to educate and present it neutrally without pushing an opinion is important.” (S8, 17y.)
		Fostering evaluation skills	“Choosing the course content so that the students can eventually form their own fact-based opinions. You were bombarded with opinions during the COVID pandemic, and that caused a lot of uncertainty. So they should be able to form their own opinions on such topics.” (T2)
Social and ethical aspects in Biology class	Inclusion is questioned	Preference for social studies	“I think that does not really belong in biology. We’ve already discussed it in religion class, but I do not think it has much place in biology.” (S9, 17y.) “I would put the social stuff more in the politics class. That’s where you could discuss anti-vaxxers and conspiracy theorists.” (S3, 14y.)
		Impact on time for scientific content	“I think the discussions [about it] are very important, but I think (...) if you also spend a lot of time on such ethical debates, then (...) you cannot do something else.” (S10, 17y.)

TABLE 6 Interest-supporting expert-student interactions (quotes from S = Student and E = Expert).

Theme	Subtheme	Category	Example quotes
Expert presentations	Presentation quality	Complex and adult-oriented	<i>"With many people, you also feel like they do not really know how to convey it. They have very interesting topics, but how to communicate it so that it's interesting but not too complex, they do not always get that."</i> (S7, 14y.) <i>"What's important when experts come is the presentation, because that's often not so interesting. It needs to be well-designed."</i> (S11, 17y.) <i>"It was a bit too adult-oriented for my taste. (...) Especially the workshops, which were not really workshops but just two-hour presentations."</i> (S5, 14y.)
		Use of specialized language	<i>"They sometimes have a different way of speaking. I do not know if they think we automatically understand it. (...) And then they thought, with that, everything was said, but they did not really consider that students or other people might not fully understand it."</i> (S4, 14y.)
Expert-student interaction	Respectful interaction	Students need to be taken seriously	<i>"The problem wasn't the language, but how they treated us. One of them spoke to us as if we were kindergarten kids."</i> (S1, 14y.)
		Understanding and patient experts	<i>"They were also more understanding. You could keep up. There was time, and you could speak up without being constantly interrupted."</i> (S12, 17y.) <i>"There were new things since we did not cover it in class, but it was okay. They always explain the technical terms and give context."</i> (S9, 17y.)
	Interaction setting	Small and intimate settings preferred	<i>"But it wasn't just our class there; it was much larger, and that's a different atmosphere, let us just say, than if it was just our class and this expert."</i> (S5, 14y.)
	Communication style	Perceived easier for younger experts	<i>"I can imagine that maybe because they do not seem as old as the teachers, and you can communicate more on the same level."</i> (E4)
Perceived value of expert engagement	Accessibility of the content	Complex content is simplified	<i>"Yeah, it was also just a bit easier than in regular class."</i> (S12, 17y.)
	Authentic and tangible insights	Real-world perspectives	<i>"It's always cool when someone from outside comes in because you get a different perspective."</i> (S11, 17y.) <i>"You also gain new insights into what everything looks like in reality."</i> (S11, 17y.)
		Research process	<i>"That the experts might guide us through the process or illustrate how the vaccine is produced, how they find it out. I find that interesting."</i> (S9, 17y.)
	Career insights	Information about careers related to the field	<i>"They were relatively open and often asked questions about medical studies. In biology courses, there are often students interested in medicine."</i> (E4)

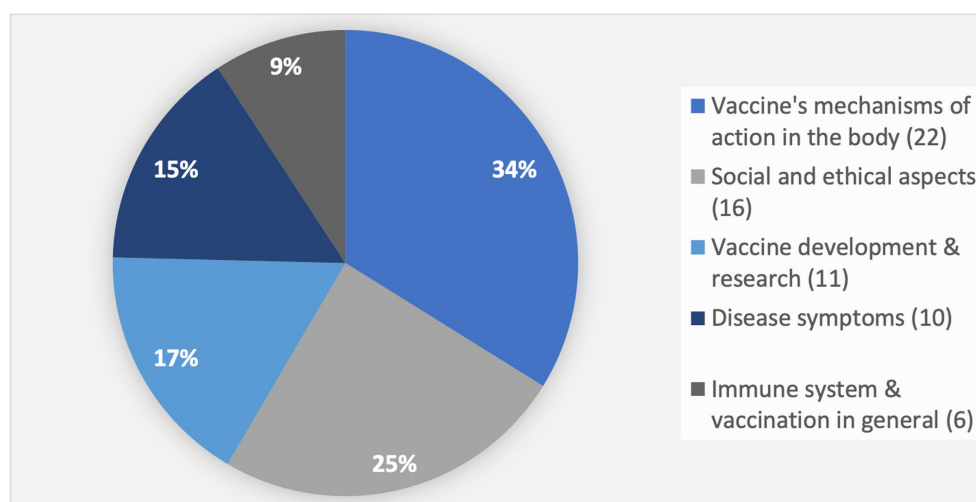


FIGURE 2
Students' interest in different aspects of the topic of vaccination (the number of respective statements is indicated in parentheses; total number $N = 65$).

Students expressed a preference for smaller, more intimate settings for interacting with experts, rather than larger public events. Younger experts, such as medical students, were perceived as more relatable and easier to communicate with, possibly due to the smaller age gap.

In terms of content, students were especially interested in learning about the experts' research and processes. From the experts' point of view, older students in particular showed an interest in careers and educational paths related to the topics discussed.

4.3.4 School organizational challenges

Teachers noted that designing lessons on vaccination is time-consuming and requires significant organizational effort, primarily because the topic is not deeply embedded in the core curriculum. This limitation prevents the extensive coverage of the topic that would be necessary for students to grasp its complexity and importance.

The preparation for such a lesson requires more time than other topics due to the lack of readily available materials from standard educational publishers, forcing teachers to search for or create content themselves.

Additionally, making the topic accessible and relevant, such as by inviting experts or organizing visits to laboratories and research facilities, involves considerable logistical efforts and coordination with colleagues. Often, there is also a lack of contacts with suitable experts who are willing to engage with students.

5 Discussion

5.1 Vaccination in school curricula

Our findings indicate that the omission of vaccination as a focused topic within school curricula results in it being addressed only superficially during instruction, leading to correspondingly low levels of knowledge among students. Although both teachers and

students consider the topic important, it currently plays only a minor role in classroom instruction within the sample studied. The surveyed teachers report that they make efforts to address the topic with their students; however, they often reach their limits due to the lack of allocated time in the curriculum and the shortage of teaching-specific materials, particularly when they aim to integrate external experts into their lessons. The involvement of experts is also occasionally hampered by the lack of relevant contacts.

To ensure the adequate coverage of vaccination in the classroom, it would be highly beneficial to more thoroughly integrate the topic into the curriculum. This would provide teachers with the necessary time to address the complexities of the subject in greater depth and also facilitate the involvement of medical experts or organize visits to laboratories and medical facilities for students. Additionally, textbook publishers would then also be more likely to develop and provide appropriate learning materials for the topic.

5.2 Students' interest in vaccination

As shown in other studies [e.g., (8, 26, 41)], students are particularly interested in human biology topics during class. Our data suggest that in the case of infectious diseases and vaccination this can be explained by the personal relevance of the subject matter and its connection to their own health. Additionally, human biology topics are perceived as tangible, which facilitates the understanding of subject content.

The topic of vaccination is generally considered interesting by students, a view that is also confirmed by teachers and experts. Students value being informed about diseases, vaccinations, and their mechanisms of action to make informed decisions. Certain aspects of the vaccination topic are particularly interesting to students: They are especially intrigued by how vaccines work in the body and by research related to vaccines. Additionally, disease symptoms are of interest, particularly when visualized or when students can relate

personally to the diseases. Ethical and social aspects of vaccination are also seen as engaging by students, especially issues like vaccine hesitancy and misinformation. Students express a desire to recognize such information and form their own opinions.

There are noticeable differences in interest concerning different diseases and their corresponding vaccines, which are linked to the topic's relevance, personal impact, symptoms, and individual agency. The students surveyed find COVID-19 more interesting than HPV and measles because COVID-19 is current and highly relevant to their lives. The cognitive component of interest is particularly strong here, as students want to understand the scientific information in order to make personal decisions about whether to get vaccinated. HPV is perceived as interesting specifically by adolescents because the vaccinations are given at this age. Despite the high personal relevance, decision-making is not the primary concern for students in relation to HPV. In the context of those surveyed, the HPV vaccination is "routinely" administered and not questioned further. As a social norm, the vaccination is considered "normal," and there is a reliance on parents and doctors. This is also reflected in very low levels of knowledge about HPV. The students surveyed find it interesting to learn that HPV can cause various types of cancers and is also relevant to boys. The novelty factor plays a role here in fostering interest. Measles is perceived as the least interesting by the respondents because vaccinations occur in early childhood. Thus, they happened long ago, and students have no influence or decision-making power regarding them, a situation further reinforced by mandatory vaccination. Consequently, personal relevance in this case is very low. A certain level of interest is sparked when students recognize the societal relevance—for example, in the context of herd immunity—or learn about measles symptoms that surprise them (novelty). Symptoms and their severity also make other diseases and corresponding vaccinations interesting, such as tropical diseases, to which there is otherwise little personal connection—except in the case of travel.

5.3 Designing interest-promoting vaccine education in school

While there is a lack of directly comparable studies on this specific topic, the interview data confirm findings related to interest-promoting education in other contexts, which recommend student-centered and activating approaches [e.g., (22, 42)]. The students' statements reveal interest-promoting factors aligned with the *basic needs*, whose fulfillment contributes to the development of interest—i.e., the need for experiencing competence, social relatedness, and autonomy (16, 18). For example, students find group work particularly engaging because it allows them to exchange ideas with peers and actively engage with the content on their own. They appreciate being able to independently and responsibly acquire content at their own pace, as is the case with station learning. Playful and creative approaches are also highly valued, especially when they promote group learning and help reduce the complexity of the topic through visualizations and illustrations. Another important point mentioned by the students in the interviews is the relevance to everyday life, which should be evident to them, as recognizing the

significance of the topic for themselves positively influences their interest. Additionally, they want to be involved in lesson planning or see value in teachers considering their suggestions and ideas in lesson design. These findings align with existing educational theories and can inform pedagogical practices in other schools and other national contexts, especially those with similar curricula and age groups.

Specifically regarding the topic of vaccination, the students' areas of interest should be taken into account and deliberately incorporated into lesson planning. This is especially important given that vaccination is a very complex subject, requiring an in-depth engagement with the content. This has been confirmed once again by the present data.

The interest and engagement with the topic are enhanced when students perceive a connection to their own lives and personal experiences, thereby recognizing the topic as relevant and important. This can be achieved in the classroom by embedding the subject matter in illustrative and authentic contexts, such as through the use of personal stories and case studies. The students expressed a desire for such concrete examples, as these make it easier for them to relate to the content. The use of (historical) case studies is also recommended by the experts interviewed and aligns with the recommendations of Reiss (4). When students learn how dangerous an infection with a particular pathogen can be, or when they can view the consequences of the disease through photos or videos, their interest is heightened. Therefore, it is advisable to specifically address the diseases and their symptoms when discussing the topic of vaccination and to demonstrate how vaccinations can help mitigate or even prevent these symptoms.

Additionally, meeting with experts can significantly foster students' interest, enhancing authenticity, practical relevance, and clarity. However, it is crucial that communication is appropriate for the audience and that the students' wishes and interests are taken into account. Moreover, students need to feel taken seriously; otherwise, their needs for a feeling of competence and social relatedness (basic needs) may not be met, which could negatively affect the development of their interest or willingness to engage with the topic of vaccination.

The interviewed students emphasize the importance of creating a respectful and trusting atmosphere when teaching about vaccination and addressing social and ethical questions, which aligns with the recommendations formulated by Reiss (9). This is crucial to prevent bullying or exclusion if some students hold different views from their peers. A factual approach is recommended in such cases, as students have found it to be particularly helpful based on their own experiences. Involving experts who are not part of the class's social dynamics and can provide practical, evidence-based information may be helpful in ensuring that the topic of vaccination is addressed in a well-informed and objective manner.

Meeting with experts can be particularly effective in fostering interest when direct contact and exchange are facilitated. In small group settings, especially with younger experts where students may feel less apprehensive, students tend to be more open and take the opportunity to ask questions. These questions may not only pertain to work processes and research but also to career paths, thereby promoting not only vaccine education but also career orientation. A positively perceived interaction between

experts and learners that positively impacts interest development requires careful planning and close collaboration between the teacher and the experts. The teacher acts as a link between the students and the experts and should be in contact with the experts beforehand to share the students' knowledge level and areas of interest. When the content and teaching methods are determined jointly with the experts, it helps ensure that students do not feel overwhelmed during the meeting and that the content aligns with their interests.

Since the topic of vaccination is both highly relevant to society and the subject of controversial debate, it is important to adequately prepare students. In addition to a solid understanding of immunobiology, they need evaluation skills to make informed and fact-based decisions. Both teachers and students alike express the need for and emphasize the importance of these skills. However, there is disagreement among respondents about when and where ethical and social aspects should be addressed in school. Some students do not see a place for this in biology class and would prefer to engage with these topics in social science subjects. This is surprising because argumentation and decision-making is explicitly included in the biology curriculum in Germany, where it is clearly stated that evaluative competencies are part of subject competence and must therefore be appropriately taught. Such competencies are “demonstrated by their (the students') understanding of both subject-specific and interdisciplinary perspectives and evaluation methods, as well as by their ability to use these to assess statements or data, based on various criteria. These competences also include the ability to form well-founded opinions, make decisions based on ethical considerations, and reflect on decision-making processes and their consequences” [(43), p. 10]. Our data suggest that this area, traditionally not embedded in the science curricula, is still not comprehensively addressed in current teaching practices.

5.4 Methods discussion

In selecting interview participants, special attention was given to including students from two different age groups. This approach was intended to provide comprehensive coverage of the school grades in which the topic of vaccination is typically addressed within the educational context. However, it is important to acknowledge that the study's findings are based on a relatively small sample size, which may limit the breadth of perspectives. Although the purposive sampling ensured rich information, the findings cannot be generalized to all students and may therefore not fully represent students in other educational systems or cultural backgrounds. Moreover, all participants held a generally positive attitude toward vaccination. While this could introduce a potential bias, it is worth noting that the attitude of the participants plays only a secondary role concerning the research question at hand.

It is also essential to consider the inherent subjectivity in both the collection and analysis of qualitative data. The responses of interviewees can be influenced by various factors, such as the atmosphere during the conversation. This atmosphere is, in turn, shaped by the relationship between the interviewer and the interviewees. For instance, if the interviewees perceive the interviewer

as likable and trustworthy, they are more likely to respond truthfully and maintain the flow of conversation (36).

Furthermore, while the analysis of the transcribed interview data was carried out using a thoroughly developed coding system, the categorization of responses can never be entirely free from subjective interpretation. Despite efforts to minimize bias through the structured use of codes, the assignment of statements to specific categories is inevitably influenced by the researchers' perspectives. To enhance transparency in this process, numerous original quotes from the interviews, along with their corresponding categorizations and interpretations, have been included in the results section. This approach allows readers to critically assess how the data were interpreted and ensures that the connection between the raw data and the derived conclusions is clear and traceable.

6 Conclusion

This study highlights the crucial role of incorporating students' perspectives into the design of vaccine education programs. Interviews with secondary school students, educators, and vaccination experts reveal that student engagement in immunobiology and vaccination topics significantly improves when educational content aligns with their interests, concerns, and prior knowledge.

Our findings indicate that students often come to the subject with limited background knowledge, leading to potential misunderstandings and disengagement. Tailoring educational approaches to address students' interests and experiences not only enhances their engagement but also improves retention of information. This underscores the need for educational strategies that do more than deliver factual content—they must connect with students on a personal level to make the topic of vaccination more relevant and compelling.

To further engage students, it is essential for educators to involve them in developing educational materials and approaches. By actively listening to and addressing students' concerns and questions, educators can create a more inclusive and effective learning environment. This approach not only educates students about the importance of vaccinations but also equips them with critical thinking skills for making informed decisions.

In conclusion, educators should consider integrating interactive and student-centered learning activities to enhance the students' interest and engagement with the topic. This includes the use of group work, which promotes peer-to-peer interaction and active learning, as well as station learning that allows students to explore content at their own pace. Incorporating playful and creative approaches, such as quizzes or creating illustrations, can engage the students and help simplify complex topics such as immunobiology and vaccines. Additionally, integrating real-world examples in the lessons and providing illustrative contexts, such as personal stories or historical case studies, is essential, as it helps students see the relevance of the material to their own lives, fostering a deeper connection to the subject matter. Expert involvement, especially through direct interaction in small groups, enhances interest and can also contribute to career orientation. Educators are encouraged to collaborate closely with experts to tailor the content and teaching approach to the students' knowledge level and interests. Lastly, to

prepare students for societal debates, such as those surrounding vaccination, it is crucial to equip them with both a solid understanding of the scientific concepts and the evaluation skills needed to make informed decisions.

Recommendations for educators

- 1 *Incorporate interactive and student-centered learning:* Engage students by integrating interactive, student-centered activities into lessons on vaccination and immunobiology. Utilize group work to promote peer-to-peer interaction and active learning, and consider station learning to allow students to explore content at their own pace.
- 2 *Utilize playful and creative approaches:* Simplify complex topics by incorporating playful, creative methods such as quizzes, role-playing, or the creation of illustrations and visual aids. These strategies enhance engagement and make challenging material more accessible.
- 3 *Connect lessons to real-world contexts:* Use real-world examples, such as personal stories, or historical case studies, to make the subject matter more relevant to students' lives. This connection fosters deeper understanding and interest in the topic.
- 4 *Involve experts for enhanced engagement:* Involve medical experts or public health professionals in teaching the topic of vaccination to provide real-world insights. Small group meetings with experts can not only deepen student interest but also contribute to career exploration.
- 5 *Collaborate with experts to tailor content:* Work closely with external experts to ensure that lesson content is adapted to the students' knowledge level and interests. This collaboration can enhance both the quality and relevance of the educational experience.
- 6 *Equip students for societal debates:* Prepare students to engage in discussions about vaccination by teaching them both the scientific facts and critical evaluation skills necessary to assess information and make informed decisions.

The insights gained from this study will contribute to the ongoing development of educational strategies and initiatives, such as the international open schooling project "Multipliers," aimed at improving science education and public health outcomes. By focusing on student-centered communication and the collaboration between schools and medical professionals, we can enhance the effectiveness of vaccine education and ultimately support the broader goal of increasing vaccination rates and public health awareness.

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the University of Bonn, Eckhard Wesemann & Thomas Rütten. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MS: Writing – original draft, Data curation, Formal analysis, Investigation. AS: Conceptualization, Methodology, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This publication received support under the EU project Multipliers which has received funding from the European Union's Horizon 2020 Research and Innovation Programme under the Grant Agreement No. 101006255. This work was supported by the Open Access Publication Fund of the University of Bonn.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 18 May 2024

ACCEPTED 29 October 2024

PUBLISHED 06 December 2024

CITATION

de Gaspi S, Magalhães Júnior CAdO,
Tracana RB, Schneider EM and
Carvalho GS (2024) Vaccination: a look at the
social representations of Brazilian children.
Front. Public Health 12:1434513.
doi: 10.3389/fpubh.2024.1434513

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Vaccination: a look at the social representations of Brazilian children

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Introduction: The pandemic caused by COVID-19 has accentuated the debate on the need for vaccination and called into question the need to increasingly bring this topic, which is widely disseminated in the scientific world, to school classes at all schooling phases. In this scenario, science education plays a key role in disseminating knowledge about the importance of vaccination and the impacting factors of a lack of immunization. In order to better understand this movement, it is necessary to understand the representations of individuals as a way of broadening paths to change this scenario.

Objectives: This study aimed to identify and analyse Brazilian primary school children's social representations of vaccination.

Methods: Using the free word recall technique, the term "vaccination" was applied to evoke children's ideas. The analysis of co-occurrences of evocations permitted us to identify their representations' centrality.

Results: The results showed that the centralizing elements guiding these children's social representations were "needle," "pain," and "health center."

Conclusion: These results show the need to prevent the phobia of needles that arises in the first vaccination experiences and reinforce the importance of discussing the subject of vaccination in science teaching. This issue is even more critical, given the spread and impact of "fake news" on social media. There is an increasing need to emphasize the importance of vaccination, not only as a factor of individual protection but also as a commitment to collective health. This study also showed that the school, as usual, must become an ally in tackling this reality with children and their families.

KEYWORDS

central core, immunization, science teaching, anti-vaccination, health

1 Introduction

1.1 The origin of vaccination and its social and educational implications

It was a long time before humans discovered a cure for certain diseases through vaccination. The first human vaccine did not emerge until the 18th century through the doctor Edward Jenner during the smallpox outbreak (1). His discovery of immunization was criticized and mistrusted by many medical scholars and scientists. It was only overcome when

his studies showed the smallpox vaccine's effectiveness. Since then, society has realized that strengthening people's immune systems is an important part of any health programme. Jemmer, in 1789, gave the health sector a relevant step forward in developing other vaccines (2, 3).

However, despite the proven benefits to human and collective health, many European movements emerged in the 1900s against vaccination (4). One justification was that the idea of compulsory mass vaccination would violate the principle of individual liberty, which was one of the ideological pillars of the 18th-century French Revolution. Similarly, in Great Britain, in 1860, the Anti-Vaccination League and Compulsory Vaccination raised doubts about the efficiency of the smallpox vaccine itself (4). The fight against disease relies not solely on society's complex understanding of science but on each person's understanding (5). This condition has led many social organizations, particularly those that manipulate social masses, to promote mistrust about the reliability of scientific experiments, discoveries, and results. Its effects vary according to society's structure, considering its political, social, and cultural contexts.

The controversial issue of vaccinating people also reached the US Supreme Court in 1900. In 1905, the US government authorized many states to create a set of actions to vaccinate their population and have the vaccination instrument incorporated into public health policy (4).

Just as the vaccine was criticized worldwide, it was no different in Brazil. From the imperial period (starting in 1882) onwards, the country began to have developmentalist ideals in favor of industrialisation and the expansion of cities. The Brazilian political play to building a modern nation saw several social movements that are important for understanding the historical context of the Brazilian vaccination system, such as the Vaccine Revolt in 1904 (6). Since then, a lot has happened, and nowadays, the vaccination issue has become part of the routine of world society and Brazilian society, primarily due to the COVID-19 pandemic. Since the vaccine revolt and intense health struggles, from the 1970s onwards, Brazil has seen relevant public policies in defense of individual and collective health, such as the birth of the "National Immunization Plan" (7).

Despite the availability of essential vaccines to protect children and adolescents, Brazilian society has been slow to recognize the importance and effectiveness of vaccination. For this reason, the federal government, together with the states and municipalities, created policies that reinforced the compulsory nature of vaccination as a factor in accessing various social benefits.

Among the policies instituted to expand access to the vaccination schedule was the birth of the "Child and Adolescent Statute," which made it compulsory for children to be vaccinated in the cases recommended by the health authorities. This instrument would make vaccination a right for children and young people (8). Although many controversies can lead to very conflicting scenarios about vaccination in Brazil, vaccination should not be seen as an obligation but as a declared right for the "Child and Adolescent Statute" itself; however, there is no question about this. Parents who do not follow the vaccination schedule established by the Ministry of Health can be held responsible.

Perceived as an important public health process, the vaccination process should be current not only in the health field but also in the education field. The pedagogical understanding of the subject must articulate a set of educational actions and guidelines to strengthen the theme, especially in Science Education. In this sense, one of the

objectives highlighted in the Brazilian "National Curriculum Parameters" for the 4th and 5th grades of Fundamental Education is to "Identify the body's natural and stimulated defenses (vaccines)" (9). In the "National Curriculum Parameters" referring to the contents for the subject of Natural Sciences, in the thematic block "human being and health," it is emphasized that:

[...] it is possible to treat the immune system as the body's natural defense mechanism, which can be stimulated by vaccines, against the action of foreign elements. The variety of vaccines, their correct usage, modes of operation, and the importance of vaccination campaigns can be investigated through interviews with health agents at healthcare centers in the region.

[...] establishing connections between body health and the existence of natural and stimulated defenses (vaccines) (9).

This concern in Science Education is also reinforced by the compulsory Brazilian National Common Curricular Base, considering that by the end of Elementary Education, students should be capable of understanding the role of the State and public policies, especially on relevant aspects in health education such as vaccination campaigns, family and community health care programs, investment in research, awareness campaigns about diseases and vectors (10).

Indeed, building knowledge becomes important to counter distorted concepts about science, as has happened by some public authorities and other parts of society regarding vaccination (11). With school-based campaigns, students armed with knowledge and skills can build solid and reliable references to strengthen the field of science and become disseminators of scientific knowledge beyond the classroom walls (11).

2 COVID-19, "fake news" and social representations

Despite the historical context reinforcing the importance of the immunization process and the debate on the subject in the most diverse social contexts, the play of interests of dominant groups has meant that the production of knowledge has often responded to issues of power and capital accumulation and has put scientific production in check, as well as spreading misinformation, such as the case of the Vaccine Revolt in 1904, which raised doubts about the effectiveness of the vaccine, not unlike what happened in a recent context with the COVID-19 vaccine by the Brazilian Federal Government (6, 12).

The advent of social media has amplified movements that cast doubt on the efficacy of vaccination, promoting the spread of so-called 'fake news' through these platforms. This has led to the daily dissemination of news and information riddled with misinformation, particularly about health and vaccination. This trend, lacking a scientific basis, has significantly harmed public health, especially by influencing individuals not to vaccinate (13).

Saraiva and Faria (11), in 2019, state:

[...] Fake News has affected the most diverse areas of people's lives, from politics to public health. Recently, fake news about the Poliomyelitis and Triple Viral vaccines and their supposed relationship with autism fueled campaigns called the Anti-Vaccine

Movement, in which parents of newborn children claimed that they refused to vaccinate their children. The scale of what happened was so grand that it triggered the reappearance of diseases already eradicated, with cases in Europe, the United States and Brazil.

Such movements cast doubt on the vaccine's efficacy and cause a drop in the number of immunized individuals in the country. Indeed, seven of the nine vaccines indicated for babies had the worst coverage rates in Brazil in 2019, at least since 2013 (14). The Ministry of Health in 2020 also reported that none of the vaccination coverage targets available under the "Childhood Immunization Programme" were met (15). In this respect, the Butantan Institute (16) recognizes that eradicated diseases can return due to a lack of immunization.

All the above encouraged us to better understand this process by understanding people's representations of vaccination. For this purpose, the Theory of Social Representations (SR) was applied. Social representations are part of ways of life, relationships, and individual or collective issues. Through social change, SR interpret concepts emerging from a historical context (17).

This Theory of SR was proposed by Moscovici in 1961 in his book "Psychoanalysis: Its Image and Its Public" (18). He understood that scientific and technological knowledge from thinking, dominant and elitist groups should not be prioritized, i.e., popular knowledge should also be the subject of SR study. In this sense, how one would try to explain the world and social objects would not only bring as a response a reproduction and duplication of concepts by society but rather how it reconstructs and represents the scientific knowledge in its daily life (19). Moscovici (20) explains that:

[...] social representation is an organized corpus of knowledge and one of the psychic activities from which men make physical and social reality intelligible, insert themselves into a group or into a daily exchange relationship, and liberate the power of their imagination.

This Theory has four main approaches (21): (i) Cultural/Anthropological and Sociogenetic, with Moscovici (20) as precursors; (ii) Structural Approach proposed by Abric; (22) (iii) Societal/Sociodynamic by Doise (23); and finally, (iv) the Dialogical, as proposed by Marková (24). In the present study, we embraced the structuralist approach (ii), which seeks to understand how social representation structures (central nucleus and peripheral system) are organized and how individuals use them to make sense of the world around them. This structuralist approach, originating in the 1970s, "was developed from the hypothesis that suggests that every representation [...] is organized in such a way that, at its Centre, are the elements that give meaning to this social representation" (25). From this perspective, every social representation is organized around a Central Nucleus (CN) and a peripheral system (PS). The CN is represented by the group's collective memory (26).

Therefore, the CN carries the group members' shared values, beliefs, behaviors, and actions towards a certain object and is the fundamental element in the structuralist-based SR study approach: "[...] it is the change of this core that will indicate a change in the SR, just as it is the difference between cores that allows us to characterize two social groups as distinct in relation to an object" (21).

Considering that SR allow us to understand how people think, act, and feel and how they symbolize their social context in the face of a certain object, we understand it as an important way to understand the vaccination issue. Given the seriousness of the topic regarding individual and collective health and the widespread need to discuss vaccination in the educational context, this study aims to investigate the children's social representations in the early grades (5th grade) of Fundamental Education on the vaccination topic. This group's choice is anchored in Moscovici (27), who assumes that young children already have direct contact with SR, as they are immersed in social phenomena like adults. Furthermore, Barra Nova (28) elucidates that when belonging to the same social group, children can carry relevant information about the context in which they are inserted and about the elements that make up their subjectivity. As members of the collective, we understand the importance of children as "active agents in society, who build their own representations and, at the same time, contribute to the production of the adult world" (28), which, therefore, makes them very suitable to the present study.

3 Methodology

A sample of 20 students from a 5th grade classroom of a municipal school in the north-western region of Paraná, Brazil, was selected to study children's social representations of vaccination as they can communicate through writing and are social subjects who "interact with people and institutions, react to adults and develop strategies to participate in the social world" (28). When asked for authorization to conduct this research, the Municipality's Education Department suggested this school. Subsequently, the parents' authorization was also requested, and the participants agreed to participate voluntarily. For the collection of SR, the free word evocation technique (29) was used to evoke free terms about "Vaccination" (30). This technique was not just chosen but meticulously selected because the most representative elements of an SR are the most accessible to consciousness and, therefore, easier to access (21, 31, 32). Thus, students were asked individually, without any reference material or dialogue with their peers and teacher, to write down the first five words that came to their mind regarding the term "Vaccination" and then rank them from one to five, with number one being the most relevant and number five being the least relevant. This process was not just a step but a crucial contribution to the respondents reassessing their choice of promptly evoked terms. Finally, the students were instructed to justify the choice of each term in a short text to "give analytical density to the evocations" (33).

This data collection technique is based on verbal expression to understand what the subjects verbalize, i.e., what is verbalized is important, as well as the order in which it occurs (21). Furthermore, the term order provides the level of salience as the more promptly a word is evoked, the greater its representativeness will be within its social group (34).

After the data collection, the evoked terms were organized into spreadsheets and divided into semantic groups. Words evoked only once and that did not fit into any group were discarded as they were not considered relevant for the representativeness of the group (35). The data were then subjected to analysis using the Iramuteq software. Initially, the prototypical analysis was conducted to identify the Central Nucleus of the social

representation based on Abric’s structural approach (22). The software performs a cross between Frequency (F) and the Mean Order of Evocation (MOE), the result of which composes the four-box frame (36). This Abric’s methodological approach enables the comparison of the central nucleus of different social groups on the same object (21).

Indeed, prototypical analysis is the first phase of a deeper analysis of word co-occurrence and organization that allows for identifying the CN of a social representation (37). However, despite its relevance, it is recommended to use complementary analyses that may present more refined and conclusive results (21, 34, 37, 38). Among the possibilities for confirming the centrality of the elements, the similarity analysis (39, 40) was carried out, also with the Iramuteq software assistance. This technique was developed by Flament and pointed out by Sá (29) as “the main technique for detecting the degree of connectedness of the various elements of a representation.”

Thus, similarity analysis helps understand the connections between the evoked terms arranged in the CN based on their associative capacity; the maximum similarity tree displays vertices and edges that interconnect them (41). The circular images represent the vertices whose radius illustrates the frequency of each evoked term. The larger the frequency of the evoked term, the larger the vertex (radius). The connection between the terms is demonstrated through the edges, indicating the co-occurrence value, that is, the number of times the respondents mentioned two terms together (the thicker the edges, the higher the correlation between the terms).

The association of prototypical and similarity analyses enables the understanding of the terms that present greater symbolic value for the researched social group and, in turn, expresses the term polysemic character, which can have different meanings in different SR due to the psychological, political, historical, cultural, or social nature to which the message content is associated (41).

4 Results and discussion

The sample of 20 students from the 5th grade of primary school comprised twelve boys and eight girls aged between 9 and 12.

From the children’s evocations of the inductive term “Vaccination,” 86 words were recorded, of which most of the children (13) evoked the requested five words, but some did less: one child wrote 4 words, five children 3 words, and one child only 2 words. The words evoked were analysed semantically and then submitted to Iramuteq software. The collection of words evoked for the term “Vaccination” generated 16 groups, whose mean Frequency (F) was 4.44 and the Mean Order of Evocation (MOE) was 2.75. The Vergès Diagram was constructed using these values, delimitating the four quadrants with their respective groups that comprise the SR (Table 1).

Table 1 shows the groups of words that make up the CN because they are the most readily evoked and accessible to the subjects (34). When grouped semantically, the “Needle” group represents the words evoked by children who readily associate the vaccine with inserting a needle into the body. This group was among the most evoked words, with a frequency of 9 and an OME of 2.60. The subsequent group, “Pain,” had an F of 9 and an OME of 2.30.

These two most readily evoked groups associate vaccination with the act of “getting needles” and the feeling of discomfort caused by this action. This relationship is evidenced through these extract examples:

TABLE 1 Elements of the social representations of 5th grade students regarding the inductive term “Vaccination.”

Central elements - 1st quadrant			Intermediate elements - 2nd quadrant		
High F and low mean order of evocations			High F and high mean order of evocations		
$F \geq 4.44$ MOE < 2.75			$F \geq 4.44$ e MOE ≥ 2.75		
Semantic group	F	MOE	Semantic group	F	MOE
Needle	9	2.6	Healthcare professional	6	3.2
Pain	9	2.3	Syringe	5	5.3
Protection	8	1.9			
Health Centre	6	2.7			

Intermediate elements - 3rd quadrant			Peripheral elements - 4th quadrant		
Low F and low mean order of evocations			Low F and high mean order of evocations		
$F < 4.44$ e MOE < 2.75			$F < 4.44$ e MOE ≥ 2.75		
Semantic group	F	MOE	Semantic group	F	MOE
Importance	4	2.50	Cure	4	2.8
Health	3	1.70	Medicine	3	3.3
Vaccine	2	1.00	Fear	3	3.3
			Cotton	3	5
			Dizziness	2	4
			Agony	2	4
			Sickness	2	3.5

“The needle is to put the vaccine inside our body”; “The needle is to pierce my arm”; “The needle injects the liquid into my body.”

Similarly, in children’s conceptions, the term vaccination is also associated with “Pain.” This interpretation can be better understood in these quotes: “It hurts to get vaccinated”; “When I get vaccinated, my arm hurts a lot”; “Some vaccinations hurt a lot.”

This greater frequency of the elements “needle” and “pain” led us to consider that the children associate the act of being vaccinated with a traumatic moment motivated by their anxiety. Indeed, children often respond in advance with anxiety and panic prior to the vaccine, which can increase suffering (42).

Furthermore, part of this behavior can be stimulated by their parents. In fact, a report by Target Saúde (43), based on an American study, indicates that there is a strong relationship between children’s anticipated fear of vaccination and their parents’ behavior, which sometimes influences their fear long before vaccination. If not worked out in childhood, this fear can also contribute to non-vaccination in adulthood (43).

This scenario was the basis for our proposal to understand children’s representations of vaccination by learning about their shared ideas, thoughts, images and knowledge of a group, in other words, whether children are influenced by their socio-cultural context. If the role of social representations is also to situate objects, people and events in the context of a community (44), then by knowing children’s understanding

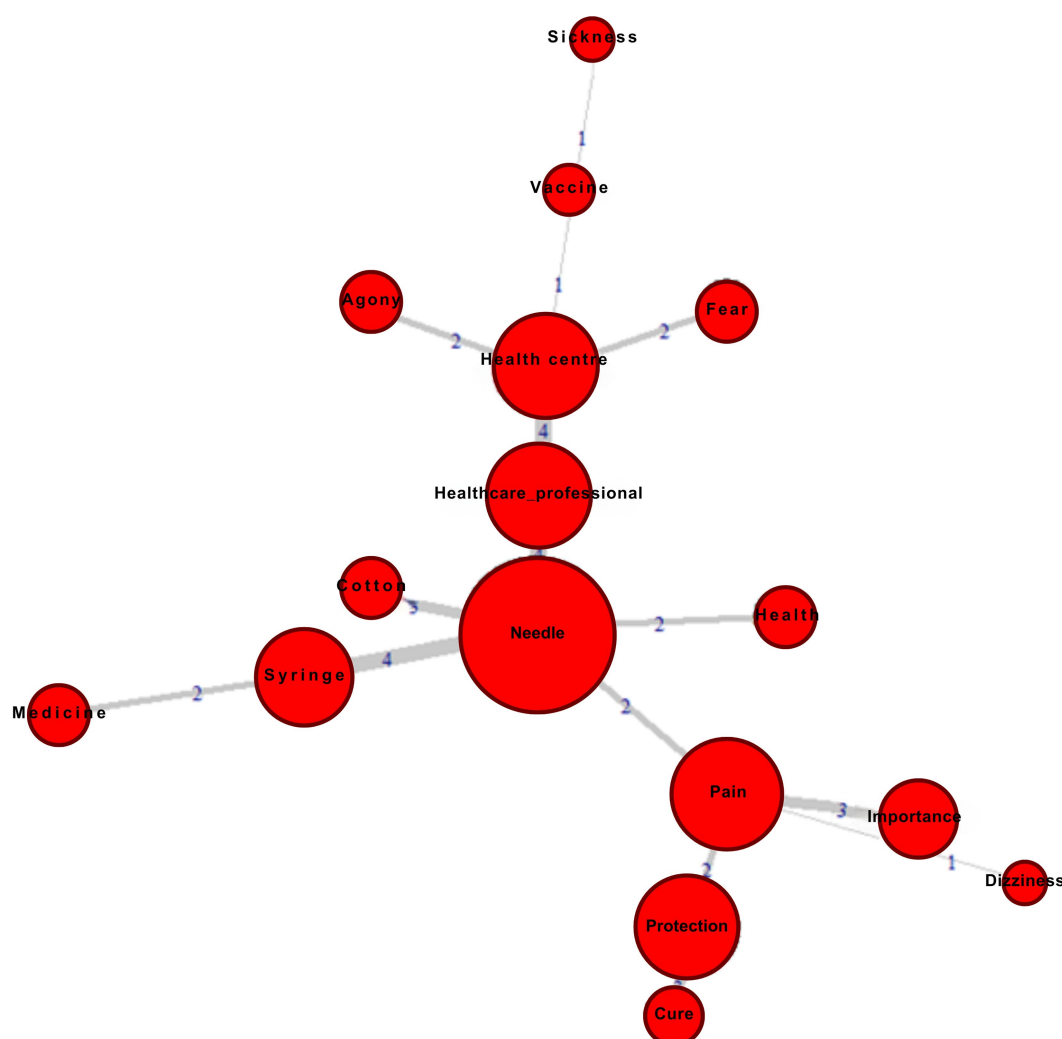


FIGURE 1
Maximum similarity tree of students in the 5th grade of primary school for the inducing term "Vaccination".

of their consensual universe, it is also possible to understand part of the context shared by adults and the school environment in which they live.

Also included in the possible CN are the "Protection" group, with a frequency of 8 evocations and an OME of 1.90, and the "Health Centre" group, with a frequency of 6 and an OME of 2.70. Despite having a lower frequency than the previous groups, these two groups indicate that children understand vaccination as the "Protection" of life, as suggested by the following statements: "The vaccine protects us from the flu"; "The vaccine is important to protect us from dengue fever"; "You have to take it to be safe." For the "Health Centre" group, the justifications refer to the geographical area or localization where they undergo the vaccination process.

This nuclear composition may strongly relate to the historical, social moment that society was sharing with the Covid-19 pandemic. However, although the children recognize that the vaccine is important, part of their justifications associate the act of immunization with some common diseases, such as the flu and dengue, as shown in the example above, with little regard for the fact that the vaccine also protects against various diseases throughout life, from childhood to old age.

This situation is also clear in the passage "Vaccines are to protect children," as if protection is only aimed at a specific age group and not society as a whole. This misconception can be gradually changed through scientific literacy that promotes an understanding of immunization as a social importance. "The topic of vaccines can be very stimulating for science teaching and opens up space for discussion of various topics from a multidisciplinary perspective and inserted into the lives of students" (45).

To check the centrality of the elements in Table 1, data were subject to Similarity Analysis, where the maximum tree is displayed in Figure 1. This analysis aimed to help deepen the study of the representational structure (46). Furthermore, this strategy also acts as a "real proof" of the four-house table in an illustrative way (21).

As expected, the similarity analysis also showed that the centralizing elements of children's social thinking were "Needle," "Pain," and "Health center," with the element "Needle" standing out as a link that relates to the other blocks. In contrast, the "Protection" element, although having a high frequency compared to the other three elements and being in the CN of the prototypical analysis, does not manifest centrality because it does not give rise to new branches (39).

Based on both analyses (prototypical analysis and similarity analysis), it becomes clear that the children's SR "Protection" group focuses particularly on the "act" of being vaccinated and the environment surrounding this moment (needle, pain, and health center) and not on the importance of vaccination itself for individual and collective health.

This situation raises important questions such as: are we effectively educating our children about the importance of vaccination? After all, if the act of getting vaccinated is more widely represented than the importance of getting vaccinated, then it is up to the school, through scientific knowledge via science teaching and health education, to address and change this process right from the early primary school years.

Indeed, regardless of age, vaccinations are part of everyone's life, and everyone lives (or should live) with the vaccination experience. In this context, Cunha and colleagues (45) state:

[...]what else do people know about vaccines? Do they know how vaccines work in our bodies? And do they know how the scientific knowledge that culminated in the invention of the vaccine was constructed? How can the topic of vaccines be helpful for science education? [...] school is a privileged place to start building this path.

Therefore, everyone, regardless of age, must have the scientific knowledge to maximize their understanding of the importance of vaccination to the detriment of the process. Promoting health education is crucial for placing children in a social context that guides them to implement health protection measures and can turn them into information agents in their family environment (47).

5 Final considerations

Many challenges have been faced throughout history in the scientific, social, political and technological fields so that today's society can have access to vaccines. However, despite the historical context, there are still families who prefer not to vaccinate their children. This sad reality has led to the reappearance of previously eradicated diseases and an increase in the number of unimmunized people around the world. This situation has been maximized following the advent of social media and the spread of the so-called "fake news" on vaccination.

Therefore, it is necessary to understand this process better and what guides it. This is why this study aimed to investigate the social representations of a social group of children about "Vaccination." The results allowed us to understand that children carry representations suggesting the act of being vaccinated rather than the importance of vaccination for health. These results reinforce the importance of discussing the topic of vaccination in the school context, especially in science teaching, especially in the face of the explosion of social networks and the spread of false news.

In addition, schools need to become allies in tackling this reality with children and their families and reinforce the importance of vaccination, not only as an individual protection factor but also as a commitment to collective health and social transformation.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Comitê Universidade Estadual de Maringá. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

SG: Writing – original draft, Writing – review & editing, Conceptualization, Formal analysis, Methodology, Validation. CM: Writing – original draft, Writing – review & editing. RT: Writing – original draft, Writing – review & editing. ES: Writing – original draft, Writing – review & editing. GC: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work was financially supported by Portuguese national funds through the FCT (Foundation for Science and Technology) within the framework of the CIEC (Research Centre on Child Studies of the University of Minho) projects under the references UIDB/00317/2020 and UIDP/00317/2020.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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OPEN ACCESS

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RECEIVED 28 June 2024

ACCEPTED 31 October 2024

PUBLISHED 24 December 2024

CITATION

Pauly L, Residori C, Bulut H, Bulaev D,
Ghosh S, O'Sullivan MP, Fritz JV,
Vaillant M, Rommes B, Samuel R, Satagopam VP, Krüger R and Leist AK (2024)
Lessons learned from the COVID-19
pandemic: identifying hesitant groups and
exploring reasons for vaccination hesitancy,
from adolescence to late adulthood.
Front. Public Health 12:1456265.
doi: 10.3389/fpubh.2024.1456265

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Lessons learned from the COVID-19 pandemic: identifying hesitant groups and exploring reasons for vaccination hesitancy, from adolescence to late adulthood

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Introduction: The COVID-19 (COronaVirus Disease-2019) pandemic highlighted the importance of assessing the rationales behind vaccine hesitancy for the containment of pandemics. In this nationwide study, representative of the Luxembourgish population, we identified hesitant groups from adolescence to late adulthood and explored motivations both for and against vaccination.

Methods: We combined data collected via online surveys for the CON-VINCE (COvid-19 National survey for assessing Vlral spread by Non-affected CarriEr)s study, 1865 respondents aged 18–84, and for the YAC (Young people And Covid-19) study, 3740 respondents aged 12–29. Data from both studies were harmonized and weighted to ensure a sample representative of Luxembourg's resident population. The surveys included information on demographic and socio-economic factors as well as vaccination hesitancy.

Results: At the time of the survey, 67.0% of respondents had been vaccinated against SARS-CoV-2 (Severe Acute Respiratory Syndrome COronaVirus-2), while 33.0% of the respondents had not yet been vaccinated. Of those not yet vaccinated, 41.8% of respondents were vaccine hesitant. The most important concerns against vaccination were that the vaccine had not been tested sufficiently (59.4%) and the fear of side effects (52.4%). The most frequent reasons for vaccination were to help society overcome the pandemic (74.8%), and to protect oneself from the consequences of infection with the virus (69.3%). The proportion of unvaccinated respondents unwilling or undecided to get vaccinated was higher in the younger age groups compared to the higher age groups.

Conclusion: Our findings contribute to improving public health policy communications, not only for future pandemics but also for routine vaccination campaigns. This will help reach those who are unwilling (26.7%) or undecided (15.1%) about vaccination and reinforce strategies that have successfully increased vaccination willingness.

KEYWORDS

vaccine education, health promotion, public health, vaccination hesitancy, vaccination willingness, COVID-19, immunity

1 Introduction

In the context of the COVID-19 (COroNaVIrus Disease-2019) pandemic, vaccination played a crucial role in enabling society to return to a normal pattern of life and in maintaining this normalcy during future seasonal outbreaks. After the declaration of the SARS-CoV-2 (Severe Acute Respiratory Syndrome CoronaVirus-2) virus outbreak as a pandemic by the World Health Organization (WHO) in March 2020 (1), COVID-19 vaccines were developed rapidly and proved to be highly effective. Studies have demonstrated that vaccine effectiveness varied across different waves of the pandemic (2). A recent WHO/Europe study revealed that COVID-19 vaccinations were associated with a significant reduction in mortality, saving over 1.6 million lives. Most of these lives were saved during the period when the Omicron variant was dominant, from December 2021 to March 2023 (3). In Luxembourg, the context of our study, roughly half a year after the first administration of a COVID-19 vaccine at the end of December 2020 (4), all adult residents had received an invitation for a free vaccination against SARS-CoV-2 by July 07, 2021 (5). Invitations for 12- to 17-year-old residents were sent from June 28, 2021 onwards (6) (Supplementary Table A.2). Without a legal framework for compulsory vaccination, the success of vaccination campaigns depends on individual willingness to be vaccinated. Previous surveys have shown high COVID-19 vaccination willingness in Luxembourg, with 82 to 86% of the adult population willing to be vaccinated against SARS-CoV-2 in mid-2021. The numbers were similar in Germany (85%) but slightly lower in France (79%) (7–9). Despite this high reported vaccination willingness and the easy access to vaccinations via numerous vaccination centers, data (October 05, 2023) from the European Centre for Disease Prevention and Control (ECDC) statistics show that only 72.7% of the total Luxembourgish population are fully vaccinated against SARS-CoV-2 (primary course). This vaccination rate is slightly below European Union (EU) / European Economic Area (EEA) average of 73.0%. With a higher proportion of the Luxembourgish population (57.9%) obtaining an additional first “booster” dose, compared to 54.8% in the EU/EEA (10).

Despite vaccination being recognized as one of the most successful public health interventions, some groups of individuals are skeptical and choose to delay or refuse vaccines. The Strategic Advisory Group of Experts on Immunization (SAGE) Working Group on Vaccine Hesitancy defined vaccine hesitancy as delay in acceptance or refusal of vaccination despite availability of vaccination services (11). In Luxembourg, surveys done in mid-2021 revealed that 13 to 14.5% of respondents did not intend to get vaccinated against SARS-CoV-2. Numbers on vaccine reluctance were similar in Germany (13%) and considerably higher in France (21%) (7–9).

To increase vaccination rates in the context of an epidemic or pandemic, public health messaging needs to target those who are undecided about vaccination, as this population may be convinced to be vaccinated compared to those unwilling to get vaccinated. Against this backdrop, we aimed to explore motivations for and against vaccination, from adolescence to late adulthood drawing on a

representative sample of residents across Luxembourg. Our results can help adapt public health policy communication in future pandemics, to reach those unwilling or hesitant to be vaccinated, and to reinforce those strategies that may increase vaccination confidence.

2 Materials and methods

2.1 Study design and participants

This study analyzes data collected from two studies using harmonized survey questions.

The recruitment of young participants from 12 to 29 years of age took place within the framework of the YAC (Young people And Covid-19) study, a nationally representative study about young people and COVID-19, aiming to identify the social, economic and health consequences of the pandemic in the younger population. A sample of the resident population stratified by gender, age and canton of residence, was drawn using simple random sampling from the National Registry of Natural Persons (RNPP) for the YAC 2021 cross-sectional survey (12). A total of 3,740 respondents participated from August to September 2021.

The recruitment of participants aged 18 to 84 years, took place in the framework of the nationally representative observational CON-VINCE (COvid-19 National survey for assessing VIRal spread by Non-affected CarriErs) study, aiming to evaluate the prevalence of SARS-CoV-2 infections in the adult population. The sampling strategy aiming for representativeness of the Luxembourgish population was based on stratification by gender, age, and canton of residence and was realized in collaboration with a specialized survey company (TNS-ILRES) within their respondent panel. The full CON-VINCE study protocol and cohort have been reported in detail elsewhere (13). Participants of the CON-VINCE study were followed up for over 12 months. In the current study, we analyze and discuss the latest follow-up assessment between April and June 2021 with a total of 1,578 respondents.

2.2 Data protection procedure

In the YAC study, in collaboration with the Centre des Technologies de l'Information de l'État (CTIE), individuals from a proportionally stratified random sample, registered at the RNPP were selected and received a sequential identification number. Selected individuals were contacted by the CTIE via personalized postal invitations. In the invitation letters, selected respondents were informed about the aims of the project and the data protection guidelines. Data was collected using a secure web interface hosted by QualtricsXM and stored on secure servers at the University of Luxembourg.

In the CON-VINCE study, participants were recruited in collaboration with the survey company based on a large representative panel of residents of Luxembourg. To allow data collection in a pseudonymized manner, a persistent identifier was assigned to each

participant. Data were collected via a secure web interface and were stored on a secure data platform at the Luxembourg Centre for Systems Biomedicine (University of Luxembourg).

2.3 Ethics

The YAC study was approved, as required for social sciences surveys conducted by the University of Luxembourg, by the Ethics Review Panel. Ethics approval was obtained for the study on 18 June 2021 (20-041-C-A (YAC+ (amendment 1))). In accordance with current regulations, the Commission Nationale pour la Protection des Données was notified prior to conducting the study. On the survey platform, all selected respondents gave consent before filling out the questionnaire (i.e., they had to explicitly agree to the privacy terms and conditions of the survey). The survey's data protection policy was provided in French, Luxembourgish and German. For respondents below the age of 16 the consent of the respondents' legal guardians was ensured by sending the invitation letters to them. As an incentive, vouchers worth €10 were offered to the first 2,000 participants upon completion of the questionnaire. Respondents were not requested to provide personal details for receiving the vouchers at any time (12).

The CON-VINCE study was conducted according to the Ethical Principles for Medical Research Involving Human Subjects, as stated in the 2013 revised version of the 1964 World Medical Association Declaration of Helsinki and registered under clinicaltrials.gov under NCT04379297. The national research ethics committee (Comité National d'Ethique de Recherche, CNER) and the Luxembourgish Ministry of Health (references 202004/01 and 831x6ce0d, respectively) approved the study. All participants completed an electronic informed consent form and had the right to withdraw from the study at any time. Further details are described in Tsurkalenko et al. (13).

2.4 Measurements

The surveys of both studies included questions about demographic and socio-economic information and information about vaccination willingness/hesitancy and their vaccination status (at least partially vaccinated). Both studies used the same questions regarding vaccination.

The reasons for vaccination willingness were asked using the question: "What are the reasons why you will agree to get vaccinated against coronavirus/COVID-19?" followed by 8 reasons that could be selected if they apply (Table 1).

The reasons for vaccination hesitancy were asked using the question: "Why [are you undecided about getting/do you think it is unlikely for you to agree to get] vaccinated against coronavirus/COVID-19?" followed by 12 reasons that could be selected if they apply (Table 1).

Given the multilingual nature of Luxembourg, the questionnaire in CON-VINCE was administered in German, French, English, and Portuguese in both studies and additionally in Luxembourgish in the YAC study.

2.5 Statistical analyses

Data from both studies were merged and weighted to represent the resident population of Luxembourg (as of January 01, 2021) as

estimated by the Institut National de la Statistique et des Etudes Economiques du Grand-Duché de Luxembourg (14). The method of weighting used was post-stratification with finite population correction, using the complete age-by-gender-by-canton population distribution.

A table of baseline demographic sample characteristics was provided, where categorical variables were described as frequencies (n), and sample proportions (%), while the continuous variables were summarized as median (IQR). The categorical factors were compared between the two cohorts through the Fisher's exact tests. For the continuous variables, Wilcoxon-Mann-Whitney tests were performed. All tests were two-tailed and a p -value below 0.05 was considered statistically significant.

Vaccination intention by age group was summarized in a bar chart using the population-weighted dataset as shown in Figure 1.

We hypothesized that there are specific motivations that explain why individuals are hesitant to get vaccinated. The reasons for vaccination willingness or vaccination hesitancy were presented as bar charts, using the weighted summaries (Figures 2–4). The corresponding tables on the reasons for vaccination willingness/hesitancy, with crude sample frequencies and sample proportions, as well as with the population prevalence estimated through weighting are provided in Supplementary Tables A.4.1–A.4.3.

Vaccination status within each level of the categorical variables (age group, gender, employment status, migration background) were summarized as frequencies (n) and sample proportions (%) and are provided in Supplementary Table A.1. A generalized linear mixed effects model (GLMM) was built to further analyze the relationship between the vaccination status and sociodemographic factors. We hypothesized that specific socio-economic factors might be associated with vaccination status. The outcome was a binary variable describing the vaccination status; the fixed effects variables were categorical sociodemographic factors (age group, gender, employment status, migration background), while the study effect (CON-VINCE/YAC) was considered as a random effect. The reported odds ratios from the GLMM are Conditional Effects (Supplementary Table A.1). The predicted probabilities of vaccination status by age group were obtained from the model. These probabilities are presented in a plot with 95% confidence intervals (Figure 5). Data analyses were performed using R (version 4.2.1).

3 Results

In a first step, we described the demographic characteristics of both cohorts (Supplementary Table A.0). In a second step, we described the vaccination status and its associations with sociodemographic factors. We visualized the predicted probabilities of vaccination status by age group after adjusting for gender, employment status, migration background and the random effect of study (CON-VINCE/YAC) in the model (Figure 5; Supplementary Table A.1). In a third step, we described vaccination intention for the different age groups (Figure 1) and reasons for vaccination willingness (Figure 2) and hesitancy (Figures 3, 4).

3.1 Vaccination status and associations with sociodemographic factors

Of the 4,760 respondents with data on vaccination, 3191 (67.0%) respondents had already received at least one COVID-19 vaccination,

TABLE 1 Questions and answers regarding vaccination willingness and hesitancy for CON-VINCE and YAC.

CON-VINCE study	YAC study
Vaccination willingness	
Will you agree to get vaccinated against COVID-19 when it is your turn?	Will you get vaccinated against coronavirus/COVID-19?
What are the reasons for you to agree to get vaccinated against COVID-19?	
I want to protect myself	I want to protect myself
I want to protect a vulnerable significant other	I want to protect my vulnerable partner
	I want to protect somebody who I am close to
I want to help our society combat the pandemic	I want to help our society combat the pandemic
It is recommended by the government	It is recommended by the government
My treating physician told me to do so	My treating physician told me to do so
It is recommended by my employer	It is recommended by my employer
I think vaccination is important in order to be able to travel safer	I think vaccination is important in order to be able to travel safer
Other reasons	I hope that a vaccination will offer greater freedom
	Other reason (free text*)
Why are you undecided about getting vaccinated against COVID-19?	
I do not believe in vaccinations in general	I do not think much of vaccinations in general
I also do not get vaccinated against other diseases	I also do not get vaccinated against other diseases
I have had bad experiences with other vaccinations	I have had bad experiences with other vaccinations
I do not feel well enough informed about vaccinations in general	I do not feel well enough informed about vaccinations in general
I do not feel well enough informed about COVID-19 vaccinations	I do not feel well enough informed about COVID-19 vaccinations
I do not think I need a vaccination against COVID-19 because I am not in the risk group	I do not think I need a vaccination against COVID-19 because I am not in the high-risk group
I prefer to wait until more people have been vaccinated	I prefer to wait until more people have been vaccinated
I am afraid of possible side effects	I am afraid of possible side effects
I am sceptical that the COVID-19 vaccine really protects	I am sceptical that the COVID-19 vaccine really protects
I am afraid that COVID-19 vaccine does not protect against future mutated forms of the Coronavirus	I am afraid that COVID-19 vaccine does not protect against future mutated forms of the coronavirus
I think that the vaccine has not been tested sufficiently	I think that the vaccine has not been tested sufficiently
Other reasons	Other reason (free text*)
	The vaccination is not currently approved for my age group
Why do you think it is unlikely for you to agree to get vaccinated against COVID-19?	
I do not believe in vaccinations in general	I do not think much of vaccinations in general
I also do not get vaccinated against other diseases	I also do not get vaccinated against other diseases
I have had bad experiences with other vaccinations	I have had bad experiences with other vaccinations
I do not feel well enough informed about vaccinations in general	I do not feel well enough informed about vaccinations in general
I do not feel well enough informed about COVID-19 vaccinations	I do not feel well enough informed about COVID-19 vaccinations
I do not think I need a vaccination against COVID-19 because I am not in the risk group	I do not think I need a vaccination against COVID-19 because I am not in the high-risk group
I prefer to wait until more people have been vaccinated	I prefer to wait until more people have been vaccinated
I am afraid of possible side effects	I am afraid of possible side effects
I am sceptical that the COVID-19 vaccine really protects	I am sceptical that the COVID-19 vaccine really protects
I am afraid that COVID-19 vaccine does not protect against future mutated forms of the Coronavirus	I am afraid that COVID-19 vaccine does not protect against future mutated forms of the coronavirus
I think that the vaccine has not been tested sufficiently	I think that the vaccine has not been tested sufficiently
Other reasons	Other reason (free text*)
	The vaccination is not currently approved for my age group

*Respondents had the option to explain their other reasons in their own words in the YAC study. These explanations were recoded to fit the answer options and/or counted as “other reasons”.

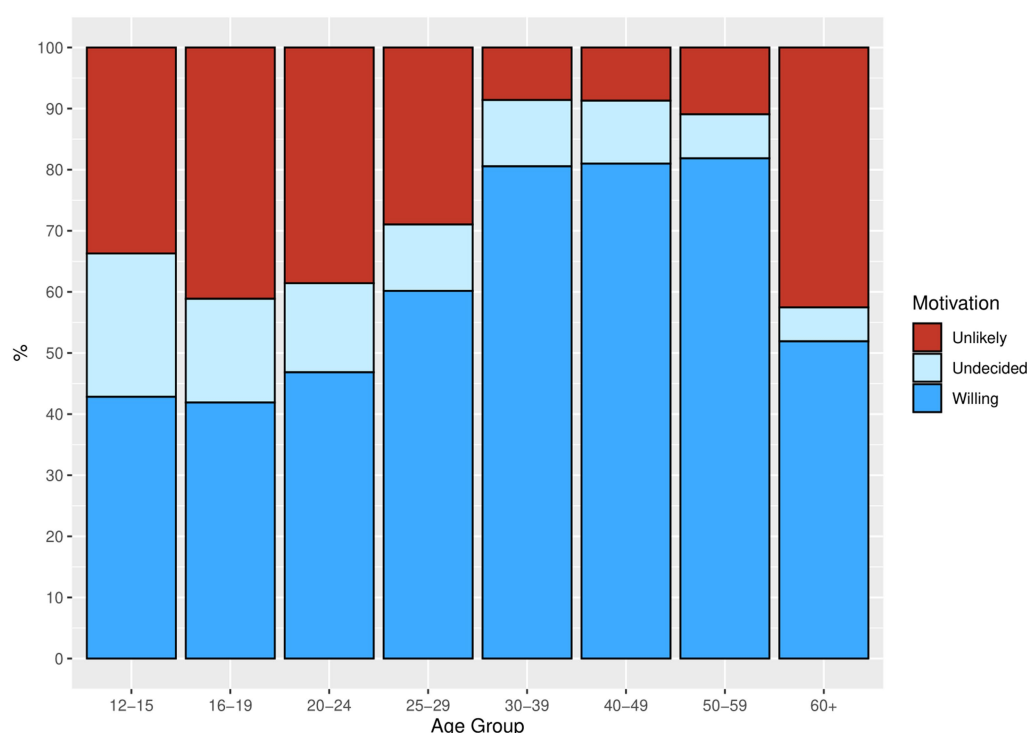


FIGURE 1
Bar chart representing vaccination willingness and hesitancy in unvaccinated by age group. Source: YAC 2021 ($n = 814$); CON-VINCE April–June 2021 ($n = 760$) weighted dataset.

whilst 1,569 (33.0%) respondents had not been vaccinated at the time of the survey.

Figure 5 shows the predicted probabilities of vaccination status by age group when adjusting for gender, employment status, migration background and study random effect in the model. The older the age group, the higher the predicted proportion of vaccinated respondents in the age group.

Results from the regression model that includes age group, gender, employment status, and migration background (Supplementary Table A.1) show that sociodemographic factors such as age group, employment status, and migration background are statistically significantly associated with vaccination status ($p < 0.05$), while gender is not related to vaccination status ($p \geq 0.05$).

The association between age group and vaccination status in this model was statistically significant at a p -value of < 0.001 for every age group with higher age being associated with higher probability of being vaccinated. The odds ratio of being vaccinated in comparison to the 12- to 15-year-old reference group range increased with age from 2.29 (95% CI: 1.82–2.88) for the 16- to 19-year-olds to 102.94 (95% CI: 48.38, 219.01) for the respondents in the 60+ age group.

For employment status, being unemployed, or being in retirement were statistically significantly associated with the vaccination status in this model. Respondents who were unemployed (OR: 0.49, 95% CI: 0.34–0.71) had a lower probability of being vaccinated than the full-time employed reference group. Respondents who were in retirement (OR: 3.26, 95% CI: 1.80, 5.93) had a higher probability of being vaccinated than the reference group.

Migration background was statistically significantly associated with vaccination status in this model for all respondents. Compared

to respondents reporting Luxembourg as their country of origin (i.e., native participants), respondents reporting their country of origin to be a Southern European country (IT, PORT, ESP) (p -value < 0.001), a country belonging to the category “other” (p -value < 0.001) or a Western European country (DE, NL, FR, BE) (p -value < 0.01) had a lower probability of being vaccinated.

3.2 Vaccination intention and reasons for vaccination intention

Of the 1569 respondents who were not yet vaccinated at the time of the survey, 913 (58.2%) indicated that it is very or rather likely that they will get vaccinated, 419 (26.7%) indicated that it is very or rather unlikely that they will get vaccinated, and 237 (15.1%) respondents indicated that they did not yet know whether they will get vaccinated (Supplementary Table A.3).

In the weighted sample, representing the actual population, this corresponds to 73.7% [95% CI: 70.8–76.5] of individuals willing to vaccinate, 15.3% [95% CI: 13.2–17.6] unlikely to vaccinate, and 11.0% [95% CI: 9.1–13.1] of those who are undecided about vaccination (Supplementary Table A.3).

The proportion of unvaccinated respondents not willing or undecided to get vaccinated in the future is higher in the younger age groups than in the older age groups (Figure 1). These results do not seem to apply to the 60+ age group, but most of the participants belonging to this age group were already vaccinated (see Figure 1). The sample of participants in 60+ age group that has not been vaccinated is quite small, $n = 25$. Therefore, reasons

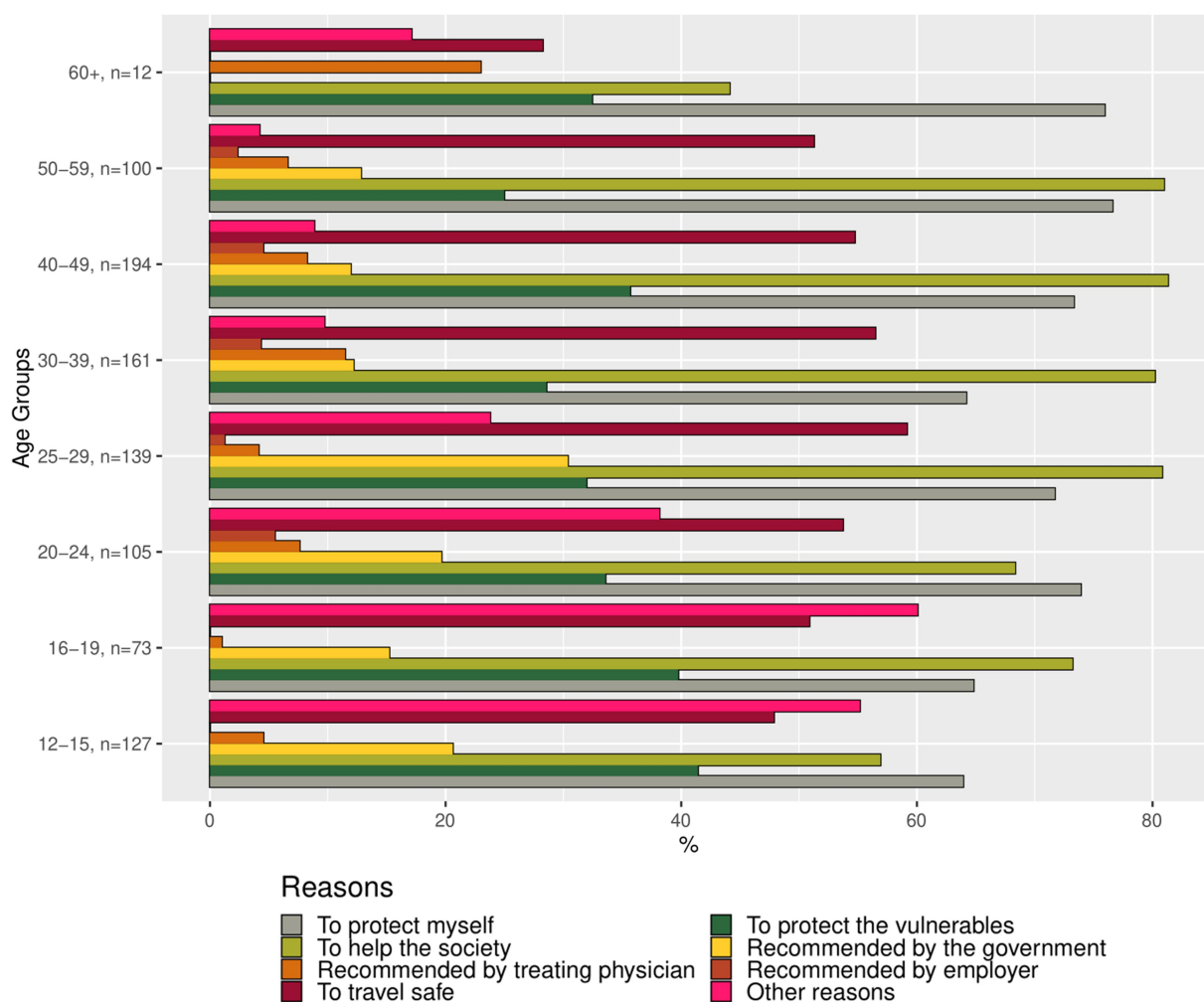


FIGURE 2

Bar chart representing the reasons for vaccination willingness among unvaccinated individuals, categorized by age group (proportions of respondents). Source: YAC 2021 ($n = 298$); CON-VINCE April–June 2021 ($n = 613$). Weighted summaries, multiple responses were possible.

for vaccine willingness/hesitancy in this subgroup should be interpreted with caution.

3.2.1 Reasons for vaccination willingness

Nine hundred and thirteen respondents were not yet vaccinated at the time of the survey but indicated that it was likely that they would get vaccinated in the future. Figure 2 shows the proportions of respondents who indicated a certain reason for their vaccination willingness by age group. Of those 913 participants willing to get vaccinated, 911 provided reasons for their willingness. The weighted and unweighted summaries on the corresponding reasons are given in Supplementary Table A.4.1.

Out of 911 respondents, a total of 681 (74.8%) reported the altruistic motivation “to help the society overcome the pandemic,” corresponding to 78.9% [95% CI: 75.2–82.1%] in the weighted analyses. This was the most named reason in those respondents who were willing to get vaccinated. For respondents from the age groups 12–15 and 20–24 as well as 60+ the self-preserving motivation “to protect myself” was the most named reason to get vaccinated. In total 631 respondents (69.3%) reported this reason, with the estimate for the population of 70.5% [95% CI: 66.5–74.2%]. Among the younger age groups, 12–29, a higher proportion of respondents indicated “recommended by the government,”

ranging from 15.2 to 30.4% in the weighted sample, and “other” reasons, in the range of 23.8–60.1% in the weighted sample, as reasons for their vaccination willingness than in the older age groups. The prevalence of these reasons in the weighted sample in respondents of age 30+ was 0.0–12.8% for “recommended by the government” reason, and 9.7–17.1% for “other” reasons (Figure 2).

3.2.2 Reasons for vaccination hesitancy: undecided to get vaccinated

A total of 237 respondents were not yet vaccinated at the time of the survey and indicated that they did not know whether they would be vaccinated in the future. Figure 3 shows the proportions of respondents who indicated a certain reason for their vaccination undecidedness by age group, and Supplementary Table A.4.2 contains the statistics on the reasons in the weighted and unweighted sample.

Of those 237 participants undecided to receive a vaccine, 229 provided reasons for their undecidedness. Out of 229 participants, a total of 120 participants (52.4%) reported to be afraid of side effects, or, 67.9% [95% CI: 58.9–75.7%] in the weighted sample. The proportion indicating being afraid of side effects in the weighted sample was higher among the older age groups than the younger age groups; by

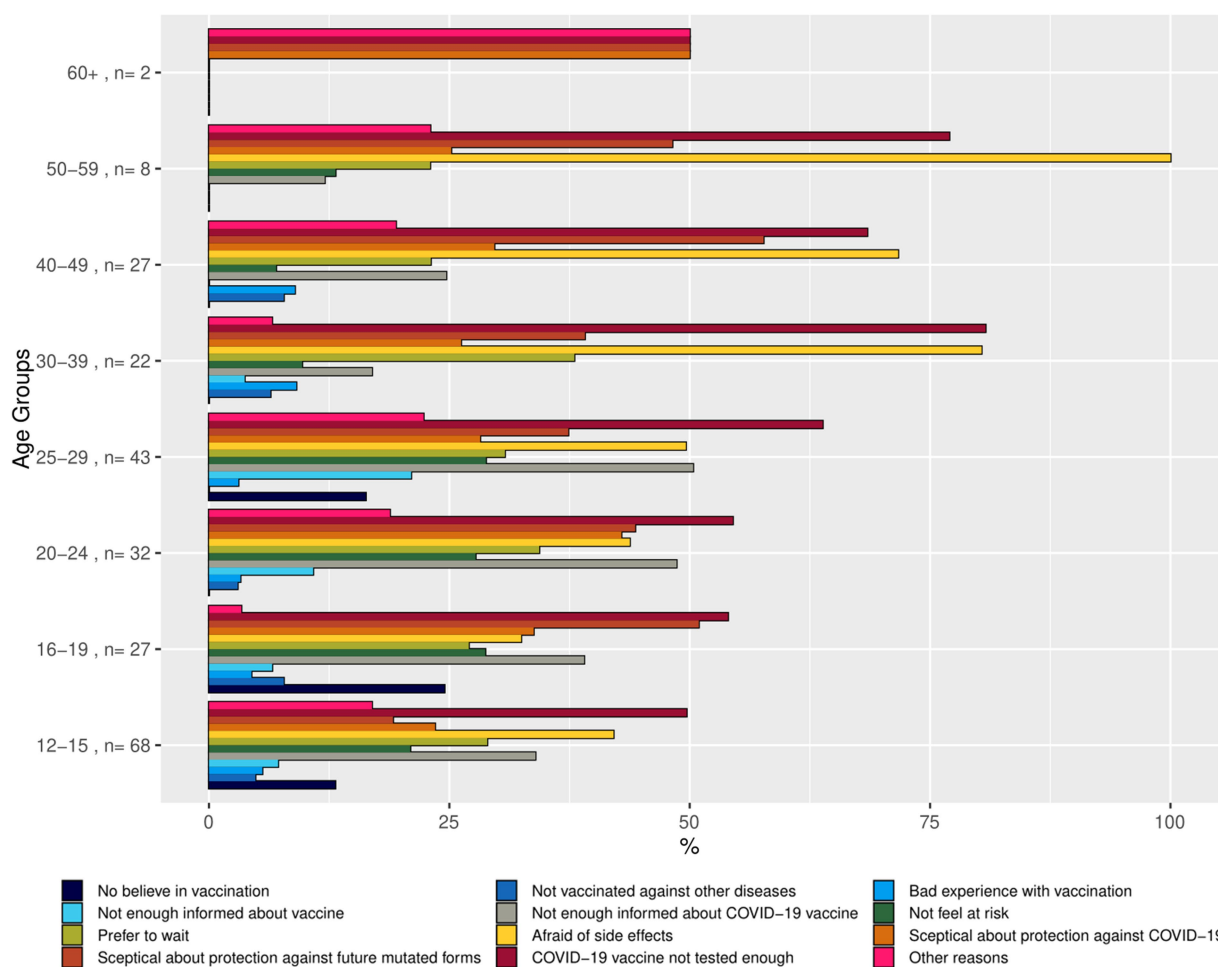


FIGURE 3

Bar chart representing reasons for vaccination hesitancy (undecided) by age group (proportions of respondents in the age group indicating the reason). Source: YAC 2021 ($n = 164$); CON-VINCE April–June 2021 ($n = 65$). Weighted summaries, multiple responses were possible.

71.6–100.0% in those of age 30–59 against 32.7–49.6% in those of age 12–29 (Figure 3). One hundred and thirty-six participants (59.4%) reported that they fear that the COVID-19 vaccine had not been tested enough, with the population estimate of 68.9% [95% CI: 59.9–76.7%]. This reason for being undecided was especially often indicated by the middle age groups aged from 30 to 59, varying from 77.0 to 80.8% after weighting (Figure 3). Reasons referencing a perceived lack of information on vaccinations in general and COVID-19 vaccinations were indicated more frequently by respondents in the younger age groups. Similarly, the younger age groups seem to feel less “at risk” than the older age groups. Namely, the weighted prevalence of respondents in the age groups 12–29 declaring they do not feel “at risk” was varying between 20.9 and 28.8%, while in the groups of 30 years or older the range was between 9.7 and 13.2% (Figure 3).

3.2.3 Reasons for vaccination hesitancy: unlikely to get vaccinated

419 respondents were not yet vaccinated at the time of the survey and indicated that it was unlikely that they would receive the vaccine in the future. Figure 4 shows the proportions of respondents who indicated certain reasons for their vaccination reluctance by age

group, and Supplementary Table A.4.3 contains the statistics on the reasons in the weighted and unweighted sample.

Of those 419 respondents unwilling to get vaccinated, 413 provided reasons for their unwillingness to get vaccinated in the future. Of those, a total of 237 (56.8%) reported that COVID-19 vaccines have not been tested enough as reason for their reluctance, 190 (45.6%) reported fear of side effects, and 190 (45.6%) reported being skeptical about the effectiveness in terms of COVID-19 protection as reason. The corresponding population estimates on the prevalence of those three reasons were 62.1% [95% CI: 54.7–69.0%], 48.6% [95% CI: 41.1–56.2%], and 41.9% [95% CI: 34.7–49.5%] respectively.

4 Discussion

In this study, we explored motivations for and against COVID-19 vaccination in the Luxembourgish population and compared vaccination hesitancy and its associated factors between adolescence and late adulthood. Understanding the critical reasons influencing the acceptance of the COVID-19 vaccines will help inform public health

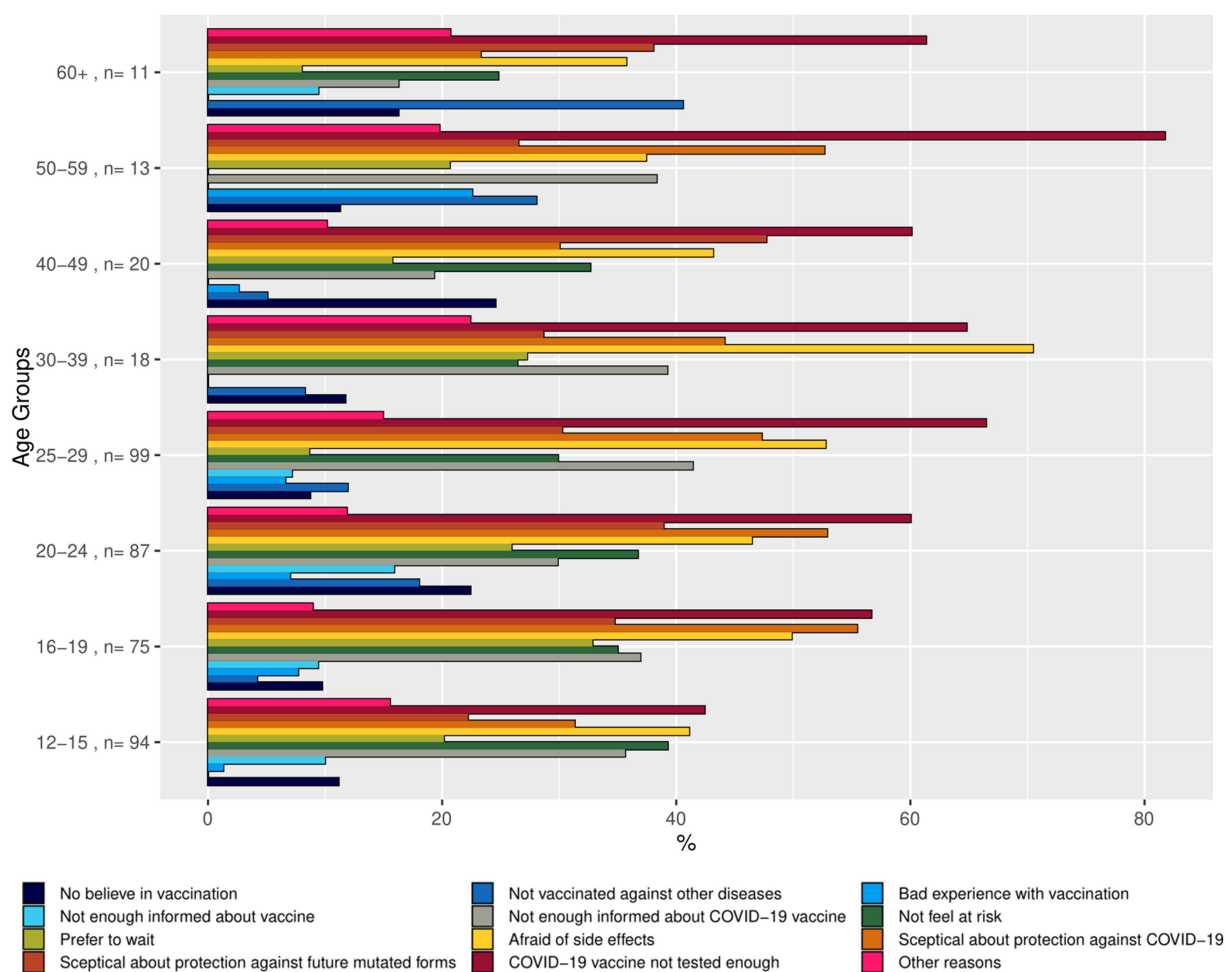


FIGURE 4

Bar chart representing reasons for vaccination unlikelihood by age group (proportions of respondents in the age group indicating the reason). Source: YAC 2021 ($n = 340$); CON-VINCE April–June 2021 ($n = 77$). Weighted summaries, multiple responses were possible.

policy communications for future pandemics but also for regular vaccination campaigns.

In our age-comprehensive sample ranging from adolescence to late adulthood, 67.0% of the respondents were already vaccinated at time of data collection. Of the respondents that were not yet vaccinated at the time of the survey, 58.2% were willing to receive the COVID-19 vaccine, 15.1% were still undecided and 26.7% did not intend to get a COVID-19 vaccination. When drawing references from the weighted analyses about the actual population, there were 73.7% willing to get vaccinated, 11.0% undecided about vaccination, and 15.3% unlikely to be vaccinated individuals.

According to the SAGE Vaccine Hesitancy Working Group and the European Centre for Disease Prevention and Control (ECDC) reasons against vaccinations are diverse and depend on time and regions, with fear of side effects, perceived low risk of vaccine preventable disease, and mistrust in health care providers to be the most common sources for vaccine hesitancy. The SAGE Working Group concluded that vaccine hesitancy is influenced by factors such as complacency [do not perceive a need for a vaccine, do not value the vaccine], convenience [access] and confidence [do not trust vaccine or provider] (11). We confirmed some of these insights in the

Luxembourgish sample ranging from adolescence to late adulthood: (A) The most prevalent reasons against vaccination were the fear of long-term-side effects and the fear that the vaccine has not been tested sufficiently. (B) The most prevalent reasons for vaccination were an altruistic motivation, specifically to help society overcome the pandemic, and the self-serving motivation to protect oneself from the virus.

Vaccine hesitancy in Europe is not a recent occurrence. It has a long history, dating back to the early 19th century when the smallpox vaccine was introduced (15). During this period, there was already a resistance to vaccination, fuelled by fears and misconceptions about the new medical intervention. Over the years, vaccine hesitancy has persisted and evolved, up to recent times, when the WHO has recognized vaccine hesitancy as one of the most serious threats to global health (16). Between 2018 and 2020, public perception of vaccines across the EU improved significantly, particularly for the seasonal influenza vaccine. However, from 2020 to 2022, these positive perceptions have reversed, with declines in the perceived importance, safety, and effectiveness of vaccines (17). Despite well-documented evidence of the effectiveness and safety of vaccines, including COVID-19 vaccines, many people continue to

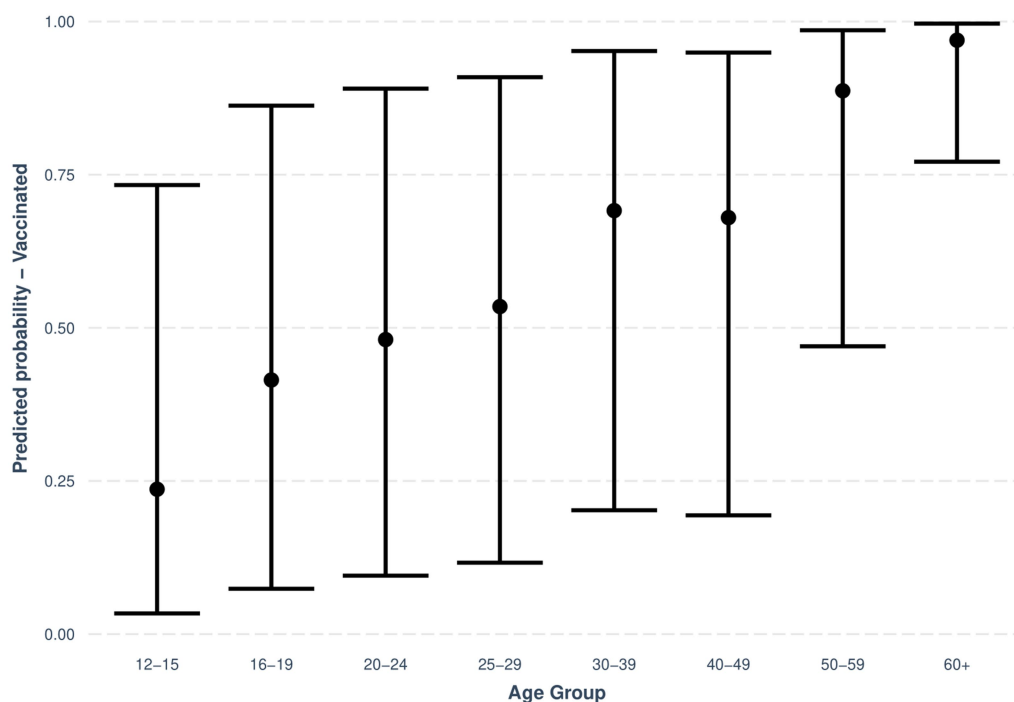


FIGURE 5
Predicted probabilities with 95% CIs for vaccination status by age group. Source: YAC 2021 ($n = 3160$); CON-VINCE April–June 2021 ($n = 1,576$).

doubt their effectiveness and safety. Enhancing public awareness about the nature of vaccine side effects may have an important impact on vaccine hesitancy (18) and can help reduce misinformation. By providing clear and accurate information about what possible side effects to expect and how common they are, health authorities can build greater trust in vaccines (19). Public education campaigns explaining the rigorous processes involved in vaccine development and approval can also reassure the public about vaccine safety.

Older age groups have consistently shown higher vaccine confidence compared to younger age groups, however this gap in confidence seems to be widening after the pandemic across most EU states (17). Additionally, our study indicates that vaccine hesitancy is more prevalent among the younger population. This could be explained by the fact that younger respondents perceive themselves as less susceptible to COVID-19 than the individuals in late adulthood. Even though the younger population experience mostly mild symptoms of the disease, they can develop long COVID or post COVID condition (20). Furthermore, with 15–42% of the younger population being asymptomatic, the younger population can unknowingly spread the virus (21). Furthermore, reasons referencing a perceived lack of information on vaccinations in general and COVID-19 vaccinations are indicated more frequently in the younger generation than in individuals in later adulthood. The information distributed by the government and the media might have reached the younger generation less effectively than the older generation and there may be a need to expand traditional health communication to include tools that reach the younger generation and messages that are attractive for and tailored to them (22). An additional challenge for vaccination in this group is the fact that children are legally dependent on their parents or guardians. Therefore, the opinion of parents

towards vaccination is an important factor in getting COVID-19 vaccinations to the younger age groups. We hypothesize that lower prevalence of vaccine hesitancy in individuals in late adulthood could also be explained by the fact that individuals in late adulthood have already experienced positive impacts of the vaccination and better understand its importance (e.g.: polio vaccine) than the younger generations. Overall, we concur with the statement that further research is needed to determine whether the observed declines in vaccine confidence among the younger population are temporary or indicative of a more enduring public health challenge (23).

To increase vaccination rates in a high vaccination-readiness country, public health messaging needs to target those unsure or rather unwilling to be vaccinated, as they are most likely to be convinced to be vaccinated. Especially the younger generation should be targeted. Concerns especially about vaccine safety and efficiency underline the need for providing clear, understandable information about the principles of vaccines, its risks, and its benefits for the individual as well as also for the population. Furthermore, given that self-protection is one of the most prevalent reasons for vaccination, public health should highlight in their vaccine communication strategies the effectiveness of the vaccine especially in the context of long-COVID. Our findings also allude to optimal communication channels for public health messages. Other studies found that most people use social media as their main source for COVID-19 information and that it is an effective dissemination route for key information (24). Given that infodemics are an important problem in the digital era, propagation of false claims and misinformation that erode trust in institutions and health policies, must be avoided (25). These channels should, in contrast, be used to spread validated information on vaccination and guidelines on the SARS-CoV-2 virus, especially to reach younger generations who,

based on our findings, do not feel sufficiently informed (22). Furthermore, the importance of digital verification services has grown over time. Global fact-checking organisation, with specialised journalists, exist to monitor online content and to verify false claims, misinformation, and refute them by retrieving the original or explaining the true facts (26). These fact checking activities should be better promoted to enhance the impact of public health messages. Research should investigate how vaccine-specific misinformation affects vaccine confidence and develop strategies to strengthen resilience to misinformation among the public (23).

Previous findings reported that during the first lockdown, in comparison to other European countries, Luxembourg residents had the highest confidence in their government and health services to deal with the health crisis (27). This highlights the importance to maintain trust in the government and health system. Previous studies have supported the idea that information related to COVID-19 should be delivered by a trusted expert, e.g., general practitioners (28), especially as findings suggest that recommendation from health professionals are positively associated with vaccine uptake. Nevertheless, in our study, only a few respondents indicated recommendation by a practitioner as a reason for vaccination willingness.

Reasons for comparatively high vaccination willingness could be related to the organizational and educational measures by the Luxembourgish public health system. With a population of approximately 650,000 over 2,586 km², Luxembourg's small size facilitated crisis management by easing the implementation of measures. However, its openness, cultural diversity, and reliance on foreign workers posed challenges for educational continuity and key sectors. The stable political system and centralized governance enabled quick government decision-making (29). Specifically, the Luxembourgish government established a vaccination campaign to increase vaccination readiness (5), implemented a mass testing ("large-scale testing") protocol and a proactive contact tracing campaign (29). The crisis communication has been overall very effective in Luxembourg (29). Due to having a clear crisis communication strategy in place before the pandemic, the crisis communication services were able to utilize numerous channels to reach a wide audience (29). They aimed to inform the population with clear public health messages disseminated, *inter alia*, directly to households via postal mail and in the five languages predominantly spoken in the country. Organizational strategies such as the Luxembourgish government sending invitations to eligible individuals might have also contributed to the high vaccine coverage, as this active intervention has been described as effective in the immunization campaign against Human papillomavirus in Italy (30). Convenient access to vaccination provided ample opportunities for vaccination, such as numerous vaccination centers spread across the country and a vaccination bus present at various events, like concerts or expositions (5, 30).

Recent findings hypothesized that a low level of vaccination willingness could be associated with a small number of COVID-19 cases and mortality reported in the media (31). At the time of the survey, in June 2021, Luxembourg experienced low rates of COVID-positive cases and mortality compared to other European countries (e.g., Italy and Portugal). This could be one further explanation why vaccination willingness in Luxembourg was not as high as that in other EU-countries according to our study, given that vaccination willingness has been shown increased with higher severity and proximity of personal experiences (32). Findings on determinants of vaccination

hesitancy may vary in different cultural or socioeconomic contexts and may also depend on policies and the mode of administration of COVID-19 vaccines, such as mandatory vaccination certification for visiting public spaces like nightclubs (33) or administering COVID-19 boosters simultaneously with an influenza vaccine (34).

4.1 Limitations

To limit participant burden, only participants that were not yet vaccinated replied to the question on vaccination willingness. At the time of the survey, 67.0% of the respondents were already vaccinated. Therefore, we only analysed the results of those who were not yet vaccinated. The studies CON-VINCE and YAC did not collect data at the exact same point in time. For the CON-VINCE participants, the questionnaires were administered from April to June 2021 and, for the younger population, YAC, from August to September 2021. At the beginning of July 2021, an invitation for vaccination against SARS-CoV-2 was sent out to every adult resident of Luxembourg, eligible for vaccination (5). Children from 12 years and older received their invitation for vaccination from the 28th of June onwards (6). This slight timepoint difference however allowed minimization of the differences in eligibility to receive the vaccine. Furthermore, although the survey was conducted in mid-2021, it provides an important snapshot of beliefs toward the COVID-19 vaccination in the Luxembourgish population. Even though the sampling strategy strove for representativeness of the Luxembourgish resident population, we could not include the hard-to-reach non-resident population (e.g., individuals without internet access, homeless people, and undocumented migrants). Lastly, the sample size of some age groups, especially participants at older ages (aged over 60 years) that have not yet been vaccinated is quite small. Therefore, we are limited in the interpretation of reasons for vaccine hesitancy in this subgroup.

4.2 Outlook

An important question will be if COVID-19 vaccine hesitancy will provoke more general vaccination hesitancy in the future. Although trends have shown an increase of vaccination confidence in the safety and importance of vaccines in general since 2018 (35), we can expect that vaccine hesitancy may increase after the COVID-19 crisis if there is no clear rise in public awareness in the vaccines' role to prevent severe disease, in contrast to widespread public beliefs that vaccines prevent infection. The context of the COVID-19 pandemic presents a complex context for vaccine confidence is concerned. Appearance of new variants mirrors the unpredictability of the situation, raising questions about the effectiveness of vaccination. Future research work should concentrate on this very important topic. Furthermore, future studies should concentrate on how we can proceed to avoid vaccine-fatigue and on the impact the booster vaccinations will have on vaccine fatigue.

Given that the European populations were recognized as being among the least vaccine confident in the world in 2016 (36), and the very diverse COVID-19 vaccination willingness in the European community, it is essential to continue to study vaccination willingness

and to compare the reasons for and against COVID-19 vaccination on a wider level.

5 Conclusion

Using a large cross-sectional, population-representative sample of residents with a large age range across adolescence and adulthood in Luxembourg, we explored motivations for and against SARS-CoV-2 vaccination and defined population groups most at risk for COVID-19 vaccination hesitancy.

Our findings highlight that vaccine hesitancy represents an important challenge, and reasons for vaccination hesitancy differ according to the age of the respondents. Our results help improve future pandemic preparedness by identifying socio-demographic groups most likely to be hesitant or reluctant towards vaccination and thus providing guidance for the adaptation of public health messaging to reach these groups. Through this, we contribute to the improvement of strategies aiming at increasing vaccination uptake.

Data availability statement

The dataset for this manuscript is not publicly available as it contains sensitive data. Any reasonable requests for accessing the CON-VINCE dataset can be directed to con-vince@lih.lu. Data of the YAC study can be accessed upon reasonable request to robin.samuel@uni.lu. All data of the manuscript will be provided upon approval by the ethics committee.

Ethics statement

The studies involving humans were approved by National Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. All participants in CON-VINCE completed an electronic informed consent form and had the right to withdraw from the study at any time. Written informed consent for participation in YAC was provided by the participants' legal guardians/next of kin.

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Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. The YAC study was funded by the University of Luxembourg, the Ministry of Education, Children and Youth, and the National Research Fund Luxembourg (FNR; 14720458/YAC). The CON-VINCE Study was funded by the National Research Fund Luxembourg (FNR 14716281/CON-VINCE/Kruger) and the André Losch Foundation (Luxembourg). The ORCHESTRA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101016167.

Acknowledgments

We would like to give special thanks to all participants of the YAC study. Additionally, we thank the Ministry of Education, Children and Youth of Luxembourg for their financial support of the study. We also would like to thank the Ministry of Education, Children and Youth of Luxembourg, the Luxembourg Government IT Centre and the members of the Centre for Childhood and Youth Research (CCY) of the University of Luxembourg for their support of the YAC study. We would like to give special thanks to all participants of the CON-VINCE study and to each volunteer that helped in sample

processing or sample kit preparation. The funders had no role in the design and conduct of the study, nor in the decision to prepare and submit the manuscript for publication. We also would like to thank the Ministry of Health of Luxembourg as well as the Directorate of Health of Luxembourg for their support. We would like to thank the Research Luxembourg COVID-19 Task Force (Frank Glod, Paul Wilmes, Lars Geffers, Jasmin Schulz, Henry-Michel Cauchie, Ulf Nehrbass, Rudi Balling) for their overall support of the CON-VINCE study. A special thanks to Ivana Paccoud and Matthias Klee for their helpful contributions and to the data protection officers Sandrine Munoz and Laurent Prévotat. Furthermore, we would like to acknowledge the whole Communication teams involved within CON-VINCE, especially Sabine Schmitz, Arnaud D'Agostini, Didier Gossens, Hélène Jacuszin for their excellent work and support during the implementation and execution of CON-VINCE. We would like to thank Philippe Lamesch for important and successful fundraising for research on COVID-19 in Luxembourg. A special thank you also for Sabine Schmitz and Jean-Paul Bertemes for their input in the CON-VINCE vaccination questionnaire.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of *Frontiers*, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1456265/full#supplementary-material>

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RECEIVED 13 August 2024

ACCEPTED 25 November 2024

PUBLISHED 03 January 2025

CITATION

Simonovic N, Gesser-Edelsburg A and
Taber JM (2025) Examining psychological
correlates of vaccine hesitancy: a
comparative study between the US and Israel.
Front. Public Health 12:1480419.
doi: 10.3389/fpubh.2024.1480419

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Examining psychological correlates of vaccine hesitancy: a comparative study between the US and Israel

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It is important to identify psychological correlates of vaccine hesitancy, including among people not from the United States (U.S.). College students were recruited between March–June 2023 in the US ($n = 330$, $M_{age} = 20.21$, 79.5% female) and in Israel ($n = 204$, $M_{age} = 23.45$, 92.6% female) to complete a cross-sectional survey on vaccine attitudes, emotions, and behavior. A 2 (Nation: US, Israel) $\times$ 2 (Vaccine Status: Vaccinated, Unvaccinated) factorial design was used. Individual ANCOVAs controlling for sociodemographic factors were conducted to test main effects of nation and vaccine status, and their interaction, across various psychological correlates of health behavior. Consistent with hypotheses, unvaccinated (vs. vaccinated) individuals reported higher perceived ambiguity, reactance, and anger as well as perceived lower susceptibility, severity, worry, positive emotion, and intentions to vaccinate. Contrary to hypotheses, unvaccinated individuals reported greater fear. Israeli (vs. American) participants reported higher perceived ambiguity, worry, fear, and anger, as well as lower perceived susceptibility. Vaccinated Americans reported higher intentions to vaccinate again in the future ($M = 2.89$, $SE = 0.08$) compared to vaccinated Israelis ($M = 2.36$, $SE = 0.08$). However, unvaccinated Americans reported lower intentions to vaccinate ($M = 1.80$, $SE = 0.15$) than unvaccinated Israelis ($M = 1.95$, $SE = 0.21$). Findings provide insight into correlates to target for vaccine promotion and emphasize the need for cultural tailoring.

KEYWORDS

vaccine hesitancy, health behavior, risk perception, emotions, ambiguity, intentions

Introduction

Prior to the onset of the COVID-19 pandemic, vaccines prevented approximately 4–5 million deaths a year (1). More recent estimates indicate that at least 14.4 million deaths were prevented in 1 year by the COVID-19 vaccine (2). Additional deaths across all vaccine-preventable illnesses (e.g., Measles, Pertussis, and COVID-19) could be averted if vaccination rates increased. However, vaccine hesitancy—the delay or refusal to receive available vaccines (3)—serves as a barrier to vaccination. The purpose of the present research is to examine psychological correlates of vaccine hesitancy in a cross-cultural sample of Americans and Israelis.

Various behavioral theories provide insight into why people do not engage in protective health behavior, such as vaccination. According to the Health Belief Model (4), Theory of Planned Behavior (5), Extended Parallel Processing Model (71), the Appraisal Tendency Framework (6–8), Reactance Theory (9), PRECEDE PROCEED Model (10), and Transtheoretical Model of Behavior Change (11), several cognitive, affective, and behavioral constructs are at play in health decisions. Some of the many constructs involved in health

decisions include risk perceptions, emotions, knowledge, reactance, and intentions. Other psychological variables relevant to health behavior that are often overlooked in major theories of health behavior include ambiguity and positive emotions. In the next section, we provide an overview of each of these variables, including a brief description and selected research pertaining to vaccination.

Psychological correlates of vaccine hesitancy

Risk perceptions refers to subjective beliefs pertaining to an outcome, such as illness. Individuals can hold beliefs about: their *susceptibility* or likelihood of contracting an illness, how *severe* or harmful the illness may be, as well as how *worried* they are about the illness (12, 13). Higher perceptions of risk about illness often predict greater vaccine use (14). However, higher perceptions of risk about vaccination, rather than the illness itself, can promote vaccine hesitancy or refusal (15).

In addition to risk perceptions, *perceived ambiguity* is another important psychological determinant of vaccine hesitancy. Ambiguity refers to the experience of uncertainty that specifically arises from perceiving information to be unreliable, low in credibility, or inadequate, which is often the case when information is conflicting, imprecise, or incomplete (16, 17). Perceiving ambiguity about vaccination (e.g., about side effects or the efficacy of the vaccine) can lead to avoidance of vaccination (18–20).

Next, *emotions* are important in understanding health behavior, as health behaviors likely occur within an emotional context (21). For example, individuals may deny or refuse vaccination because they experience *fear* about potential side effects of vaccination (22, 23). *Anger* is another emotion that may lead to hesitation to vaccinate (24, 25). Indeed, anger may activate schemas of distrust in others and lead to greater mistrust in the medical system (26). As for *positive emotions* (e.g., happiness, relaxation, etc.), more research is needed to understand the relationship between positive emotions and health behavior (27). However, related to vaccination, researchers have demonstrated that vaccine hesitant individuals are less likely to experience positive emotions compared to their counterparts who are more inclined to vaccinate (28). Further, there are various positive experiences (affective and cognitive) that may contribute to positive emotion—such as experiences of hope, optimism, trust, and altruism—that can, in turn, promote vaccination (25, 29–33). Indeed, vaccines may offer hope and optimism, such as in the case of a cancer vaccine or an AIDS vaccine that can improve survival outcomes and reduce transmission (34, 35). Further, fostering trust and altruistic motives may increase willingness to vaccinate (36, 37). Future cross-cultural research on vaccination behavior should assess these factors. Another factor relevant to health behavior engagement is knowledge. In particular, those who have a better understanding of what actually presents a health risk are more likely to engage in behaviors aimed at avoiding that health risk. Indeed, adults who are more knowledgeable about preventive health behaviors (e.g., handwashing or avoiding crowds) are more likely to engage in these behaviors during a pandemic (38, 39). Further, researchers have demonstrated a relationship between higher knowledge about vaccination and a positive attitude toward vaccination (40).

Finally, *intentions* are an especially important component of health behavior because intentions to engage in a behavior, or lack thereof, often precede the decision to engage in health behavior (41).

However, experiencing *reactance*—a motivational state in which people attempt to re-establish autonomy in the face of feeling like their freedom is threatened (9)—can decrease intentions to vaccinate (42).

Importantly, no singular health behavior theory provides a comprehensive model of all psychological factors relevant to vaccination, and including all variables across health behavior theories would be beyond the scope of the present research. With our aim to examine psychological correlates of vaccine hesitancy, including some afforded less attention in major theories of health behavior, we selected correlates for inclusion based on variables that overlap across many different theories of health behavior (e.g., risk perception, knowledge, and intentions) or have received less attention across major theories of health behavior (e.g., ambiguity and emotions). We also included psychological reactance because this variable can be especially relevant in contexts with government involvement (43)—as was the case during the COVID-19 pandemic—that may lead individuals to feel a threat to their freedom. Thus, we expected that the real-world occurrence of the COVID-19 pandemic would be a fitting context to evaluate this psychological correlate of health behavior.

Sociodemographic factors and individual level differences relevant to vaccination

Prior research has demonstrated a relationship between general and COVID-19 specific vaccination behavior with various sociodemographic factors (44). For example, in one study conducted with US respondents, individuals who were more vaccine hesitant for COVID-19 were younger and more likely to be female and Black and American Indian or Alaskan Native (45). The direction of the relationship between various sociodemographic factors and vaccination behavior is not always consistent, such as in the case of education or religious affiliation (46).

Various individual level differences may also play a role in health behavior and thus may be relevant to vaccine hesitancy. A meta-analysis of research on health literacy—skills required for people to access, understand, and make use of health information (47)—indicated that health literacy is positively, but weakly, associated with healthier behaviors (48). In another meta-analysis on dispositional optimism, or the tendency to expect outcomes to be good (49), optimism was associated with various physical health outcomes with a small to moderate effect size (50). Another relevant and important construct is tolerance for uncertainty. Although additional research is needed to determine the extent and strength of relationships, tolerance for uncertainty has been associated with medical decision making across several studies (51). In the present study, we assessed these sociodemographic factors and individual level differences because we considered them to also be relevant to vaccination.

The present research

Although several research studies have examined the relationship among various factors relevant to health behavior and vaccination, further research is needed to include diverse populations. Including diverse populations would lead to a better understanding of what predicts vaccine behavior among different samples, which in turn, would inform strategic approaches to encourage vaccination (e.g., tailoring of health communications). Indeed, researchers concluded

from a systematic review of the literature on vaccine hesitancy that most research on this topic is derived from Europe and the Americas (52).

Importantly, the present research extends upon decades of prior work on predictors of vaccine hesitancy by exploring the role of the cultural context. The goal of this research was not to test a specific health behavior theory, but rather to apply what we might expect based on major theories of health behavior to better understand psychological correlates of vaccine hesitancy in a cross-cultural context. Specifically, in the present research, we collected separate samples of American and Israeli participants in order to conduct a cross-cultural comparison of psychological correlates of vaccine hesitancy. Indeed, additional research on psychological correlates of vaccine hesitancy is needed among non-US samples. We use a 2 (Nation: US, Israel) $\times$ 2 (Vaccine Status: Vaccinated, Unvaccinated) factorial design. Further, the present research was specifically conducted in the context of the COVID-19 pandemic. However, what is learned in the present context can also provide insight for various other vaccination campaigns as well as during a future pandemic.

Hypotheses

1. Consistent with various theories of health behavior and research, we hypothesized that unvaccinated individuals (compared with vaccinated individuals) would report higher levels of perceived ambiguity and higher reactance, as well as lower risk perceptions of COVID-19, lower perceived knowledge about COVID-19 and COVID-19 vaccination, and lower intentions to vaccinate.
2. Next, we hypothesized that unvaccinated individuals (compared with vaccinated individuals) would report higher levels of anger and lower levels of fear while thinking about COVID-19 vaccination. Importantly, we included generalized measures of emotion—that is, we did not assess why individuals experienced anger or fear about COVID-19 vaccination—however, we based our hypotheses on possible reasons these emotions may have been experienced. That is, we expected that unvaccinated individuals would report experiencing higher anger in response to government mandates of vaccination, but lower fear about COVID-19 vaccination, consistent with lower risk perceptions from Hypothesis 1 (e.g., “COVID-19 is not severe and so there is no reason to feel fear from the COVID-19 vaccine as it’s unnecessary”).
3. We treated analyses regarding positive emotions as exploratory due to less research on positive emotions in the literature on health behavior.
4. Further, although we expected to observe cultural differences in the prevalence of psychological correlates of health behaviors across samples, we treated these analyses as exploratory. For example, perceptions of ambiguity or risk may differ among cultures but we did not have specific hypotheses for sample differences relevant to nationality. Rather, we examined differences across cultures to inform culture-specific interventions.

General methods

Overview

Data were collected in March–June 2023 from two studies with the same design and measures that separately took place in the

United States and Israel. Recruitment occurred for each study simultaneously at Kent State University in the United States and at University of Haifa in Israel. Each university provided IRB approval. Eligibility criteria included being age 18 years or older, a resident of either the United States or Israel, and fluency in either English or Hebrew depending on respective location. Of note, although participants were not directly asked if they were an American or Israeli citizen, they were categorized as American or Israeli depending on their respective university, where they indicated living, and their language fluency. It is possible that non-citizens were incorporated into the sample, although they would likely comprise a small percentage of the overall sample. Analyses concerning relationships of perceived ambiguity with risk perceptions, emotions, intentions, and information seeking are reported elsewhere (72).

Study design and procedure

Participants were recruited using the SONA system subject pool through the Department of Psychological Sciences at Kent State University and the School of Public Health at University of Haifa. Each study was administered online through Qualtrics as a survey on attitudes and beliefs regarding vaccination. Participants first completed a screener to confirm they were eligible to participate followed by informed consent. After this step, participants completed a survey of measures including vaccination history, perceptions of ambiguity and risk, emotion, behavioral intentions, individual level differences, and demographic items.

Participants

Data collection occurred until the end of the academic semester across each university. Data were collected from 234 Israeli participants and 336 American participants. Data from 36 participants (6 Americans and 30 Israelis) were then removed due to low responsiveness (i.e., less than half the survey was completed). The final sample for analyses included 330 American and 204 Israeli participants (combined $n = 534$).

Measures

The survey underwent pilot testing with American and Israeli participants to confirm that participants understood each measure. Of note, all measures were translated from English to Hebrew for use with Israeli participants. To guarantee that measures were translated accurately, 3 bilingual, native Hebrew speakers reviewed the translation of measures. Measures that are relevant to hypotheses are reported below.

Vaccination status

Vaccination status was assessed with one item (created for this study): “Are you fully vaccinated against COVID-19, which means that you received either a single-dose vaccine (such as Johnson & Johnson) or a two-dose series vaccine such as Pfizer or Moderna? The names of authorized vaccines include: Pfizer, AstraZeneca, Moderna, Johnson & Johnson, Sinopharm BIBP, CoronaVac, Covaxin, Novavax, Convidecia, and Sputnik V” (coded as 0 = No, 1 = Yes). Participants were also given the option to respond “Do not know,” and those who did were recoded as missing data for this item (this only applied to 3 Israeli participants).

Psychological correlates

Three measures of *risk perception* were used: perceived susceptibility (adapted from (53); average of 3 items; $\alpha_{\text{American}} = 0.77$, $\alpha_{\text{Israeli}} = 0.59$), worry (adapted from (53, 54); average of 3 items; $\alpha_{\text{American}} = 0.95$, $\alpha_{\text{Israeli}} = 0.96$), and perceived severity (adapted from (55); average of 12 items; $\alpha_{\text{American}} = 0.90$, $\alpha_{\text{Israeli}} = 0.88$). Items assessing *perceived susceptibility* were: “I feel very vulnerable to being infected with COVID-19 in the next year” (1 = strongly disagree to 7 = strongly agree), “Overall, how likely is it that *you* will be infected with COVID-19 in the next year?” (1 = extremely unlikely to 7 = extremely likely) and “Overall, how do you think *your* chance of being infected with COVID-19 in the next year compares to other [women/men] of your age in [United States/Israel]?” Items assessing *worry* were: “How [anxious are you/much do you worry/much are you concerned/about being infected with COVID-19?” (1 = not at all to 7 = a lot)]. Finally, items assessing *perceived severity* were: “COVID-19 is [a serious condition/ dangerous/ life-threatening] for [immunocompromised individuals/older adult individuals/young adults/children] without any pre-existing health conditions” (1 = strongly disagree to 4 = strongly agree). For the perceived severity items, participants could select “do not know,” and those who did were recoded as missing data (no participants responded “do not know” for this measure).

Perceived ambiguity (adapted from (56, 57); average of 3 items; $\alpha_{\text{American}} = 0.80$, $\alpha_{\text{Israeli}} = 0.82$) was assessed with, “There are many limitations of the existing information about COVID-19 vaccines,” “There is a lot that is unknown about COVID-19 vaccines” and “Leading scientists and experts have conflicting opinions about COVID-19 vaccines” (1 = strongly disagree, 4 = strongly agree).

Emotions (58) included subscales for *fear* (average of 4 items; $\alpha_{\text{American}} = 0.90$, $\alpha_{\text{Israeli}} = 0.89$), *anger* (average of 4 items; $\alpha_{\text{American}} = 0.92$, $\alpha_{\text{Israeli}} = 0.95$), *happiness* (average of 4 items; $\alpha_{\text{American}} = 0.89$, $\alpha_{\text{Israeli}} = 0.83$), and *relaxed* (average taken from 4 items; $\alpha_{\text{American}} = 0.89$, $\alpha_{\text{Israeli}} = 0.85$). In this measure, participants were asked to indicate the extent to which they experience specific affective states when they think about COVID-19 vaccination (1 = not at all to 7 = an extreme amount). Items used to assess fear include “fear,” “worry,” “panic,” and “scared.” Items used to assess anger include “anger,” “rage,” “mad,” and “pissed off.” Items used to assess happiness include “happy,” “enjoyment,” “satisfaction,” and “liking.” Finally, items used to assess relaxation include: “calm,” “relaxation,” “chilled out,” and “easygoing.”

Two separate items were used to assess perceived knowledge: *perceived knowledge about COVID-19* (59) and *perceived knowledge about COVID-19 vaccination* [modified from (59)]. The former was assessed with: “Overall, how would you rate your level of knowledge about COVID-19 (for example, what it is, how it is transmitted, how to protect yourself, etc.)?” and the latter was assessed with: “Overall, how would you rate your level of knowledge about COVID-19 vaccination (for example, what options there are, what are the benefits and side effects, etc.)?” (1 = no knowledge at all to 4 = a lot of knowledge; 5 = do not know). Responses of “do not know” were again coded as missing data (for the perceived knowledge about COVID-19 item, this only applied to 10 American participants and 7 Israeli participants, and for the perceived knowledge about COVID-19 vaccination item, this only applied to 9 American participants and 9 Israeli participants).

Reactance [adapted from (60); average of 3 items; $\alpha_{\text{American}} = 0.92$, $\alpha_{\text{Israeli}} = 0.87$] included items such as “Vaccination recommendations

from the government annoy me” and “The government is trying to manipulate me with these vaccination recommendations” (1 = strongly disagree; 5 = strongly agree).

Intentions (created for this study) consisted of a single item: “I intend to get vaccinated against COVID-19 at some point in the future” (1 = strongly disagree; 4 = strongly agree).

Sociodemographic factors and individual level differences

Standard demographic items were measured: *age* (continuous), *gender* (coded as 0 = female, 1 = male), *year in school* (coded as 1 = freshman, 2 = sophomore, 3 = junior, 4 = senior, and 5 = graduate student), *race* (in the American sample only; coded as 0 = non-white, 1 = white) and *religious affiliation* (in the Israeli sample only; coded as 0 = non-Jewish, 1 = Jewish). Participants also reported individual level differences. *Tolerance for ambiguity* (61) was assessed as the average of 6 items (1 = strongly disagree to 4 = strongly agree; $\alpha_{\text{American}} = 0.73$, $\alpha_{\text{Israeli}} = 0.76$). In this measure, participants were asked to imagine they are “considering having a medical test that checks for cancer,” but conflicting opinions about the test exist. They were then asked to rate their agreement with statements such as “I would be afraid of trying the test” (1 = strongly disagree, 4 = strongly agree). *Health literacy* (62) was assessed as the average of 3 items, such as “How often do you have problems learning about a medical condition because of difficulty understanding written information?” (1 = none of the time to 5 = all of the time; $\alpha_{\text{American}} = 0.57$, $\alpha_{\text{Israeli}} = 0.23$). Finally, *dispositional optimism* (63) was assessed as the average of 6 items, such as “I rarely count on good things happening to me” (scored so that higher values indicate greater optimism; 1 = strongly disagree to 5 = strongly agree; $\alpha_{\text{American}} = 0.85$, $\alpha_{\text{Israeli}} = 0.65$).

Overview of analyses

All analyses were conducted in IBM SPSS Statistics Version 27. First, we conducted chi square tests and ANOVAs (depending on whether the dependent measure was a categorical or continuous variable), to determine whether American and Israeli participants differed on any sociodemographic and individual level difference variables. Sociodemographic and individual level difference variables that were not equally distributed across groups were then controlled for in subsequent ANCOVAs that were used to test hypotheses. Next, 12 ANCOVAs controlling for gender, age, education, health literacy, and dispositional optimism were conducted to test main effects of nation and vaccine status, and their interaction, across various psychological correlates of health behavior including: health cognitions (perceived ambiguity, perceived susceptibility, worry, perceived severity, perceived knowledge about COVID-19, perceived knowledge about COVID-19 vaccination, and reactance), emotion (fear, anger, happiness and relaxation), and vaccination intentions.

Results

See Table 1 for bivariate correlations among study variables. The nature of these correlations was generally consistent with expectations. For example, individuals who reported higher worry about COVID-19, perceived higher severity of COVID-19, and

TABLE 1 Bivariate correlations among study variables.

	1	2	3	4	5	6	7	8	9	10	11	12
1. Perceived ambiguity	–	0.01	–0.07	–0.17**	–0.05	–0.23**	0.46**	0.31**	0.28	–0.37**	–0.31**	–0.37**
2. Perceived susceptibility		–	0.41**	0.13**	0.01	0.04	–0.06	0.02	–0.02	–0.03	–0.07	0.08
3. Worry			–	0.26**	0.04	0.08**	–0.09*	0.17**	0.06	0.12	0.02	0.18**
4. Perceived Severity				–	0.09	0.12*	–0.37**	–0.11**	–0.24**	0.27**	0.24**	0.48**
5. Perceived COVID-19 knowledge					–	0.48**	–0.17**	–0.06	–0.03	0.15**	0.12**	0.15**
6. Perceived COVID-19 vaccine knowledge						–	–0.22**	–0.05	0.01	0.24**	0.23**	0.22**
7. Reactance							–	0.42**	0.46**	–0.46**	–0.44**	–0.62**
8. Fear								–	0.73**	–0.12**	–0.25**	–0.23**
9. Anger									–	–0.11*	–0.21**	–0.37**
10. Happiness										–	0.72**	0.45**
11. Relaxed											–	0.40**
12. Vaccination intentions												–
M	2.78	3.09	2.50	2.89	3.28	2.92	2.53	2.14	1.91	2.24	2.71	2.61
SD	0.69	1.24	1.54	0.55	0.80	0.90	1.14	1.39	1.40	1.35	1.46	0.94
Range	1–4	1–7	1–7	1.25–4	1–5	1–5	1–5	1–7	1–7	1–7	1–7	1–4

* $p < 0.05$, ** $p < 0.01$.

higher knowledge about COVID-19 and COVID-19 vaccines also reported higher intentions to vaccinate. Further, individuals who experienced higher reactance reported lower intentions to vaccinate. With respect to variables that are not generally considered in major theories of health behavior, such as perceived ambiguity and emotion, we note that people who perceived higher ambiguity about COVID-19 vaccines also perceived COVID-19 to be less severe, reported lower knowledge about COVID-19 vaccines, experienced higher reactance, had lower intentions to vaccinate, and also reported higher fear, lower happiness, and lower relaxation. In the interest of brevity, we do not provide an extensive discussion of all correlations, because these analyses were secondary to the others reported and discussed in more detail.

See Table 2 for the distribution of sociodemographic characteristics and individual level differences among samples. Findings from preliminary chi square tests and ANOVAs demonstrated that the samples of American and Israeli participants differed on several sociodemographic and individual level difference factors: gender [$X^2(1) = 18.18, p < 0.001$], age [$F(1,533) = 133.64, p < 0.001$], education [$F(1,533) = 137.98, p < 0.001$], health literacy [$F(1,529) = 20.13, p < 0.001$], and dispositional optimism [$F(1,524) = 5.58, p = 0.019$]. Compared with the Israeli sample, the American sample was younger, had a greater proportion of males (21.5% male in the American sample versus 7.4% male in the Israeli sample), and had a higher level of education (i.e., there were more Americans at a later year in school). Further, compared with the Israeli sample, the American sample self-reported higher health literacy, but lower levels of dispositional optimism. Thus, these factors were controlled for in subsequent ANCOVAs.

See Table 3 for descriptive statistics and Table 4 for inferential statistics from ANCOVAs. When reviewing the main effects of Nation (US, Israel) on various psychological correlates of health behavior, Israeli participants reported higher perceptions of

ambiguity, higher worry, higher fear, and higher anger compared to American participants. However, Israeli participants reported lower perceived severity of COVID-19 compared to American participants. There were no significant differences in perceived susceptibility, perceived knowledge about COVID-19 and COVID-19 vaccination, reactance, happiness, relaxation, or vaccination intentions as a function of nation. When reviewing the main effects of Vaccination Status (Vaccinated, Unvaccinated) on various psychological correlates of health behavior, there were significant differences between vaccinated and unvaccinated participants on perceptions of ambiguity, perceptions of susceptibility, perceptions of severity, worry, reactance, fear, anger, happiness, relaxation, and intentions to vaccinate. Of note, significant differences between vaccinated and unvaccinated individuals on these factors were mostly consistent with hypotheses and theoretically expected relationships. Consistent with hypotheses, unvaccinated individuals reported higher perceptions of ambiguity, higher reactance, and higher anger compared to vaccinated participants. Further, unvaccinated individuals reported lower perceptions of susceptibility, lower perceptions of severity, lower worry about getting COVID-19, lower positive emotion (happiness and relaxation), and lower intentions to vaccinate in the future for COVID-19 compared to their vaccinated counterparts. Inconsistent with hypotheses, unvaccinated individuals reported higher fear compared with vaccinated participants. There were no significant differences in perceived knowledge about COVID-19 or COVID-19 vaccination as a function of vaccination status.

There was only one significant interaction between nation and vaccination status, and this was in regard to intentions to vaccinate. Vaccinated Americans reported higher intentions to vaccinate ($M = 2.89, SE = 0.08$) compared to vaccinated Israelis ($M = 2.36, SE = 0.08$). However, unvaccinated Americans reported lower intentions to vaccinate ($M = 1.80, SE = 0.15$) compared to unvaccinated Israelis ($M = 1.95, SE = 0.21$). See Figure 1 for a depiction of this relationship.

TABLE 2 Distribution of sociodemographic characteristics and individual level differences.

Sociodemographic variables	U.S. (<i>n</i> = 330)		Israel (<i>n</i> = 204)	
	<i>M</i> (SD)	Range	<i>M</i> (SD)	Range
Age (in years)	20.21 (2.34)	18–34	23.45 (4.15)	19–55
	<i>N</i>	Percentage %	<i>N</i>	Percentage %
Gender				
Female	262	79.4	188	92.6
Male	66	20.0	13	6.4
Race				
White	268	81.5	–	–
Black or African American	28	8.5	–	–
American Indian or Alaska Native	0	0	–	–
Asian or Asian American	14	4.3	–	–
Native Hawaiian or Pacific Islander	0	0	–	–
Middle Eastern or North African	2	0.6	–	–
Other	15	4.6	–	–
I would rather not report this	2	0.6	–	–
Religious affiliation				
Jewish	–	–	108	56.3
Christian	–	–	17	8.9
Muslim	–	–	48	25.0
Druze	–	–	14	7.3
Other	–	–	1	0.5
Atheist	–	–	3	1.6
I would rather not report this	–	–	1	0.5
Education				
Freshman	94	28.5	169	82.8
Sophomore	91	27.6	14	6.9
Junior	84	25.5	16	7.8
Senior	58	17.6	2	1.0
Graduate student	3	0.9	3	1.5
Individual differences	U.S. (<i>n</i> = 330)		Israel (<i>n</i> = 204)	
	<i>M</i> (SD)	Range	<i>M</i> (SD)	Range
Tolerance for ambiguity	2.50 (0.47)	1–3.67	2.45 (0.53)	1–4
Health literacy	3.86 (0.77)	1.67–5	3.56 (0.68)	2.33–5
Dispositional optimism	3.04 (0.78)	1–5	3.19 (0.60)	1–4.83

Valid percentage was reported to account for missing data. Race was collected only in the American sample, whereas religious affiliation was collected only in the Israeli sample. For this reason, we were not able to check whether these variables differed across samples. Valid data is unavailable for gender among 2 participants in the American sample and 2 participants in the Israeli sample. Gender [$\chi^2(1) = 18.18, p < 0.001$], age [$F(1,533) = 133.64, p < 0.001$], education [$F(1,533) = 137.98, p < 0.001$], health literacy [$F(1,529) = 20.13, p < 0.001$], and dispositional optimism [$F(1,524) = 5.58, p = 0.019$] differed between samples. Tolerance for ambiguity did not significantly differ between samples [$F(1,524) = 1.448, p = 0.229$].

Discussion

Vaccine hesitancy is considered one of the top threats to global health (64). Thus, it is important to better understand vaccine hesitant individuals to appropriately intervene. Beyond a broad need to better understand vaccine hesitancy, there is a more immediate

need to understand cultural differences and tailor behavioral health interventions appropriately. In the present study, we examined psychological correlates of vaccine hesitancy in a cross-cultural sample of Americans and Israelis. Although findings across samples were mostly consistent with hypotheses and theory, there were differences across cultures.

TABLE 3 Health cognitions, emotions, and intentions as a function of nation and vaccine status.

Outcome	Nation				Vaccine Status			
	U.S. (<i>n</i> = 319)		Israel (<i>n</i> = 190)		Vaccinated (<i>n</i> = 459)		Unvaccinated (<i>n</i> = 50)	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
Health cognitions								
Perceived ambiguity	2.82	0.07	3.12	0.10	2.78	0.03	3.16	0.11
Perceived susceptibility	2.75	0.12	3.11	0.17	3.19	0.06	2.67	0.19
Worry	2.02	0.14	2.57	0.21	2.61	0.07	1.99	0.23
Perceived severity	2.89	0.05	2.60	0.08	2.87	0.03	2.61	0.09
Perceived COVID-19 knowledge	3.25	0.07	3.27	0.10	3.20	0.04	3.32	0.12
Perceived COVID-19 vaccine knowledge	2.92	0.08	2.88	0.11	2.78	0.04	3.01	0.13
Reactance	2.96	0.10	3.28	0.15	2.47	0.05	3.77	0.16
Emotion								
Fear	2.05	0.13	2.99	0.19	2.17	0.07	2.87	0.21
Anger	1.93	0.13	2.95	0.19	1.91	0.07	2.97	0.21
Happiness	1.98	0.13	1.70	0.19	2.29	0.07	1.40	0.21
Relaxed	2.46	0.14	2.06	0.20	2.79	0.07	1.73	0.22
Intentions								
Intentions to vaccinate	2.34	0.08	2.15	0.12	2.62	0.04	1.87	0.13

Psychological correlates of vaccine hesitancy

Compared with participants who self-reported that they were vaccinated, those who self-reported that they were not vaccinated also reported in the present research that they perceived higher ambiguity about the COVID-19 vaccines, felt higher negative emotion and lower positive emotion about the COVID-19 vaccines, experienced higher reactance about vaccination recommendations, thought they were less susceptible to be infected with COVID-19, thought that getting COVID-19 was less severe, felt less worry about getting COVID-19, and indicated lower intentions to receive a future COVID-19 vaccination. Overall, findings are consistent with how these psychological correlates of health behavior are expected to operate across various theoretical frameworks. These results are also mostly consistent with hypotheses, with the exception of one finding. Inconsistent with the hypothesis that unvaccinated individuals would report lower fear when thinking about COVID-19 vaccines compared with vaccinated individuals, we instead found that unvaccinated individuals reported higher fear. This result may have occurred if unvaccinated individuals were unvaccinated in part due to fear of the vaccines themselves.

Overall, a different profile of thoughts and feelings between vaccinated and unvaccinated individuals emerged. Importantly, findings provide concrete areas for intervention when it comes to vaccine hesitancy. That is, public health officials and practitioners might focus on changing these thoughts and feelings of unvaccinated individuals to match those held by vaccinated individuals. For example, focusing on decreasing perceptions of ambiguity with “normalization of uncertainty” interventions [e.g., (20, 65)] may

prove useful. Further, applying a self-affirmation intervention can reduce the effects of reactance [e.g., (66)]. Indeed, the present research provides tangible areas to focus on for vaccination interventions.

Despite several differences, vaccinated and unvaccinated participants did not differ in their perceptions of knowledge about COVID-19 and COVID-19 vaccination. It is possible that the timing of data collection and the saturation of information about COVID-19 led to similar levels of perceived knowledge among vaccinated and unvaccinated individuals across both countries. More specifically, the pandemic had been ongoing for several years at the time of data collection. Further, technology had increased the availability and overwhelm of several voices on COVID-19, referred to as a “saturation” effect (67). In turn, people across countries may have generally felt knowledgeable about COVID-19 and COVID-19 vaccination. Indeed, the average responses to the perceived knowledge measures were above the midpoint for both American and Israeli participants.

Cross-cultural differences

Israeli participants reported higher perceptions of ambiguity about COVID-19 vaccines, higher fear and higher anger about COVID-19 vaccines, as well as higher worry about COVID-19, compared to American participants. Further, Israeli participants reported lower perceptions of COVID-19 severity compared to American participants. Although exact reasons for these cultural level differences is unknown, these differences underscore the need to examine health behavior within a cultural context. One interpretation for these cultural differences may be related to politicization of the vaccine. Indeed, the vaccines were highly

TABLE 4 Inferential statistics of nation, vaccine status, and their interaction on health cognitions, emotions, and intentions.

Outcome	Nation			Vaccine Status			Interaction		
	<i>F</i>	<i>p</i> -value	Partial eta squared	<i>F</i>	<i>p</i> -value	Partial eta squared	<i>F</i>	<i>p</i> -value	Partial eta squared
Health cognitions									
Perceived ambiguity	6.48	0.011	0.013	12.03	0.001	0.023	0.05	0.821	0.000
Perceived susceptibility	2.88	0.090	0.006	7.00	0.008	0.014	0.02	0.879	0.000
Worry	4.49	0.035	0.009	6.86	0.009	0.014	0.18	0.669	0.000
Perceived severity	11.49	<0.001	0.022	13.31	<0.001	0.026	0.33	0.563	0.001
Perceived COVID-19 knowledge	0.02	0.888	0.000	0.99	0.321	0.002	1.45	0.230	0.003
Perceived COVID-19 vaccine knowledge	0.09	0.770	0.000	3.03	0.083	0.006	1.45	0.230	0.003
Reactance	2.94	0.087	0.006	58.97	0.000	0.105	2.66	0.104	0.005
Emotion									
Fear	16.05	0.000	0.031	10.55	0.001	0.021	1.53	0.217	0.003
Anger	18.69	0.000	0.036	24.36	0.000	0.046	2.26	0.133	0.004
Happiness	1.42	0.234	0.003	16.76	0.000	0.032	0.00	0.998	0.000
Relaxed	2.50	0.114	0.005	20.81	0.000	0.041	0.66	0.418	0.001
Intentions									
Intentions to vaccinate	1.58	0.209	0.003	30.20	0.000	0.057	6.51	0.011	0.013

Due to missing data across variables, df of *F* statistics varied (1–2, 495–506).

politicized in both countries, but there was stronger involvement of authorities and limits to freedom in Israel during the vaccine rollout. COVID-19 vaccines were disseminated in Israel earlier than other countries due to a deal with Pfizer that allowed Pfizer to collect individuals' personal vaccine data. Additionally, this deal also made Pfizer the dominant vaccine available in Israel, compared with more options that were available in the United States and elsewhere around the world. The United States and much of the world followed the data on vaccine efficacy and rollout from Israel's vaccination campaign (73). This arrangement and subsequent debates among Israeli experts regarding vaccination policy may have created more vaccine reluctance and hesitation among the Israeli sample (68). Further, Israel also offered a "green pass" incentive at a federal level to allow people who were fully vaccinated, participating in a vaccine trial, or who recently recovered from COVID-19 to have access to locations that were otherwise closed off to prevent the spread of infection [i.e., businesses; (69)]. This restriction on movement at a federal level, although done to help prevent spread of infection, may have contributed to more negative sentiment among the Israeli sample.

Beyond the political context, several additional factors may help explain the observed differences between Israeli and American participants. First, differences in socio-cultural characteristics may have played a role. Israel's more collectivist society with dense social networks (74) may have amplified the spread of both emotions and opinions about vaccination among community members. In contrast, a stronger emphasis on individualism and personal rights in the United States (75) may have led to more varied reactions to COVID-19 vaccines. Second, differences in media environment may have been important. Israel's small size may have facilitated more uniform media coverage of vaccination issues through mainstream

channels. The more diverse media landscape and multiple information sources in the United States (see for example (76))—including the prevalence of social media as a source of COVID-19 news (77)—and the polarization of trust in various news outlets (78) may have created less unified social norms around vaccination, allowing for a broader range of perspectives and potentially influencing emotional responses. Third, Israel's centralized healthcare system, while enabling rapid and uniform policy implementation, may have intensified feelings of institutional control. The decentralized U.S. system allowed for more flexibility in vaccine rollout and policy enforcement, potentially reducing feelings of systemic pressure. Fourth, the historical context between countries may also explain differences in results. Israel's previous experience with national emergencies may have influenced both institutional trust and emotional responses to government mandates. The United States has a longer history of vaccine debates predating COVID-19 (79), which may have positioned the COVID-19 vaccine within an existing framework of vaccine attitudes. Finally, demographic differences in average age, population density, and family structure between the countries may have influenced risk perception and vaccine attitudes. Additionally, varying levels of ethnic and cultural diversity between the nations may have affected institutional trust and response to health policies.

Indeed, paying greater attention to cross-cultural differences in vaccine hesitancy can allow the respective health ministries in each country to then frame health communications based on the needs of their respective populations. Future researchers may even consider whether these higher perceptions of ambiguity, fear, and anger about COVID-19 vaccines or lower perceptions of COVID-19 severity may have had an unintended spillover effect among Israelis toward other vaccines and vaccine-preventable illnesses.

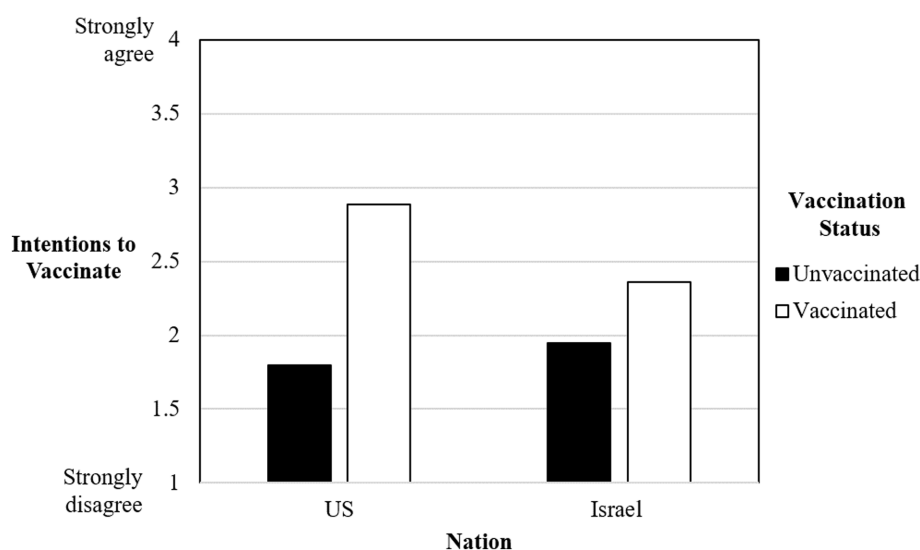


FIGURE 1
Interaction between nation and vaccination status on intentions to vaccinate.

Interaction effect

In the present research, whether individuals were vaccinated or not was associated with whether individuals also reported they were interested in receiving a future COVID-19 vaccination. First, vaccinated Americans reported higher intentions to receive a COVID-19 vaccine in the future compared to vaccinated Israelis. Second, unvaccinated Americans reported lower intentions to vaccinate in the future compared to unvaccinated Israelis. Thus, again, it is important to examine how health behavior might differ in different cultural contexts.

Limitations

There are limitations of the present research. First, we recruited convenience samples from universities, and the samples are not nationally representative. Indeed, as demonstrated by Table 2, most of the participants in the present research were young adult females, with limited diversity in gender and age. Indeed, males and females differ in COVID-19 risk perceptions and vaccine hesitancy, such that females perceive higher COVID-19 risk, but also tend to be more hesitant toward vaccination (70). Future research should include a more diverse sample in terms of age and gender, and also consider factors such as socioeconomic status. Second, there were also more vaccinated than unvaccinated participants, and future research should increase efforts to recruit unvaccinated participants. Third, data were collected while the pandemic was ongoing for several years (i.e., March–June 2023) rather than at the start of the pandemic in March 2020. Thus, associations among variables may have been weaker than at the start of the pandemic. Fourth, we cannot identify why certain cross-cultural differences exist, as this requires more in-depth research. Indeed, qualitative work may be beneficial for interviewing individuals and isolating themes relevant to their vaccination decisions. Fourth, we examined emotions about COVID-19 vaccination generally, and the exact target of negative and positive emotions (i.e., *why* participants experienced the specific

emotions in regard to COVID-19 vaccination) was not examined. Future research should delve further into understanding these emotions. Additionally, the intentions item was written to be broad to apply to both vaccinated and unvaccinated individuals' experiences (i.e., "I intend to get vaccinated against COVID-19 at some point in the future"). Thus, it is unknown how participants specifically interpreted this measure. Indeed, individuals may have a difference in opinion regarding the primary vaccination vs. additional booster shots, and this may have been reflected in their answers. Future research might consider these differences.

Conclusion

In the present research, we use cross-sectional data to provide a description of public perceptions about COVID-19 vaccination among vaccinated and unvaccinated Israeli and American adults. Findings revealed cross-cultural differences between the United States and Israel on psychological correlates of vaccine hesitancy. Continued cross-cultural research is necessary for increased vaccination efforts through tailoring of vaccination materials.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Kent State University IRB (approval number 20-166) and the University of Haifa IRB (approval number 463/22). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

NS: Conceptualization, Formal analysis, Methodology, Resources, Writing – original draft, Writing – review & editing. AG-E: Conceptualization, Methodology, Resources, Supervision, Writing – review & editing. JT: Conceptualization, Methodology, Resources, Supervision, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

Dr. Simonovic gratefully acknowledges financial support for a postdoctoral fellowship during the time of this research from the Fulbright U.S. Scholars Program, which is sponsored by the U.S. Department of State and the Fulbright Israel Commission. The contents of this publication are solely the responsibility of the author and do not necessarily represent the official views of the Fulbright

Program, the Government of the United States, or the Fulbright Israel Commission.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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OPEN ACCESS

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RECEIVED 09 October 2024

ACCEPTED 16 December 2024

PUBLISHED 06 January 2025

CITATION

Dires AA, Workie DL and Teklie AK (2025)
Exploring factors influencing childhood
immunization status in East Africa using
multilevel ordinal logistic regression analysis.
Front. Public Health 12:1508303.
doi: 10.3389/fpubh.2024.1508303

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Exploring factors influencing childhood immunization status in East Africa using multilevel ordinal logistic regression analysis

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Introduction: Childhood vaccinations are crucial in safeguarding children from infectious diseases and are recognized as one of the most cost-effective public health interventions. However, children in East African countries face more than a fifteen-fold increased risk of death from vaccine-preventable diseases compared to those in high-income nations. This study aimed to identify the factors influencing childhood immunization status in East Africa.

Methods: A sample of 22,734 children aged 12 to 23 months was included to assess immunization status, utilizing recent data from the Demographic and Health Survey conducted between 2015 and 2022 across ten East African countries. A Level-3 multilevel generalized odds model with a logit link function was employed for the analysis.

Results: Among the 22,734 children in the sample, only 67.4% were fully immunized, 27.7% were partially immunized, and the remaining were not immunized at all. The null hypothesis of proportionality was rejected based on the Brant test. Consequently, various partial and non-proportional odds models were fitted, with the generalized odds model demonstrating the best fit compared to other ordinal regression models. The findings indicated that 43.14% of the variation in children's immunization status was attributable to differences between countries, while 18.18% was due to variations between regions. Specific factors associated with immunization status revealed that mothers who attended antenatal care were 1.23 times more likely to fully immunize their children compared to those who did not, and those who received postnatal care were 1.13 times more likely to do so. Additionally, mothers who had antenatal and postnatal services were 1.07 and 1.08 times more likely, respectively, to fully or partially immunize their children compared to those who did not.

Conclusion: The fitted generalized odds model indicated that several factors significantly associated with childhood immunization status included maternal age, number of antenatal and postnatal care visits, tetanus injections received by mothers, vitamin A intake, presence of health documentation, place of delivery, birth order, mother's occupation, sex of the household head, distance to health facilities, maternal education, community maternal education, community wealth index, and community media exposure. Therefore, it is recommended that interventions focus on enhancing household wealth, educating mothers, and improving health systems.

KEYWORDS

child immunization, ordinal logistic model, multilevel analysis, East Africa, status

Introduction

Immunization serves as a straightforward, safe, and economical method to shield children from potentially dangerous diseases (1). To safeguard children against infectious diseases, vaccinations are administered either actively through vaccines or passively via immunoglobulin, which activates the immune system (2). Presently, basic childhood immunizations (such as BCG, pentavalent, polio, and measles) prevent an estimated 3.5 to 5 million deaths each year from diseases like tuberculosis, diphtheria, tetanus, pertussis, influenza, polio, and measles (3). However, in 2021, it was estimated that approximately 25 million children globally were either unvaccinated or inadequately vaccinated. Among these, around 18 million children did not receive any doses of the diphtheria-tetanus-pertussis (DTP) vaccine (4). This reduction in vaccination coverage has resulted in an increase in the number of unvaccinated children worldwide, rising from 13 million in 2019 to about 18 million in 2021, marking a nearly 40% increase. Furthermore, in 2022, there were still 20.5 million children lacking essential vaccines globally, which is 2.1 million more than in 2019 (5). The COVID-19 pandemic has also caused a significant decline in routine immunization rates, posing a serious risk to children's health worldwide (6).

Africa has the highest under-five mortality rate globally, accounting for 40% of deaths in this age group, primarily due to vaccine-preventable diseases (VPDs) (7). Between 2019 and 2020, the number of zero-dose children remained stable at 0.3 million in the European Region but increased in the African Region from 7.1 million to 7.7 million (8). It is estimated that one in five African children does not receive all necessary vaccinations. As a result, over 30 million African children under five continue to suffer from VPDs each year, with more than 500,000 of these children dying annually (9). Nearly 44% of the 55,102 children aged 12 to 23 months enrolled in 25 surveys conducted in sub-Saharan Africa from 2013 to 2020 missed vaccination opportunities, indicating they were either unvaccinated or under-vaccinated (10).

The WHO immunization schedule indicates that East Africa has a low rate of childhood vaccination coverage, with only 69.21% of children aged 12 to 23 months receiving all recommended vaccinations. This figure varies significantly between countries. According to the UN statistics division, East Africa comprises 19 countries: Burundi, Comoros, Djibouti, Ethiopia, Eritrea, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Rwanda, Seychelles, Somalia, Somaliland, Tanzania, Uganda, Zambia, and Zimbabwe (11, 12) and in this region various factors influence a child's vaccination status, including the child's health, maternal healthcare, and socio-demographic characteristics (13).

However, when evaluating the reasons for complete or partial vaccination coverage in East Africa, critical factors such as the presence of unvaccinated children is often overlooked. While some studies have examined children's vaccination status using two-level logistic regression models in various East African countries, none have employed three-level ordinal logistic regression analysis. The existing research has analyzed various factors affecting vaccination coverage, but aside from studies conducted in Ethiopia (14, 15) using two-level ordinal logistic regression and classical ordinal logistic regression models, the literature primarily relies on binary and multinomial logistic regression, categorizing vaccination status as fully vaccinated or not fully vaccinated. However, a child's vaccination status is typically classified as fully vaccinated, partially vaccinated, or not vaccinated, considering the natural order of these categories. Despite previous studies exploring the prevalence and factors associated with complete basic childhood vaccination in East Africa (13, 16), there remains a gap in research specifically examining childhood vaccination status and related factors among children aged 12 to 23 months using pooled DHS data in this region.

Consequently, it is essential to investigate vaccination coverage and the factors influencing childhood vaccination status across East Africa to assess cross-national differences. This study aims to analyze recent pooled DHS data (2015–2022) from ten East African countries, focusing on factors affecting immunization status in children aged 12 to 23 months using three-level ordinal logistic regression analysis.

Methods

Data source and study design

This study utilized data from the latest Demographic and Health Surveys (DHS) conducted across ten East African countries. The selection of these countries was based on the availability of relevant variables and household cluster GPS coordinates (latitude and longitude). The DHS provides comprehensive country-level data from

TABLE 1 Description of the sample size and the respective recent DHSs.

Country	Survey year	Total number of women's having children aged 12–23 months old	
		Un-weighted sample	Weighted sample
Burundi	2016–17	2,585	2,669
Ethiopia	2016	1,870	1,943
Kenya	2022	3,534	3,158
Madagascar	2021	2,304	2,296
Malawi	2015–16	3,192	3,177
Rwanda	2019–20	1,558	1,617
Tanzania	2022	2,088	2,130
Uganda	2016	2,787	2,718
Zambia	2018	1,899	1,861
Zimbabwe	2015	1,093	1,165
Total		22,910	22,734

Abbreviations: AIC, Akaike information criteria; ANC, Antenatal care; BCG, Bacille Calmette Guérin; BIC, Bayesian information criteria; CI, Confidence interval; DHS, Demographic and Health Survey; DTP1, Diphtheria-Tetanus-Pertussis containing vaccine1; DTP3, Diphtheria-Tetanus-Pertussis containing vaccine3; EA, Enumeration area; EPI, Expanded program on immunization; FML, Full maximum likelihood; ICC, Intra-class correlation; LMIC, Low and middle income countries; LRT, Likelihood ratio test; MCV1, Measles containing vaccine1; OPV, Oral polio vaccine; PNC, Postnatal care; POM, Proportional odds model; PPOM, Partial proportional odds model; ReML, Restricted maximum likelihood; VPD, Vaccine-preventable disease; WHO, World Health Organization.

surveys conducted between 2015 and 2022 (Table 1). We chose DHS data because it is the most extensive resource for information regarding low- and middle-income countries. The analysis included a sample of 22,734 women with children aged 12 to 23 months. The data were extracted from the Kids Record (KR) files of the DHS, which is a nationwide survey carried out every five years in low- and middle-income nations.¹ The DHS is representative of each country and emphasizes critical maternal and child health indicators, including the immunization status of children. A multistage sampling approach was implemented, beginning with the selection of clusters (enumeration areas, or EAs), followed by systematic sampling of households within these chosen EAs.

Variables of the study

Response variable

In this study, the response variable was defined as “children’s immunization status,” which is classified into three categories: fully immunized, partially (incompletely) immunized, and not immunized, in accordance with the national vaccination and Expanded Program on Immunization (EPI) schedule (17). According to the World Health Organization (WHO) guidelines, a child aged 12 to 23 months is considered not immunized if they have not received any of the eight required vaccines (one dose of BCG, at least three doses of the pentavalent vaccine, three doses of oral polio vaccine (OPV), and one dose of the measles vaccine), and is coded as “0.” A child is classified as partially (incompletely) immunized if they missed at least one of the eight vaccines, receiving a code of “1.” Conversely, a child is deemed fully immunized if they have received all eight vaccines, which is coded as “2” (13, 15, 18–22). Information on vaccination status for children comes from the DHS Kids Record (KR) files, which are designed to capture detailed health indicators, including immunization status. The vaccination status is categorized based on whether children received all required vaccines as per the national Expanded Program on Immunization (EPI) guidelines. The analysis considers the availability of health records as an independent variable, which is crucial since having proper health documentation can significantly influence immunization rates. This variable reflects the accessibility and utilization of healthcare services, underscoring its importance in understanding the broader context of vaccination coverage.

Independent variables

The selection of independent variables associated with children’s immunization status was informed by existing knowledge and previously published literature (7, 10, 14, 15, 22–25). The variables age of mother, marital status, mother education level, father education level, occupation of mother, occupation of father, sex of household head, access of mass media, number of children, birth order, birth interval, weight at birth, sex of child, presence of vaccination document, place of delivery, antenatal follow up, postnatal follow up, distance to health center, tetanus injection before birth, talking vitamin A₁ were potential lower level variables, while community

mother education, community wealth index, community media exposure, and residence were the potential higher level (level-two) variables.

Statistical analysis

Data analysis was conducted using R version 4.3.3, where categorical variables were summarized by frequencies and percentages. To address the prevalent missing values in the DHS data, a multiple imputation technique was employed, restoring natural variability and accounting for uncertainty in statistical inference (26). Given the ordinal nature of the outcome variable, children’s immunization status (not immunized, partially, and fully immunized), a three-level ordinal logistic regression model was utilized. This hierarchical model recognizes that children are nested within regions or provinces, which are further nested within countries.

The proportional odds (PO) assumption underlies this model; if satisfied, it allows for consistent effects of independent variables across outcome categories (27). If not, alternative models such as the Partial Proportional Odds Model (PPOM) (28), Generalized Ordered Logit Model (GOM) (29), Continuation Ratio Model (CRM) (30), and Adjacent-Categories Logit Model (ACM) (31) can be applied (Figure 1).

The PPOM accommodates variables that meet the PO assumption while allowing flexibility for those that do not. The GOM extends the ordinal logistic regression by relaxing the proportionality constraint, enabling varied effects of explanatory variables. The CRM allows for distinct intercepts and coefficients for each response category comparison, while the ACM focuses on estimating odds between adjacent categories of the ordinal response. Overall, the use of a three-level ordinal logistic regression model is appropriate for analyzing children’s immunization status, considering the hierarchical data structure and the necessity to address the proportional odds assumption.

Model building, parameter estimation, and test of model adequacy

Model building can adopt either a top-down or bottom-up approach, with the latter being more prevalent due to its efficiency. The top-down method starts with a complex model, risking long computation times and convergence issues, while the bottom-up strategy begins with a simple intercept-only model and iteratively adds parameters, testing their significance after each inclusion (32, 33) and variables with *p*-value of 0.25 or much more will exclude from the final covariate analysis (34). To assess the variation in children’s immunization status across clusters, we employed the Likelihood Ratio (LR) test, Intra-class Correlation Coefficient (ICC), and Proportional Change in Variance (PCV). The ICC quantifies heterogeneity in immunization status between clusters, indicating the proportion of total variation attributable to cluster differences and the PCV measures the proportion of variance explained by predictors at each model level (35). Parameter estimation in this context involves maximizing the log-likelihood function using Full Maximum Likelihood (FML) or Restricted Maximum Likelihood (RML). RML is generally preferred as it reduces bias by accounting for fixed effects (36). Testing model fit includes assessing the significance of fixed and

¹ <https://www.dhsprogram.com/Data>

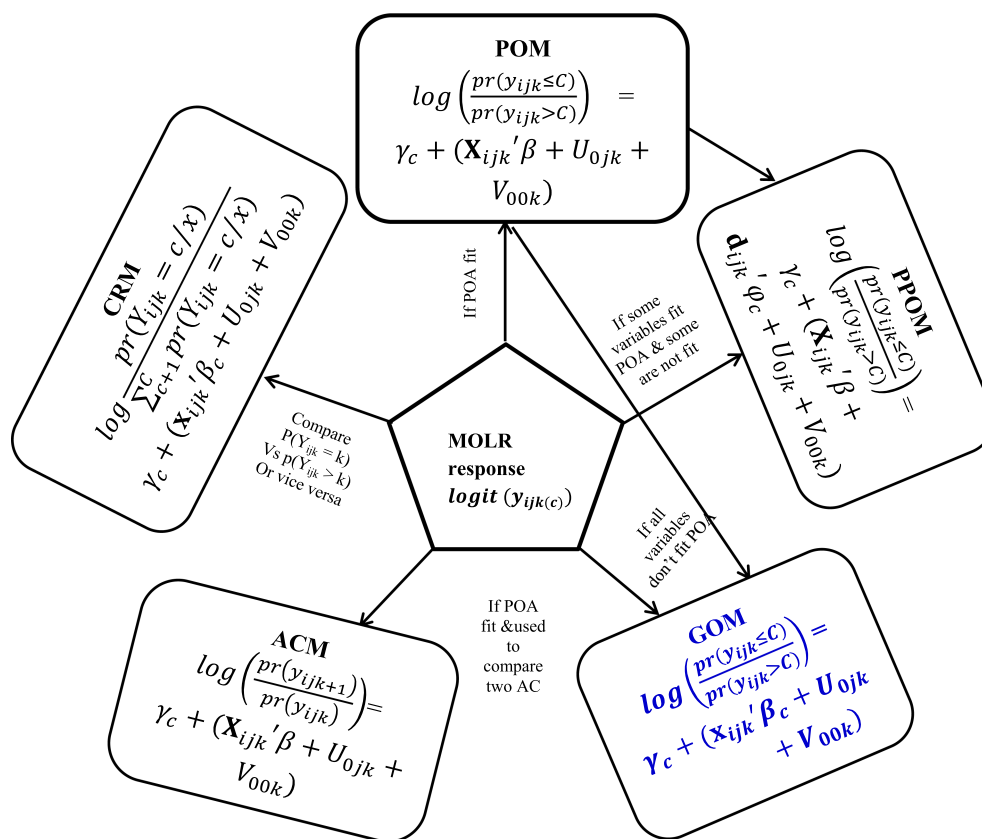


FIGURE 1
Different types of three-level ordinal logistic regression models.

random effects, with the Wald ratio employed for hypothesis testing (32). Finally, model selection is guided by Akaike's Information Criterion (AIC) and log-likelihood statistics, where the model with the lowest AIC and highest -2LL is considered the best fit for the data.

Results

Immunization status in East Africa

In East Africa, the overall immunization coverage stands at 67.4%, with 27.7% of children being partially immunized and 4.9% not immunized at all. Among the 15,323 fully immunized children, the highest coverage is observed in Malawi at 15.8%, followed closely by Burundi at 14.8% and Kenya at 14.5%. Conversely, the rates of non-immunized children are particularly concerning in Madagascar, where 37.3% of children lack vaccinations, followed by Ethiopia at 28.1% and Zimbabwe at 9.8% (Figures 2, 3).

Economic and socio-demographic characteristics of respondents and children

A total of 22,734 weighted women with children aged 12–23 months were included in the study, revealing that the majority of respondents, specifically 10,473 women, were in the 25–34 age group. Regarding parental educational status,

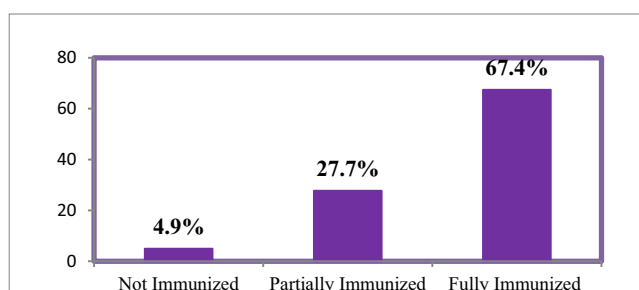


FIGURE 2
Children of age 12–23 months vaccination status in East Africa.

approximately 11,419 mothers and 10,779 fathers had only primary education, and this group exhibited the highest proportion of children who were either not vaccinated or partially vaccinated. In contrast, parents with secondary education demonstrated significantly higher rates of full immunization for their children, with 74.1% of mothers and 71.4% of fathers achieving this status. Additionally, nearly 70% of the communities surveyed were classified as having a poor wealth index, and over 80% of the respondents lived in rural areas. These socio-demographic factors highlight the relationship between parental education and child vaccination rates, emphasizing the need for targeted interventions to improve immunization coverage, particularly among less educated populations (Table 2).

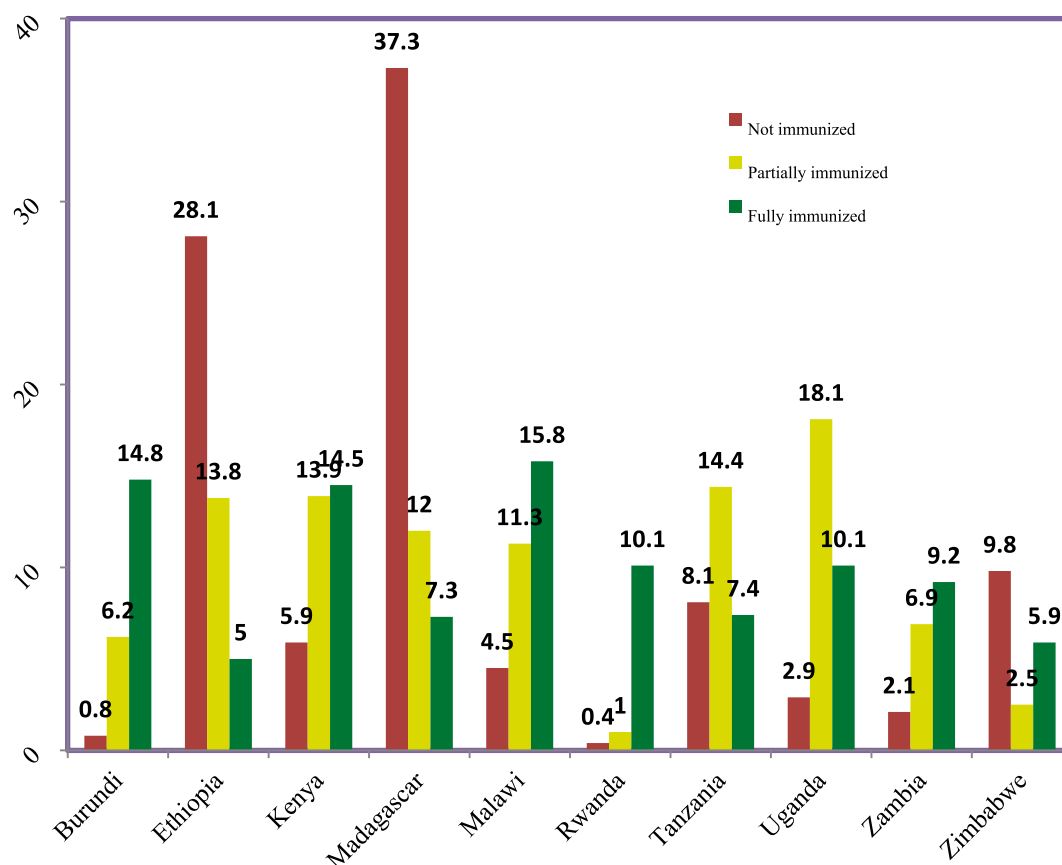


FIGURE 3
The prevalence of immunization status of children among East African countries.

Model comparison for the three-level model

Due to the violation of the parallel line regression assumption (Brant test) (χ^2 : 978.23, p -value = 0.000), the PO model was excluded. Subsequently, various other models were applied to the data. Among the models considered, the GOM model exhibited the best fit based on AIC, BIC, and -2LL values (Table 3).

Factors associated with experiencing children immunization status

The GOM results for the fixed effects in Table 4 present two comparisons: the first contrasts fully immunized children with those who are partially or not immunized, while the second compares fully or partially immunized children to those who are not immunized, from left to right in the table. In the univariate analysis except sex of child all other variables were significantly associated with child immunization status. But based on these results at a 5% level of significance, factors significantly associated with childhood immunization status include the mother's age, antenatal care (ANC) visits, postnatal care (PNC) visits, the number of tetanus injections received by mothers, vitamin A supplementation, presence of health documentation, number of children, place of delivery, mother's

occupation, sex of the household head, distance to the health facility, mother's education, residence, community-level maternal education, community-level wealth index, and community-level media exposure.

Table 4 indicates that, controlling for other factors, children whose mothers are aged 25–34 and 35–49 years have 1.14 [OR = 1.14, CI: 1.08–1.20] and 1.24 [OR = 1.24, CI: 1.20–1.28] times higher odds of being fully immunized compared to those whose mothers are aged 15–24. Additionally, the odds of children aged 12–23 months being fully immunized are 1.23 [OR = 1.23, p = 0.001] times higher if their mothers had antenatal care. Children whose mothers received postnatal care have odds of being fully immunized that are 1.13 [OR = 1.13, p = 0.001] times higher. For tetanus injections, children born to mothers with 3+ injections are 1.36 [OR = 1.36, CI: 1.30–1.42] times more likely to be fully immunized compared to those with no injections. The odds increase to 1.06 [OR = 1.06, CI: 1.02–1.10] for children whose mothers received vitamin A. The model shows that children with health documentation have 1.11 [OR = 1.11, p = 0.0035] times higher odds of being fully immunized. Children born in health facilities are also 1.12 [OR = 1.12, CI: 1.04–1.20] times more likely to be fully immunized. Educational attainment also plays a role; children of mothers with secondary or higher education have 1.30 [OR = 1.30, CI: 1.10–1.50] and 1.87 [OR = 1.87, CI: 1.75–1.99] times higher odds of full immunization than those of non-educated mothers.

Distance to health facilities negatively impacts immunization; children whose mothers perceive distance as a major problem have lower odds of being fully immunized [OR = 0.86, CI: 0.78–0.94].

TABLE 2 Frequency distribution of covariates for different categories of immunization status.

Variables	Categories (codes)	Immunization Status		
		Not-immunized	Partially- immunized	Fully-immunized
Age of mother	15–24 (0)	386 (5.1)	2,181 (28.6)	5,062 (66.3)
	25–34 (1)	499 (4.8)	2,795 (26.7)	7,179 (28.4)
	35–49 (2)	233 (5)	1,315 (28.4)	3,084 (66.6)
Mother educational level	No education (1)	518 (11.3)	1,581 (34.5)	2,489 (54.3)
	Primary (2)	418 (3.7)	3,165 (27.7)	7,836 (68.6)
	Secondary (3)	161 (2.9)	1,282 (23)	4,127 (74.1)
	Higher (4)	22 (1.9)	262 (22.6)	873 (75.5)
Father educational level	No education (1)	415 (10.5)	1,298 (32.8)	2,244 (56.7)
	Primary (2)	429 (4)	3,021 (28)	7,329 (68)
	Secondary (3)	232 (3.7)	1,541 (24.9)	4,423 (71.4)
	Higher (4)	42 (2.3)	430 (23.9)	1,330 (73.8)
Marital status	Married (1)	832 (5.3)	4,213 (26.9)	10,604 (67.8)
	Not married (2)	286 (4)	2078 (29.4)	4,721 (66.6)
Occupation of father	Yes (1)	998 (4.7)	5,766 (27.4)	14,282 (67.9)
	No (2)	120 (7.1)	525 (30.1)	1,043 (61.)
Occupation of mother	Employed (1)	642 (4.1)	4,218 (26.7)	10,948 (69.3)
	House wife (2)	476 (6.9)	2073 (29.9)	4,377 (63.2)
Sex of household	Male (1)	871 (4.9)	4,814 (27.2)	12,005 (67.9)
	Female (2)	247 (4.9)	1,477 (29.3)	3,320 (65.8)
Household wealth index	Poor (1)	6,541 (63.7)	697 (6.8)	3,034 (29.5)
	Middle (2)	3,041 (68.7)	192 (4.3)	1,192 (26.9)
	Rich (3)	5,743 (71.5)	230 (2.8)	2065 (25.7)
Access to media exposure	Yes (1)	7,997 (71.2)	342 (3)	2,894 (25.8)
	No (2)	7,329 (63.8)	776 (6.7)	3,396 (29.5)
Number of living children	1–2 (0)	7,284 (70.2)	399 (3.8)	2,686 (25.9)
	3–4 (1)	4,776 (67.8)	323 (4.6)	1941 (27.6)
	5+ (2)	3,264 (61.3)	397 (7.5)	1,664 (31.2)
Birth order of child	First order (1)	203 (3.8)	1,346 (25.1)	3,820 (71.1)
	2–3 (2)	361 (4.3)	2,216 (26.1)	5,917 (69.7)
	4 and above (3)	555 (6.3)	2,728 (30.7)	5,589 (63)
Birth interval of child	<=23 months (1)	226 (8.2)	927 (33.5)	1,615 (58.3)
	24–47 months (2)	596 (4.8)	3,399 (27.8)	8,218 (67.3)
	> = 48 months (3)	296 (4)	1964 (25.3)	5,494 (70.7)
Weight of child	Small (1)	370 (5.5)	1900 (27.9)	4,531 (66.6)
	Average (2)	487 (4)	3,265 (27)	8,356 (69)
	Large (3)	262 (6.8)	1,126 (29.4)	2,439 (63.7)
Sex of child	Male (1)	566 (5)	3,178 (27.9)	7,654 (62.1)
	Female (2)	552 (4.9)	3,113 (27.4)	7,671 (67.7)
Health documentation	Yes (1)	117 (0.6)	3,844 (21.3)	14,102 (78.1)
	No (2)	1,002 (21.5)	2,446 (52.4)	1,223 (26.2)
Place of delivery	Home (1)	782 (15.6)	1937 (38.4)	2,308 (46)
	Health facility (2)	336 (1.9)	4,354 (24.6)	13,018 (73.5)
ANC	Yes (1)	663 (3.1)	5,736 (26.9)	14,910 (70)
	No (2)	455 (31.9)	555 (38.9)	415 (29.2)

(Continued)

TABLE 2 (Continued)

Variables	Categories (codes)	Immunization Status		
		Not-immunized	Partially- immunized	Fully-immunized
PNC	Yes (1)	201 (3.0)	1788 (25)	5,164 (72)
	No (2)	918 (5.9)	4,502 (28.8)	10,161 (65.3)
Distance to health Facility	Big problem (1)	592 (6.7)	2,644 (29.8)	5,620 (63.5)
	Not Big problem (2)	526 (3.8)	3,647 (26.3)	9,705 (69.9)
Tetanus injection	Not received (1)	591 (11.5)	1,406 (27.4)	3,131 (61.1)
	1–2 (2)	355 (2.6)	3,619 (26.7)	9,598 (70.7)
	3 and above (3)	172 (4.3)	1,265 (31.3)	2,597 (64.4)
Vitamin A ₁	Yes (1)	284 (1.7)	3,965 (23.1)	12,908 (75.2)
	No (2)	835 (15)	2,325 (41.7)	2,417 (43.3)
Residence	Urban (1)	121 (2.5)	1,371 (28.3)	3,347 (69.2)
	Rural (2)	998 (5.6)	4,919 (27.5)	11,978 (66.9)
Community mother education	Low (1)	518 (11.3)	1,581 (34.5)	2,489 (54.3)
	High (2)	600 (3.3)	4,710 (26)	12,836 (70.7)
Community wealth index	Low (1)	889 (6.0)	4,226 (28.8)	9,582 (65.2)
	High (2)	229 (2.8)	2065 (25.7)	5,743 (71.5)
Community media exposure	Low (1)	809 (6.1)	3,542 (26.9)	8,829 (67)
	High (2)	310 (3.2)	2,798 (28.8)	6,496 (68)

TABLE 3 Model comparison on different three level OLR models.

Type	AIC	BIC	-2LL	p-value
PPOM	8,69.625	1,116.144	-1,267.5	<0.000
GOM	8,865.602	1,115.817	-1,062.3	<0.000
ACM	8,865.835	1,115.833	-1,475.2	<0.000
CRM	8,869.145	1,116.163	-1,478.8	<0.000

The bold values indicates that the best fit model based on AIC, BIC, and -2LL values.

Female-headed households show a reduced likelihood of full immunization compared to male-headed households [0.51 times]. Children from larger families (3–4 or 5+ children) are significantly less likely to be fully immunized compared to those from families with 1–2 children [OR = 0.44 and 0.22, respectively]. Employed mothers are 0.8 [OR = 0.8, CI: 0.72–0.88] times less likely to fully vaccinate their children compared to housewives. Rural children are 0.55 [OR = 0.55, CI: 0.51–0.59] times less likely to be fully immunized than those in urban areas. Communities with higher wealth indices and media exposure correlate with higher immunization rates [OR = 1.33 and 1.18, respectively]. Finally, children in communities with high maternal education levels are 1.40 [OR = 1.40, CI: 1.34–1.46] times more likely to be fully immunized compared to those in communities with low maternal education.

The random component output variance at the country and region level decreased from 3.67 and 1.55 to 2.8 and 1.3, respectively. This decrement suggests that the inclusion of the predictors explains some of the variation at both the country and regional levels compared to the null model (Table 5). Also, it reflects that the proportion of explained variance (PCV) for the country level in relation to child immunization status, by considering both level – 1 and level-2 predictors, were 23.7%. This means that 23.7% of the variability in child immunization status at the country level could be accounted for

these predictors. Similarly, the PCV for the region level is 0.161, indicating that 16.1% of the variability at the level-2 (region) is explained by the combination of level-1 and level-2 predictors.

Discussion

The objective of this study was to investigate the factors that influence childhood immunization status in ten East African countries, comprising a total of 132 regions based on recent DHS data.

In this study, a single outcome measure of “immunization status of children” was computed based on the World Health Organization (WHO) guidelines of the eight recommended vaccine types, and recoded into ordinal outcome. Various models, including PPOM, GOM, ACM, and CRM, were applied to the data, and a comparison of these models was conducted. According to the AIC and BIC criteria, the GOM model demonstrated the best fit. Consequently, the GOM model was selected to identify significant determinants of a child’s immunization status. Among the five models considered in this study, the fourth (Random coefficient) model yielded the best parameter estimates. Therefore, the significant predictors in the selected model were presented and interpreted at a 5% significance level.

The study revealed an overall full vaccination coverage of 67.4% (15,322,716 children) and the highest proportions of fully immunized children were observed in Malawi (15.8%), followed by Burundi (14.8%) and Kenya (14.5%). Conversely, Madagascar (37.3%), Ethiopia (28.1%), and Zimbabwe (9.8%) had the highest rates of non-immunized children. These findings align with existing literature on childhood vaccination in East Africa but indicate lower rates than those reported in Pakistan, possibly due to differences in healthcare infrastructure, access to services, and survey methodologies (13, 37). Key predictors of immunization status identified through the GOM

TABLE 4 Maximum likelihood estimates of fixed effects.

Predictors	Categories	Fully vs partially or not immunized		Fully or partially vs not immunized	
		AOR (95%CI)	p-value	AOR (95%CI)	p-value
Intercept	-	0.04 (0.0126, 0.0674)	<0.001***	0.06 (0.0.04, 0.08)	<0.001***
Mother's age	15–24	1		1	
	25–34	1.14 (1.0773, 1.2027)	0.0017**	1.12 (0.9671, 1.2729)	0.126
	35–49	1.24 (1.1988, 1.2812)	<0.001***	1.25 (1.2088, 1.2912)	<0.001***
ANC	No	1		1	
	Yes	1.23 (1.1300, 1.3300)	<0.001***	1.07 (1.0092, 1.1307)	0.0062**
PNC	No	1		1	
	Yes	1.13 (1.1084, 1.1516)	<0.001***	1.08 (1.0584, 1.1016)	0.0011**
TT	Not received	1		1	
	1–2	1.02 (0.9808, 1.0592)	0.867	1.05 (1.0050, 1.0951)	0.0166*
	3 and above	1.36 (1.2953, 1.4247)	<0.001***	1.21 (1.1061, 1.3139)	<0.001***
Vitamin A ₁	No	1		1	
	Yes	1.06 (1.0169, 1.1031)	0.019*	1.23 (1.0281, 1.4319)	0.0044
Health documentation	No	1		1	
	Yes	1.11 (1.0473, 1.1727)	0.0035**	1.38 (1.2604, 1.4996)	<0.001***
Place of delivery	Home	1		1	
	Health facility	1.12 (1.0396, 1.2004)	<0.001***	1.34 (1.2460, 1.4341)	<0.001***
Distance to health facility	Not big problem	1		1	
	Big problem	0.86 (0.7757, 0.9443)	0.048*	0.88 (0.7938, 0.9662)	0.0086**
Sex of house hold head	Male	1		1	
	Female	0.51 (0.4081, 0.6119)	<0.001***	0.41 (0.3081, 0.5119)	<0.001***
Number of Child	1–2	1		1	
	3–4	0.44 (0.37,0.51)	<0.001***	0.53 (0.33, 0.73)	<0.001***
	5+	0.22 (0.14, 1.30)	0.3306	0.18 (0.11,1.20)	0.2511
Occupation of Mother	House wife	1		1	
	Employed	0.80 (0.7216, 0.8784)	<0.001***	0.73 (0.6321, 0.8279)	<0.001***
Mother education	No education	1		1	
	Primary	1.13 (0.9281, 1.3319)	0.261	1.23 (0.99, 1.47)	0.0266
	Secondary	1.30 (1.0981, 1.5019)	<0.001***	1.11 (1.0865, 1.1335)	<0.001***
	Higher	1.87 (1.7504, 1.9896)	<0.001***	1.25 (1.0716, 1.4284)	<0.001***
Residence	Urban	1		1	
	Rural	0.55 (0.51, 0.59)	<0.001***	0.48 (0.42, 0.54)	<0.001***
Community wealth Index	Low	1		1	
	High	1.33 (1.2849, 1.3751)	<0.001***	1.34 (1.2028, 1.4772)	<0.001***
Community media exposure	Low	1		1	
	High	1.18 (1.1369, 1.2231)	<0.001***	1.22 (1.0906, 1.3494)	<0.001***
Community mother education	Low	1		1	
	High	1.40 (1.3392, 1.4608)	<0.001***	1.37 (1.3288, 1.4112)	<0.001***

*** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$). CI, Confidence interval; AOR, Adjusted Odds Ratio, 1 = estimate value for reference group, and ---have no categories (for continuous variable).

model included maternal age, antenatal care (ANC) visits, postnatal care (PNC) visits, tetanus injections received, vitamin A1 supplementation, health documentation, place of delivery, maternal occupation, household head's sex, number of children, distance to health facilities, maternal education, community wealth index, and media exposure. Children with mothers aged 15–24 were less likely to

be fully immunized compared to those with older mothers, supporting findings from similar studies in the region (13, 14, 22, 38). Antenatal care visits were a strong predictor of childhood immunization, as they provide critical education about vaccination benefits and schedules (13, 15, 19, 20, 39–41). Similarly, children whose mothers attended postnatal check-ups had higher odds of being fully or partially

TABLE 5 Maximum likelihood estimates of random effect.

Estimate	Subject	Estimate	Std. Error	AOR (95% CI)
Intercept	Country	1.03	0.021	2.8 (2.69,2.92) ***
Intercept	Region (country)	0.26	0.011	1.3 (1.27,1.33) ***
PCV country	0.237	-	-	-
PCV region	0.161	-	-	-

PCV, proportional change in variance, and *** ($p < 0.001$), Std. Error, standard error; CI, Confidence interval; OR, Odds Ratio.

immunized, reinforcing the importance of continuous healthcare engagement (15). The study also found that mothers who received tetanus injections during pregnancy were more likely to ensure their children were fully immunized. This trust in healthcare providers, developed through positive vaccination experiences, significantly influences childhood immunization rates (23, 42). Vitamin A1 supplementation during pregnancy was associated with higher immunization rates, likely due to increased interaction with healthcare services (22). Presence of health documentation was another significant factor, as mothers with vaccination records were more likely to have fully vaccinated children. This suggests that documentation reinforces accountability and facilitates adherence to immunization schedules (22, 23). Delivery location significantly impacted immunization status, with children born in healthcare facilities having higher immunization rates than those born at home. This is attributed to immediate vaccination opportunities provided during facility births, such as the BCG vaccine (10, 13–15, 19, 43–45). Distance to health facilities posed a considerable barrier to immunization, with mothers reporting distance as a significant issue having lower odds of fully immunizing their children. This aligns with findings from multiple studies indicating that access to healthcare resources is crucial for vaccination uptake (7). The analysis also indicated that children from female-headed households were less likely to be fully immunized compared to those from male-headed households. This may be due to additional time constraints faced by female heads of households, impacting their ability to prioritize immunization appointments (15, 40). Families with a higher number of children aged 12–23 months showed lower immunization rates, as larger family size negatively correlates with vaccination status. This is consistent with literature suggesting that resource allocation and parental engagement diminish with increased child numbers (15).

Maternal employment status also influenced immunization rates, with employed mothers less likely to fully vaccinate their children. This could be due to time constraints that make it challenging to attend vaccination appointments. Educational attainment among mothers was positively associated with children's immunization status. Children of mothers with secondary or higher education were more likely to be fully vaccinated, highlighting the role of education in accessing reliable health information and resources (10, 13–15, 22–24, 40, 43–45). Rural residency was linked to lower vaccination rates compared to urban areas, likely due to socioeconomic factors, including lower parental education and limited access to healthcare facilities (14, 15, 19, 22, 23, 39, 40, 45). Community wealth index emerged as a significant predictor of immunization status, with children from wealthier communities having higher odds of being fully vaccinated. This suggests that socioeconomic status directly influences access to healthcare services (13, 23). Finally, community-level media exposure and maternal education were significantly

affected vaccination rates. Children in a community with higher media exposure and maternal education were more likely to be fully immunized, as media can play a crucial role in educating and motivating parents about the importance of vaccinations (23).

Conclusion

This study highlights the critical issue of immunization coverage among children aged 12–23 months in East Africa. The findings indicate significant disparities in immunization rates, particularly in Madagascar, Ethiopia, and Zimbabwe, where non-immunization rates are notably high. A three-level ordinal logistic regression analysis identified key predictors of immunization status, including maternal age, antenatal and postnatal care visits, tetanus injections, vitamin A supplementation, and various community factors. These results underscore the ongoing challenges in achieving comprehensive immunization coverage in the region. Authors recommend that enhancing maternal education, improving healthcare access, engaging communities, and addressing socioeconomic barriers to boost childhood vaccination rates across the region. Programs that elevate maternal education led to better-informed mothers who seek vaccinations. Strengthening access to antenatal and postnatal care is essential, as is promoting community awareness of vaccination. Finally, improving household wealth and reducing poverty are vital, as economic stability correlates with better health outcomes and higher vaccination rates.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://www.dhsprogram.com/Data>.

Ethics statement

The studies involving humans were approved by Ethical Review Board of Central Statistical Agency (CSA). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

AD: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration,

Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. DW: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors are indebted to the DHS for giving us permission to use the data for our purpose.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 18 September 2024

ACCEPTED 18 December 2024

PUBLISHED 10 January 2025

CITATION

Ye Y and Su AT (2025) The influence of factors related to public health campaigns on vaccination behavior among population of Wuxi region, China.
Front. Public Health 12:1498296.
doi: 10.3389/fpubh.2024.1498296

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The influence of factors related to public health campaigns on vaccination behavior among population of Wuxi region, China

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Background: Public health campaigns are essential for promoting vaccination behavior, but factors such as socioeconomic status, geographical location, campaign quality, and service accessibility influence vaccine uptake. In the Wuxi region of China, disparities in vaccination behavior are seen between urban and rural populations and among different socioeconomic groups. This study aims to explore the factors related to public health campaigns that affect vaccination behavior in Wuxi, contributing to better public health strategies.

Methods: A cross-sectional survey was conducted among 750 participants in Wuxi, focusing on their perceptions of socioeconomic status, geographical location, health campaign quality, and vaccination convenience. The questionnaire was developed based on a literature review and expert input using the Delphi method. Data were analyzed using descriptive statistics, reliability and validity tests, correlation analysis, and regression analysis, employing both SPSS and R software.

Results: Socioeconomic status, geographic location, campaign quality, and accessibility all significantly influence vaccination behavior. Higher socioeconomic backgrounds, urban residency, better campaign quality, and greater accessibility to vaccination services are positively correlated with higher vaccination uptake. Regression analysis revealed that public health campaigns and accessibility are particularly influential in promoting vaccination behavior.

Conclusion: To improve vaccination rates, targeted strategies focusing on low socioeconomic groups, rural areas, and improving campaign quality and service accessibility are necessary. Public health campaigns should be clear, culturally relevant, and utilize multiple communication channels. Future research should address misinformation, explore behavioral economics, and integrate emerging technologies like AI to optimize vaccination efforts.

KEYWORDS

public health campaigns, vaccination behavior, socioeconomic status, geographical disparities, health campaign quality, vaccination service accessibility

1 Introduction

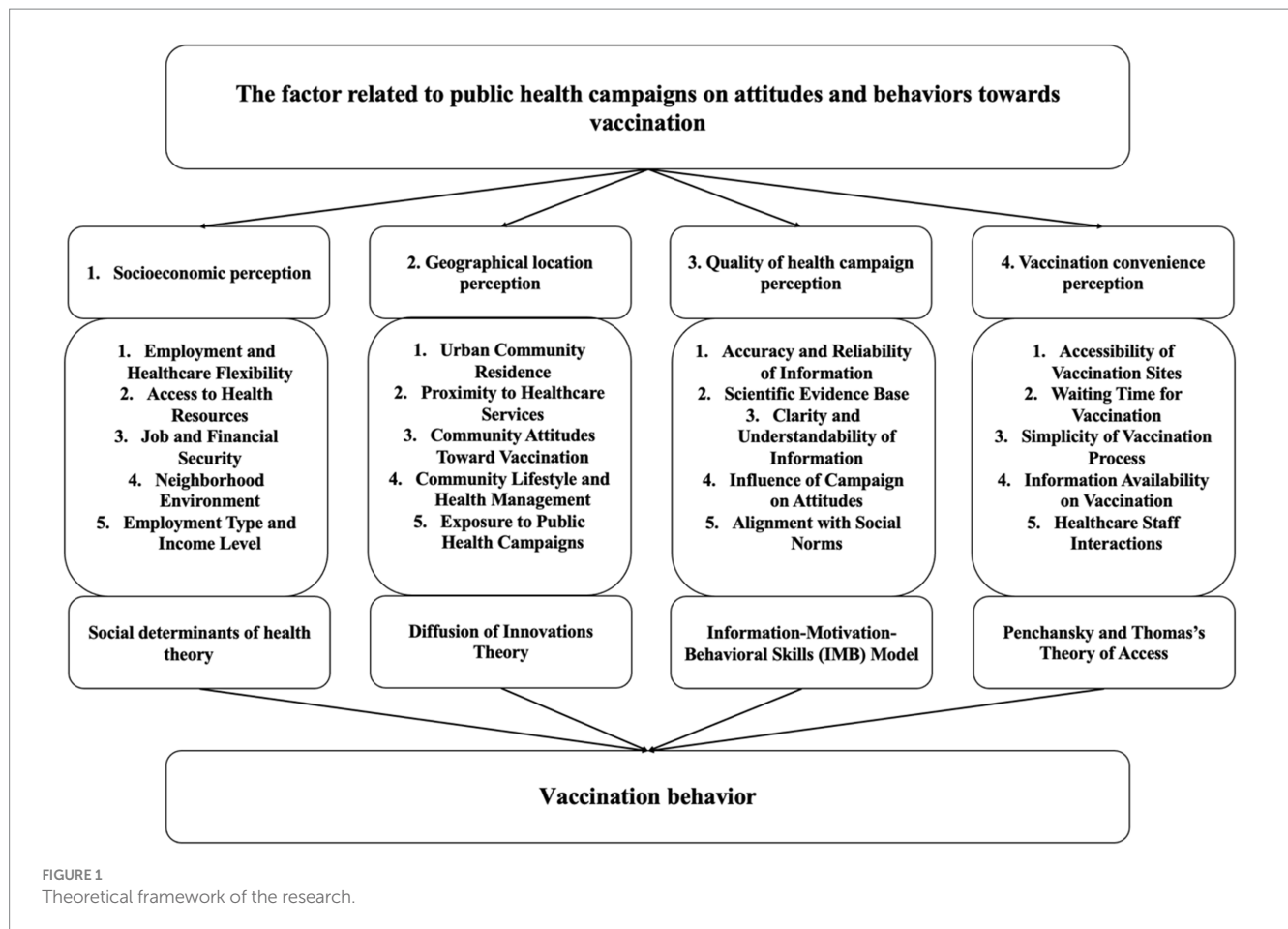
In recent years, with the continuous and in-depth implementation of China's Expanded Program on Immunization (EPI), vaccination coverage has seen a significant increase, particularly in urban areas. By October 2024, the average vaccination rate for national immunization program vaccines among school-age children nationwide had reached 99.13%,

highlighting China's notable achievements in the field of public health. However, despite the overall high vaccination rate, there remains a noticeable gap between urban and rural areas, especially in rural regions where vaccination rates and vaccine accessibility are still relatively low. The disparity between urban and rural areas is one of the prominent challenges facing China's vaccination efforts. Urban residents typically have more convenient access to vaccination services, with better-developed medical infrastructure, allowing them to receive vaccines more quickly and easily. In areas like Wuxi, urban residents not only have easier access to vaccines but also possess a higher level of health awareness, which enables them to actively participate in vaccination campaigns (1). However, in rural areas, residents face a series of obstacles to vaccination, including a lack of medical resources, inconvenient transportation, and insufficient vaccine promotion. Due to the limited medical facilities in rural areas, many residents have to travel long distances to reach vaccination sites, and the waiting times and inconveniences during the vaccination process further reduce their willingness to get vaccinated. Additionally, the channels for information dissemination in rural areas are limited, and vaccine promotion campaigns often fail to reach all areas, affecting rural residents' awareness and participation in vaccination efforts. Higher-income groups in China show higher levels of participation in vaccination. This demographic generally has greater health awareness, enabling them to promptly access the latest vaccine information, and they often have more financial resources and time to complete vaccination procedures. Moreover, higher-income groups usually have higher education levels, which allows them to better understand the necessity and importance of vaccination. In contrast, the vaccination behavior of lower-income groups is restricted by various factors. On one hand, the economic burden may lead them to prioritize other living expenses over vaccination, resulting in delays or neglect of vaccination. On the other hand, lower-income groups have fewer channels to obtain relevant health information, and their awareness of vaccines is relatively low. Coupled with a possible lack of trust in the government and healthcare institutions, this further affects their vaccination decisions (2). In China, public health promotion plays an important role in encouraging vaccination behavior. However, how to increase vaccination rates, particularly among rural and low-income populations, remains a key issue in the field of public health. First, the uneven distribution of medical resources is a major challenge. While urban areas have relatively developed medical facilities, rural areas still suffer from weak medical infrastructure, with insufficient vaccination sites and a lack of healthcare personnel, which directly affects the vaccination rate in rural areas. Secondly, the lack of information dissemination also limits the effectiveness of vaccine promotion. Public health campaigns often fail to comprehensively reach remote corners of rural areas, leaving some residents with insufficient awareness of the importance of vaccination.

Globally, public health campaigns have played a crucial role in promoting vaccination (3–7). Successful campaigns often employ strong communication strategies and community engagement, as seen in the eradication of smallpox and the Global Polio Eradication Initiative (8, 9). However, challenges such as cultural resistance, misinformation, and logistical barriers can undermine efforts, as evidenced by the dengue vaccine controversy in the Philippines (10, 11). The role of digital media has also become prominent, both as a tool for spreading accurate information and a platform for misinformation, particularly during the COVID-19

pandemic (12). Although recent campaigns have addressed these challenges by utilizing behavioral science and customizing strategies for specific audiences, there are still gaps in understanding the factors that drive vaccination behavior. Socio-economic factors are insufficiently explored in the literature, particularly in terms of how economic status affects healthcare access and vaccine acceptance (13). Additionally, disparities between urban and rural vaccination rates require more investigation, as rural areas often face poorer healthcare infrastructure (14). The quality and design of public health campaigns are another area needing more study, particularly regarding which aspects most effectively change vaccination behavior (15). Lastly, logistical barriers, such as limited access to vaccination sites and lengthy waiting times, have not been thoroughly studied in terms of their impact on vaccination uptake (16). The role of public health campaigns in influencing vaccination behavior is widely recognized. The COVID-19 pandemic, for example has highlighted the importance of effective vaccination campaigns. It also, however revealed significant disparities in vaccine uptake influenced by various factors, including socio-economic status, geographic location, quality of public health information, mis- and dis-information and accessibility of vaccination services (1, 17).

The correlation between individuals' socioeconomic status and vaccination behaviors is well-documented, with factors such as income, education, and occupation playing a significant role. Higher socioeconomic status often leads to better healthcare access, health literacy, and trust in healthcare systems, which promotes vaccination uptake, while lower socioeconomic groups face barriers like misinformation and economic instability (18, 19). To address these disparities, policies aimed at reducing costs and improving access are effective (20). The Social Determinants of Health Theory explains how socioeconomic factors like income, education, employment security, and neighborhood conditions shape health behaviors, including vaccination (21). Geographic location also significantly impacts vaccination behaviors. Urban residents, with closer access to healthcare and public health campaigns, tend to have higher vaccination rates than rural residents, who face longer travel times and lower health literacy (22). The Diffusion of Innovations Theory suggests that urban populations are more likely to adopt new health interventions, while rural areas may adopt them more slowly due to limited resources and differing social norms (23). Public health campaign effectiveness is another critical factor, relying on the quality of messages, delivery methods, and cultural sensitivity. Campaigns that are clear, consistent, and address safety concerns are more successful, as explained by the Information-Motivation-Behavioral Skills (IMB) Model, which emphasizes providing accurate information, motivation, and access skills (24, 25). Convenience in accessing vaccination services, including the proximity of vaccination centers and ease of scheduling, plays a crucial role in improving vaccine uptake. The Theory of Access, by Penchansky and Thomas, highlights the importance of availability, accessibility, affordability, and acceptability of healthcare services (26, 30). These factors—socioeconomic status, geographical location, public health campaign quality, and convenience—form the theoretical framework of this study, guided by the Social Determinants of Health Theory, Diffusion of Innovations Theory,



Information-Motivation-Behavioral Model, and Theory of Access, as reflected in the questionnaire designed for this research as shown in Figure 1.

The Wuxi region in China presents unique challenges in public health intervention activities due to its blend of urban and rural areas, diverse socioeconomic statuses, and varying public health infrastructures. In Wuxi, the disparities in vaccination behavior between urban and rural areas, as well as among different socio-economic groups, are particularly striking. While urban areas generally exhibit higher vaccination rates, rural areas are often left behind due to factors such as limited access to healthcare facilities, lower health literacy, and logistical challenges (27). In addition, individuals from lower socio-economic backgrounds in both urban and rural settings may have different perceptions and attitudes toward vaccination, influenced by their educational and economic statuses. Besides, factors such as the availability of vaccination centers, ease of scheduling appointments, and the efficiency of the vaccination process can significantly influence an individual's decision to get vaccinated. This is particularly relevant in regions like Wuxi, where the distribution of healthcare resources and infrastructure is uneven.

Given these considerations, this study aims to examine the influence of selected factors related to public health campaigns on vaccination behavior, from the perspective of the targeted recipient population in the Wuxi region, China. By exploring these dynamics, the study seeks to contribute to the broader understanding of how

public health strategies can be tailored to different contexts to improve vaccination uptake and, hopefully, the public health outcomes.

The central research question guiding this study is: "What are the factors related to public health campaigns that could influence the vaccination behavior among the population in the Wuxi region of China?" Specifically, the research questions are:

- What is the correlation between the socioeconomic status and vaccination behavior among the population of the Wuxi region, China?
- Are there any disparities in the vaccination behavior between the urban and rural population of the Wuxi region?
- What are the perceived characteristics of public health campaigns that can influence the vaccination behavior among the population?
- What are the perceived logistic factors that can affect the vaccination behavior of the population?

This leads to the following four hypotheses:

- Hypothesis 1 (H1): Individuals from higher socio-economic backgrounds are more likely to engage in vaccination behavior.
- Hypothesis 2 (H2): Urban residents are more likely to get vaccinated compared to rural residents.

- (iii) Hypothesis 3 (H3): Public health campaigns that are perceived as accurate, meticulous, and comprehensible have a more positive impact on vaccination behavior.
- (iv) Hypothesis 4 (H4): Greater convenience in accessing vaccination services (more vaccination sites, shorter waiting time, simpler vaccination process) leads to better vaccination behavior.

Figure 2 shows the research hypothesis diagram of this article, including independent variables, dependent variables, and corresponding hypotheses.

2 Methods

2.1 Overview

The study design is cross-sectional survey among the study participants sampled from the population of the Wuxi region, China. The information on the independent and dependent variables will be obtained at the same time using questionnaire.

2.2 Sample size, sampling strategy and data collection procedure

The sample size for this study was calculated using the method proposed by Hair et al. (28), applying a sample-to-variable ratio of 15:1 for exploratory factor analysis. With 35 independent variables, the initial sample size required was 525 participants. Considering a 30% non-response rate, the final sample size was increased to 750 respondents. The study employs a stratified random sampling method to ensure the sample reflects the population of Wuxi, Jiangsu, focusing on urban and rural distinctions. The population is divided into distinct strata, with each stratum sampled randomly to ensure equal selection chances. The primary strata are urban and rural residents, enabling the study to investigate differences in vaccination behavior between these groups.

Inclusion criteria for participants include being a resident of Wuxi, China, and aged 18 or older to ensure informed consent. Exclusion criteria consist of participants unable to read Mandarin Chinese or those refusing to participate and provide consent. Data was collected via an online self-administered questionnaire, distributed through the WeChat app or face-to-face interactions. The process was regularly monitored to ensure adequate response rates, with reminders sent every 2 weeks to participants who had not completed the questionnaire. After three reminders, non-respondents were excluded.

The questionnaire includes demographic information such as gender and education level, as well as independent variables: socioeconomic perception, geographical location perception, health campaign quality perception, and vaccination convenience perception. The dependent variable is vaccination behavior. The study first conducted a literature review to set measurement standards for public health campaigns and vaccination behavior. Guided by experts using the Delphi method, a scientific questionnaire was designed. Factor analysis then validated its structure and items, ensuring the quantitative measures met reliability and validity standards.

2.3 Statistical analysis

This study employs several statistical analyses, executed using both SPSS and R software, to explore the relationships between socioeconomic, geographic, and health campaign factors with vaccination behavior. First, descriptive statistics are used to summarize demographic variables, including age, gender, education, marital status, number of children, occupation, field of work, and type of residence.

Next, a reliability and validity analysis are conducted to assess the internal consistency and accuracy of the measurement instruments. Cronbach's alpha is used to evaluate the reliability, ensuring the stability and consistency of the scales measuring constructs such as socioeconomic perception, geographical location perception, quality of health campaigns, and vaccination convenience. Kaiser-Meyer-Olkin (KMO) and factor analysis are applied to assess the suitability of the data for exploratory factor analysis, confirming the validity of the constructs.

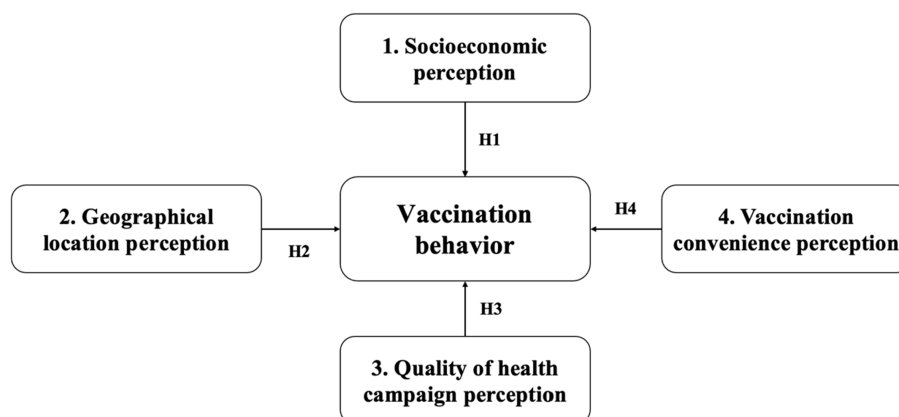


FIGURE 2
Research hypothesis diagram.

Following this, correlation analysis is performed to examine the linear relationships between the independent variables (socioeconomic perception, geographical location perception, quality of health campaigns, and vaccination convenience) and the dependent variable (vaccination behavior). Pearson's correlation coefficient is used to quantify the strength and direction of these relationships, providing insight into how these factors influence vaccination behavior.

Finally, regression analysis is employed to determine the predictive power of the independent variables on vaccination behavior. Multiple regression models are developed to assess the effects of socioeconomic status, geographic location, quality of health campaigns, and vaccination convenience on three aspects of vaccination behavior: willingness to receive vaccines, actual vaccinations after the age of 18, and future vaccination intentions. This analysis helps to identify the significant predictors of vaccination behavior, with a focus on the influence of accessibility, public health campaign quality, and socioeconomic and geographic factors.

3 Results

3.1 Descriptive statistics

The gender distribution of the respondents reveals a fairly balanced composition with a slight male predominance. Out of 719 participants, 351 (48.8%) are male, 335 (46.6%) are female, and 33 (4.6%) preferred not to disclose their gender. The mean value of the age is 35.1, and the median is 36, while the standard deviation is 10.8. The age distribution is relatively even, but it is more prominent in groups [20, 25) and [40, 45). According to Figure 3, there is no significant difference between the males and females (Figure 4).

Education levels among the participants vary significantly, ranging from primary school to doctoral degrees. The majority of respondents hold a bachelor's degree (33.1%), followed by senior high school graduates (29.8%) and junior high school graduates (16.8%). Participants with a master's degree constitute 14.7%, while those with primary school education, doctoral degrees, or preferring not to disclose their education level represent a smaller fraction (2.6, 1.8, and 1.1% respectively).

Marital status data shows that 44.1% of respondents are single, 36.0% are married, 10.0% are divorced, 1.9% are widowed, and 7.9% preferred not to disclose their marital status.

The number of children per respondent also shows notable variability. A significant portion of the participants (61.6%) reported having no children, while 31.3% have one child, 6.8% have two children, and a minimal 0.3% have three children.

Occupation data reveals a diverse range of professional backgrounds. The largest groups are students (27.4%) and government or public service employees (22.1%), followed by private sector employees (non-healthcare) at 18.6%, and self-employed individuals at 10.7%. Smaller groups include healthcare professionals (3.2%), educators (4.7%), unemployed individuals (6.8%), retired individuals (2.1%), and those specifying other occupations (4.3%).

Field of work further diversifies the respondent pool with notable representations from various sectors. Students again form the largest group (26.8%), followed by individuals in engineering and technology (13.6%), government or public administration (13.5%), business and finance (12.1%), and non-profit/community service (7.2%). Other sectors include healthcare and medical services (4.0%), education and academic research (4.9%), arts and entertainment (4.0%), and unemployed/retired individuals (9.7%).

Type of residence data shows that the majority of respondents reside in single-family homes (42.8%) and apartments/condominiums (34.8%). Shared housing, such as dormitories or roommate situations, accounts for 15.6%, while assisted living facilities and temporary housing constitute smaller portions (4.0 and 2.8% respectively).

Table 1 presents the sociodemographic characteristics of the respondents. Overall, the respondents show diversity in terms of gender, education level, marital status, number of children, occupation, field of work, and type of residence. Among them, the education level is mainly dominated by bachelor's degree holders, marital status is primarily single, the majority of respondents have no children, and occupation and field of work cover a wide range. The type of residence is mainly single-family homes or apartments.

Table 2 the chi-square test results reveal various insights across different sociodemographic variables. For gender, the Pearson Chi-Square value is 32.762 with a *p*-value of 0.109, indicating no

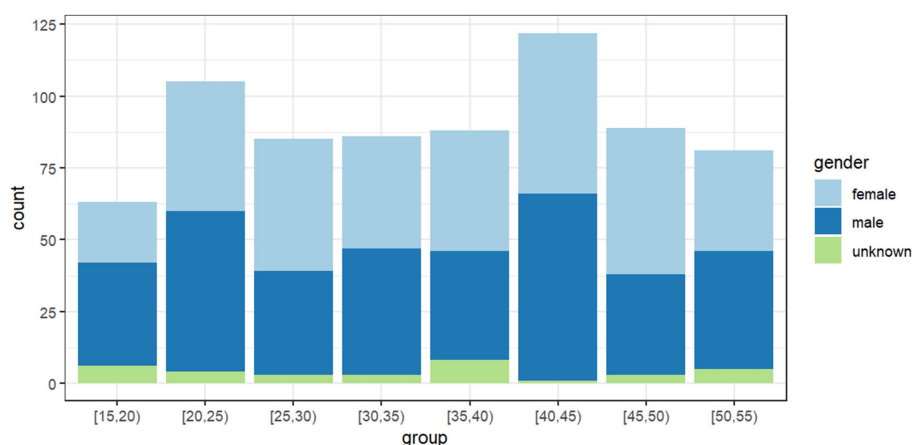


FIGURE 3
The gender count among different age groups.

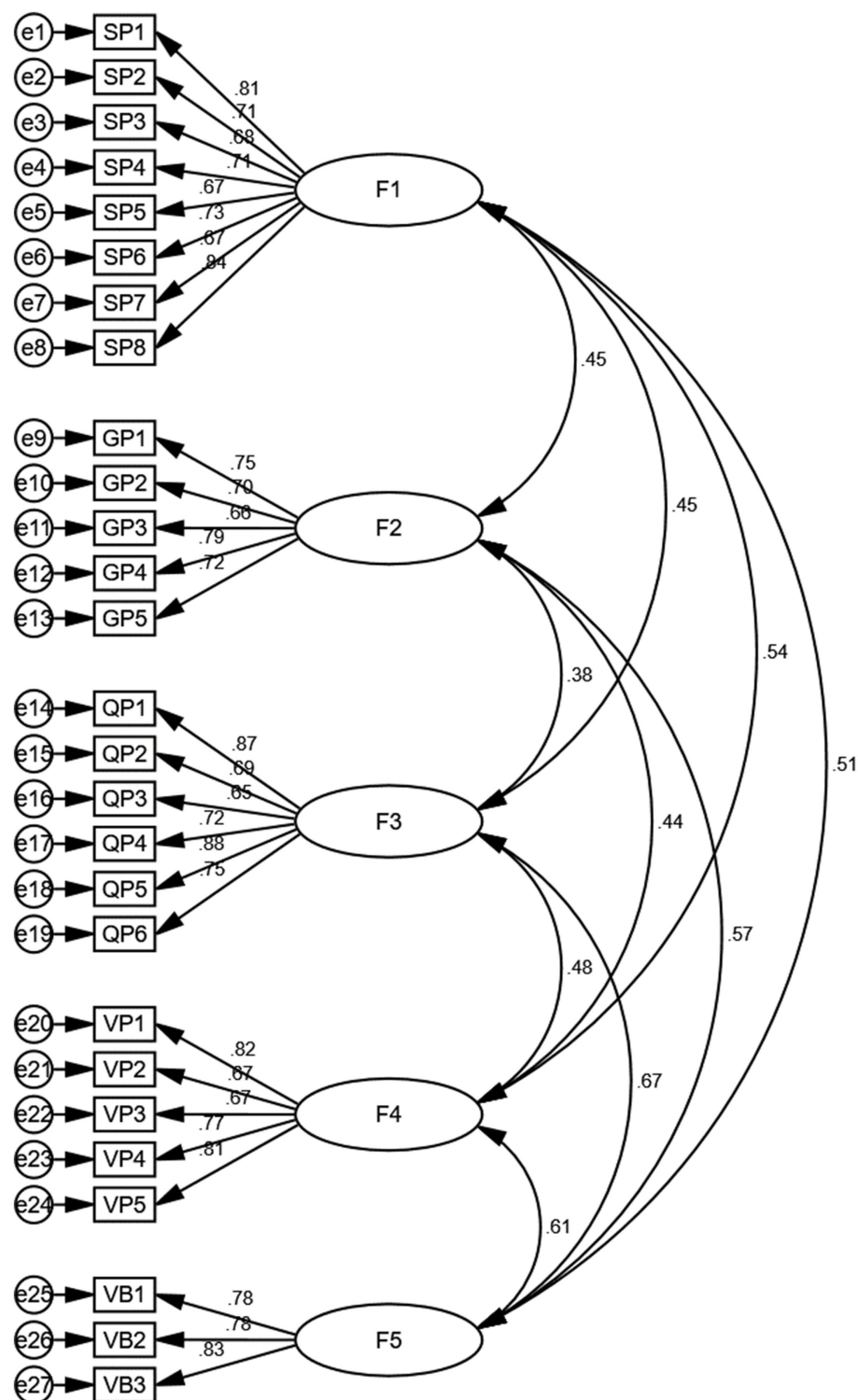


FIGURE 4

Path diagram of a structural equation model illustrating hypothesized relationships. F1: Socioeconomic perception, F2: Geographical location perception, F3: Quality of health campaign perception, F4: Vaccination convenience perception, F5: Vaccination behavior.

significant association. However, for education, there is a significant association with a Pearson Chi-Square value of 98.145 and a p -value of 0.022, supported by the Likelihood Ratio ($p = 0.005$) and Linear-by-Linear Association ($p = 0.002$). Marital status and number of children both show no significant associations with p -values of 0.612

and 0.835, respectively. Occupation reveals a marginally significant association ($p = 0.04$), though the Likelihood Ratio ($p = 0.14$) suggests weaker evidence. Field of work presents a significant association ($p = 0.013$), supported by the Likelihood Ratio ($p = 0.007$) and the Linear-by-Linear Association ($p = 0.004$). Finally, type of residence

TABLE 1 Sociodemographic characteristics of the respondents.

Variable	N	Mean	Standard deviation
Gender	719	1.5577	0.58218
Education	719	3.5035	1.13303
Marital status	719	1.936	1.15333
Number of children	719	1.4576	0.63384
Occupation	719	4.4395	1.78945
Field of work	719	5.975	2.49276
Type of resident	719	1.8915	0.99269

shows no significant association, with a Pearson Chi-Square p -value of 0.32. Overall, education and field of work appear to have the strongest associations with other variables.

3.1.1 Socioeconomic perception and vaccination behavior

In addition to demographic factors, the perception of health campaign quality also plays a crucial role in influencing vaccination behavior. Understanding how individuals perceive the effectiveness and trustworthiness of health campaigns can shed light on their willingness to get vaccinated. A positive perception of health campaigns may enhance public trust and acceptance of vaccines, thereby improving vaccination rates across different demographic groups. This underscores the importance of effective communication strategies in health campaigns aimed at increasing vaccination uptake. An example of the impact of health campaign quality can be seen in the HPV vaccination initiatives in several countries. In Australia, a well-structured health campaign was launched to promote the HPV vaccine among adolescents. The campaign utilized clear messaging, targeted outreach, and endorsements from trusted healthcare professionals. As a result, vaccination rates among teenage girls rose significantly from around 20% to over 80% within a few years. The campaign's success was attributed to its high perceived quality, which effectively addressed concerns and misinformation about the vaccine.

3.1.2 Geographical location perception and vaccination behavior

The geographical location perception section of the questionnaire mainly assesses participants' views on their living environment (urban or rural) and the accessibility of healthcare resources. This perception may influence the availability of vaccination services and individuals' willingness to get vaccinated. The survey includes evaluations of the distance to vaccination sites, transportation convenience, and healthcare service quality. By comparing vaccination behaviors under different geographical location perceptions, the study seeks to identify disparities between urban and rural residents in terms of vaccine access and decision-making, providing a basis for optimizing vaccination strategies in various regions.

3.1.3 Perception of health campaign quality and vaccination behavior

Health campaigns that are perceived as high-quality, credible, and informative are likely to foster better vaccination behaviors. Factors contributing to the perception of campaign quality include message clarity, delivery methods, and the perceived expertise of health

authorities. Tailoring these campaigns to address specific demographic concerns and preferences can further enhance their effectiveness. As such, continuous assessment of public perceptions regarding health campaigns is vital for refining strategies to promote vaccination and improve overall public health outcomes. In the UK, there was a notable decline in MMR vaccination rates following the publication of a controversial study linking the vaccine to autism. In response, the National Health Service (NHS) launched a comprehensive campaign to restore public trust and encourage vaccination. The campaign emphasized transparency, addressed specific parental concerns, and utilized multiple platforms, including social media, community outreach, and partnerships with healthcare providers. As a result, MMR vaccination rates rose significantly over the following years, with uptake returning to pre-scandal levels. This case demonstrates how effectively addressing public perceptions and concerns can lead to improved vaccination behavior.

3.1.4 Perception of vaccination convenience and vaccination behavior

The vaccination convenience perception section of the questionnaire primarily measures participants' views on the ease of the vaccination process, including appointment procedures, distance to vaccination sites, waiting times, and service availability. The convenience of vaccination is a key factor influencing vaccination behavior. By analyzing the relationship between convenience perception and vaccination behavior, the study seeks to identify areas for optimizing vaccination services and provide empirical evidence for strategies aimed at increasing vaccination rates. Higher convenience perception is generally associated with greater willingness to get vaccinated, making the improvement of vaccination processes a critical approach to boosting vaccination coverage.

Table 3 presents the descriptive statistics of the independent variables based on a sample size of 719 participants. The mean score for socioeconomic perception is 3.1219, with a standard deviation of 0.83062, indicating moderate perceptions of socioeconomic status with some variability among respondents. The geographical location perception has a higher mean of 3.8503 and a standard deviation of 0.80636, suggesting that most participants view their geographical location more favorably in terms of healthcare accessibility. The quality of health campaign perception also has a relatively high mean of 3.8389 and a standard deviation of 0.82964, reflecting generally positive views on the effectiveness of health promotion efforts. Lastly, the vaccination convenience perception has a mean of 3.3994 and a standard deviation of 0.77883, indicating a moderate level of perceived convenience regarding the vaccination process (Tables 4–11).

Vaccination rates differ between urban and rural areas, with urban residents showing a higher vaccination rate of 96.87% compared to 93.75% for rural residents. This discrepancy can be attributed to several factors. Urban residents often have better access to information regarding vaccination policies and benefits, coupled with superior medical infrastructure, making vaccination more accessible. Furthermore, urban populations may exhibit a stronger vaccination awareness due to higher levels of education and exposure to health campaigns. Conversely, rural areas may face challenges such as limited healthcare resources, logistical issues, and lower vaccine awareness, all of which contribute to the lower vaccination rates.

Educational attainment demonstrates a strong positive correlation with vaccination rates. Individuals with primary school education

TABLE 2 Differences in demographic factors generate differences in vaccination behavior.

	Chi-square test	Value	Degrees of freedom	Asymptotic significance (two-sided)
Gender	Pearson Chi-square	32.762a	24	0.109
	Likelihood ratio	33.212	24	0.1
	Linear-by-linear association	3.894	1	0.048
	Number of valid cases	719		
Education	Pearson chi-square	98.145	72	0.022
	Likelihood ratio	106.202	72	0.005
	Linear-by-linear association	9.55	1	0.002
	Number of valid cases	719		
Marital status	Pearson chi-square	13.816	16	0.612
	Likelihood ratio	16.11	16	0.445
	Linear-by-linear association	1.289	1	0.256
	Number of valid cases	719		
Number of children	Pearson chi-square	7.336	12	0.835
	Likelihood ratio	8.364	12	0.756
	Linear-by-linear association	0.155	1	0.694
	Number of valid cases	719		
Occupation	Pearson chi-square	121.509	96	0.04
	Likelihood ratio	111.059	96	0.14
	Linear-by-linear association	1.796	1	0.18
	Number of valid cases	719		
Field of work	Pearson chi-square	57.518	36	0.013
	Likelihood ratio	60.043	36	0.007
	Linear-by-linear association	8.231	1	0.004
	Number of valid cases	719		
Type of resident	Pearson chi-square	18.067	16	0.32
	Likelihood ratio	19.014	16	0.268
	Linear-by-linear association	0.595	1	0.44
	Number of valid cases	719		

TABLE 3 Description of the independent variable statistics.

Variable	N	Mean	Standard deviation
Socioeconomic perception	719	3.1219	0.83062
Geographical location perception	719	3.8503	0.80636
Quality of health campaign perception	719	3.8389	0.82964
Vaccination convenience perception	719	3.3994	0.77883

exhibit the lowest vaccination rate at approximately 94.74%, while those with advanced degrees (Master's and Doctoral levels) have rates near universal vaccination, at 99.06 and 99%, respectively. This trend highlights the pivotal role of education in promoting vaccine uptake. Higher education levels enhance individuals' ability to comprehend the scientific basis and importance of vaccines, leading to increased adherence. Additionally, individuals with advanced education are more likely to prioritize health and demonstrate greater compliance

TABLE 4 Vaccination rates by urban and rural residency.

Location	Vaccination rate
Rural	93.75%
Urban	96.87%

with public health policies. These findings suggest that targeted educational campaigns for populations with lower educational attainment could significantly boost overall vaccination coverage.

Vaccination rates vary across age groups, with a notable trend of higher uptake among middle-aged individuals compared to younger or older age groups. The 18 and under cohort exhibits lower vaccination rates, potentially due to parental hesitancy or policy restrictions for minors. In contrast, the 18–30 age group shows a significant increase, likely driven by higher educational attainment and frequent social interactions. The 30–50 age group achieves the highest vaccination rates, reflecting their heightened health awareness and societal responsibilities during prime working years. However,

TABLE 5 Vaccination rates by educational level.

Education level	Vaccination
Primary school	94.74%
Junior high school	94.21%
Senior high school	97.20%
Bachelor degree	97.06%
Master degree	99.06%
Doctoral degree or higher	99.00%

TABLE 6 Vaccination rates by age group.

Age group	Vaccination
(0, 18]	95.45%
(18, 30]	98.25%
(30, 50]	95.83%
(50, 100]	98.39%

TABLE 7 Reliability analysis and KMO test.

Variables	Cronbach's α	KMO*	N
Socioeconomic perception	0.899	0.916	8
Geographical location perception	0.844	0.853	5
Quality of health campaign perception	0.888	0.907	6
Vaccination convenience perception	0.860	0.870	5
Vaccination behavior	0.837	0.721	3

*KMO, Kaiser-Meyer-Olkin values.

rates slightly decline in the 50 and older group, possibly due to vaccine safety concerns or pre-existing health conditions. These findings underscore the need for tailored vaccination strategies, such as enhancing safety communication for older adults and engaging parents of minors to address hesitancy effectively.

3.2 Reliability and validity analysis

The reliability and validity of the questionnaires used in this study are critical for ensuring the consistency, stability, and accuracy of the measurement of the predetermined concepts. A Cronbach's α value greater than 0.7 is generally considered acceptable, while values above 0.8 indicate good reliability, and those above 0.9 signify excellent reliability.

For the socioeconomic perception variable, the Cronbach's α coefficient is 0.899, which indicates excellent reliability. This high value demonstrates that the items measuring socioeconomic perception are consistently reflecting the underlying construct. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.916, which is well above the acceptable threshold of 0.5, suggesting that the data is suitable for factor analysis. The number of items (N) included in this variable is eight, further supporting the robustness of the reliability assessment.

The geographical location perception variable has a Cronbach's α coefficient of 0.844, indicating good reliability. The KMO measure for

this variable is 0.853, which also supports the suitability of the data for factor analysis. With five items included in this variable, the reliability analysis confirms that the items are consistently measuring the intended construct.

The quality of health campaign perception variable demonstrates a Cronbach's α coefficient of 0.888, indicating excellent reliability. The KMO measure for this variable is 0.907, which is high and confirms the appropriateness of the data for factor analysis. This variable includes six items, ensuring a comprehensive assessment of the quality of health campaigns.

The vaccination convenience perception variable has a Cronbach's α coefficient of 0.860, reflecting excellent reliability. The KMO measure for this variable is 0.870, indicating that the data is suitable for factor analysis. With five items included in this variable, the reliability analysis shows that the items are consistently measuring the perception of vaccination convenience.

The dependent variable, vaccination behavior, has a Cronbach's α coefficient of 0.837, indicating good reliability. The KMO measure for this variable is 0.721, which is acceptable and supports the suitability of the data for factor analysis. This variable includes three items, demonstrating that the items are reliably measuring vaccination behavior.

Construct validity is evaluated using factor loading, composite reliability (CR), and average variance extracted (AVE). High factor loadings (greater than 0.6) indicate that the items are well-correlated with the latent construct they are intended to measure. Composite reliability (CR) values greater than 0.7 are considered acceptable, while AVE values above 0.5 indicate good convergent validity.

For the socioeconomic perception variable, the factor loadings for the eight measurement items range from 0.671 to 0.837, demonstrating strong correlations with the latent construct. The Cronbach's α coefficient is 0.899, the CR is 0.901, and the AVE is 0.534, all of which indicate excellent construct validity. These results confirm that the items accurately measure the socioeconomic perception construct.

The geographical location perception variable shows factor loadings ranging from 0.663 to 0.787, indicating good correlations with the latent construct. The Cronbach's α coefficient is 0.844, the CR is 0.847, and the AVE is 0.525, which demonstrate good construct validity. These findings confirm that the items effectively measure the geographical location perception construct.

For the quality of health campaign perception variable, the factor loadings for the six measurement items range from 0.655 to 0.875, with the majority above 0.7, indicating strong correlations with the latent construct. The Cronbach's α coefficient is 0.888, the CR is 0.894, and the AVE is 0.587, all of which indicate excellent construct validity. These results validate that the items accurately measure the quality of health campaign perception construct.

The vaccination convenience perception variable shows factor loadings ranging from 0.666 to 0.820, indicating strong correlations with the latent construct. The Cronbach's α coefficient is 0.860, the CR is 0.864, and the AVE is 0.863, which demonstrate excellent construct validity. These findings confirm that the items effectively measure the vaccination convenience perception construct.

Finally, the vaccination behavior variable has factor loadings ranging from 0.776 to 0.834, indicating strong correlations with the latent construct. The Cronbach's α coefficient is 0.837, the CR is 0.840,

TABLE 8 Validity analysis.

Variables	Measurement item	Factor loading	Cronbach's α	CR*	AVE*
F1: Socioeconomic perception	SP1	0.815	0.899	0.901	0.534
	SP2	0.707			
	SP3	0.675			
	SP4	0.712			
	SP5	0.673			
	SP6	0.734			
	SP7	0.671			
	SP8	0.837			
F2: Geographical location perception	GP1	0.746	0.844	0.847	0.525
	GP2	0.699			
	GP3	0.663			
	GP4	0.787			
	GP5	0.722			
F3: Quality of health campaign perception	QP1	0.874	0.888	0.894	0.587
	QP2	0.695			
	QP3	0.655			
	QP4	0.720			
	QP5	0.875			
	QP6	0.749			
F4: Vaccination convenience perception	VP1	0.820	0.860	0.864	0.863
	VP2	0.666			
	VP3	0.666			
	VP4	0.775			
	VP5	0.809			
F5: Vaccination behavior	VB1	0.781	0.837	0.840	0.636
	VB2	0.776			
	VB3	0.834			

*CR, composite reliability; AVE, average variance extracted.

TABLE 9 The summary result of VB3.

Significant variables for VB3	Future vaccination intentions			
	S.E.	β	t	p
SP	0.027	0.235**	8.585	<0.0001
GP	0.032	0.221***	6.933	<0.0001
QP	0.036	0.194***	5.408	<0.0001
VP	0.029	0.237***	8.058	<0.0001
R^2	0.4369			
ΔR^2	0.4337			
F	138.5***			

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

and the AVE is 0.636, all of which indicate good construct validity. These results validate that the items accurately measure the vaccination behavior construct.

The reliability and validity analyses of the questionnaires demonstrate that the measurement instruments used in this study are both consistent

TABLE 10 The summary result of VB1.

Significant variables for VB1	Willingness to receive vaccine			
	S.E.	β	t	p
SP	0.030	0.238**	7.878	<0.0001
GP	0.035	0.255***	7.252	<0.0001
QP	0.040	0.185***	4.676	<0.0001
VP	0.032	0.202***	6.259	<0.0001
R^2	0.3898			
ΔR^2	0.3864			
F	114***			

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

and accurate in measuring the intended constructs. The high Cronbach's α coefficients and KMO measures confirm the internal consistency and suitability of the data for factor analysis, while the strong factor loadings, composite reliability, and average variance extracted values validate the construct validity of the questionnaires.

TABLE 11 The summary result of VB2.

Significant variables for VB2	Number of vaccines received			
	S.E.	β	<i>t</i>	<i>p</i>
SP	0.030	0.296***	9.788	<0.0001
GP	0.035	0.172***	4.876	<0.0001
QP	0.040	0.206***	5.173	<0.0001
VP	0.032	0.256***	7.882	<0.0001
R^2	0.4132			
ΔR^2	0.4091			
<i>F</i>	100.4***			

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

3.3 Correlation analysis

The correlation analysis provides critical insights into the linear relationships between socioeconomic perception, geographical location perception, quality of health campaign perception, vaccination convenience perception, and vaccination behavior, thereby elucidating the strength and direction of these relationships using the confirmatory factor analysis via structural equation modeling.

3.3.1 Socioeconomic perception and other variables

The structural equation modeling analysis found that the correlation between socioeconomic perception and geographical location perception is 0.45, indicating a moderate positive linear relationship. This suggests that individuals with a higher socioeconomic perception are more likely to have a positive perception of their geographical location.

The correlation between socioeconomic perception and quality of health campaign perception is 0.45, also indicating a moderate positive linear relationship. This implies that individuals who perceive their socioeconomic status favorably are likely to have a positive perception of the quality of health campaigns.

Additionally, the correlation between socioeconomic perception and vaccination convenience perception is 0.54, indicating a strong positive linear relationship. This suggests that individuals with a higher socioeconomic perception tend to perceive vaccination as more convenient.

Lastly, the correlation between socioeconomic perception and vaccination behavior is 0.51, indicating a moderate positive linear relationship. This means that individuals with a favorable perception of their socioeconomic status are more likely to exhibit positive vaccination behavior.

3.3.2 Geographical location perception and other variables

The correlation between geographical location perception and quality of health campaign perception is 0.38, indicating a moderate positive linear relationship. This suggests that individuals who perceive their geographical location positively are likely to have a favorable perception of the quality of health campaigns.

The correlation between geographical location perception and vaccination convenience perception is 0.44, indicating a moderate

positive linear relationship. This implies that individuals who perceive their geographical location positively tend to perceive vaccination as more convenient.

Moreover, the correlation between geographical location perception and vaccination behavior is 0.57, indicating a strong positive linear relationship. This suggests that individuals with a favorable perception of their geographical location are more likely to exhibit positive vaccination behavior.

3.3.3 Quality of health campaign perception and other variables

The correlation between quality of health campaign perception and vaccination convenience perception is 0.48, indicating a strong positive linear relationship. This implies that individuals who perceive the quality of health campaigns positively are likely to perceive vaccination as more convenient.

Furthermore, the correlation between quality of health campaign perception and vaccination behavior is 0.67, indicating a very strong positive linear relationship. This suggests that individuals with a favorable perception of the quality of health campaigns are highly likely to exhibit positive vaccination behavior.

3.3.4 Vaccination convenience perception and vaccination behavior

The correlation between vaccination convenience perception and vaccination behavior is 0.61, indicating a strong positive linear relationship. This means that individuals who perceive vaccination as convenient are more likely to exhibit positive vaccination behavior.

3.3.5 Summary of correlation analysis

The correlation analysis reveals significant positive linear relationships between the variables under study. The moderate to strong positive correlations between socioeconomic perception, geographical location perception, quality of health campaign perception, and vaccination convenience perception with vaccination behavior suggest that these independent variables are likely to influence vaccination behavior positively.

Specifically, the strongest correlation is observed between quality of health campaign perception and vaccination behavior, indicating that the perceived quality of health campaigns plays a crucial role in shaping vaccination behavior. This finding underscores the importance of delivering high-quality health campaigns to promote positive vaccination behavior among the population.

The strong positive correlation between vaccination convenience perception and vaccination behavior highlights the significance of making vaccination services accessible and convenient to encourage higher vaccination rates.

The moderate positive correlations between socioeconomic perception, geographical location perception, and vaccination behavior suggest that improving perceptions of socioeconomic status and geographical location can also positively impact vaccination behavior.

These findings provide a robust basis for hypothesis testing and causal inference in subsequent analyses. The positive linear relationships between the independent variables and vaccination behavior indicate that enhancing socioeconomic perceptions, geographical location perceptions, the quality of health campaigns, and vaccination convenience can potentially lead to improved

vaccination behavior. This correlation analysis, therefore, forms a crucial component of understanding the impact of public health campaigns on attitudes and behaviors toward vaccination, guiding future interventions and policy decisions to enhance vaccination uptake.

3.4 Regression analysis

The results from the regression analysis provide significant insights into the factors influencing vaccination behavior among a sample of 719 individuals. The regression model includes several predictors such as the level of education, field of work, perceptions related to vaccination convenience, quality of health campaign, geographical location, and socioeconomic status.

The regression analysis conducted for VB1, VB2, and VB3 reveals important insights into the relationship between socio-economic factors, urban residency, public health campaign quality, and accessibility to vaccination services on vaccination behavior. The dependent variable in each case represents a dimension of vaccination behavior, including willingness to receive vaccines recommended by public health campaigns (VB1), the actual number of vaccines received after the age of 18 (VB2), and future vaccination intentions (VB3). The independent variables—socio-economic position (SP), geographic location (GP), the quality of public health campaigns (QP), and the accessibility of vaccination services (VP)—serve as predictors in each regression model.

For VB1, the significant predictors were SP ($\beta = 0.238, p < 0.01$), GP ($\beta = 0.255, p < 0.001$), QP ($\beta = 0.185, p < 0.001$), and VP ($\beta = 0.202, p < 0.001$), with an R^2 value of 0.3898, indicating that approximately 39% of the variance in willingness to receive vaccines could be explained by the independent variables. Among these, GP showed the highest contribution to vaccination willingness, with a standardized β value of 0.255. This indicates that urban residency plays a strong role in influencing willingness to get vaccinated. The high β values for both SP and VP suggest that socio-economic status and accessibility to vaccination sites also significantly influence the decision-making process. These results support Hypotheses 1, 2, and 4, confirming that individuals from higher socio-economic backgrounds and those living in urban areas are more likely to engage in vaccination behavior, while better accessibility to vaccination services enhances this behavior as well. The contribution of QP, though significant, was slightly lower than that of SP, GP, and VP, indicating that while the quality of public health campaigns matters, it may not be as influential as socio-economic or geographic factors.

In the case of VB2, the dependent variable, which measured the number of vaccinations received after the age of 18, was again predicted by SP ($\beta = 0.296, p < 0.001$), GP ($\beta = 0.172, p < 0.001$), QP ($\beta = 0.206, p < 0.001$), and VP ($\beta = 0.256, p < 0.001$), with an R^2 value of 0.4132, suggesting that 41.32% of the variance in actual vaccination behavior could be explained by these predictors. Interestingly, SP contributed the most to VB2, with a β value of 0.296, implying that socio-economic factors have a greater influence on actual vaccination rates than they do on mere willingness. This finding lends further support to Hypothesis 1, demonstrating that individuals from higher socio-economic backgrounds not only express greater willingness but also follow through with actual vaccinations more frequently. VP also showed a strong effect ($\beta = 0.256$), suggesting that convenience and accessibility play a substantial role in determining how often individuals get

vaccinated, which supports Hypothesis 4. The relatively lower contribution of GP ($\beta = 0.172$) compared to VB1 might suggest that geographic location is less influential when it comes to actual behavior than it is for willingness. The consistent performance of QP across both VB1 and VB2 highlights that well-executed public health campaigns do indeed result in higher vaccination rates, supporting Hypothesis 3.

For VB3, the dependent variable measured future vaccination intentions, and the regression results showed that all four predictors were significant once again: SP ($\beta = 0.235, p < 0.01$), GP ($\beta = 0.221, p < 0.001$), QP ($\beta = 0.194, p < 0.001$), and VP ($\beta = 0.237, p < 0.001$), with an R^2 value of 0.4369, indicating that 43.69% of the variance in future vaccination intentions was explained by these variables. In this case, VP had the highest contribution ($\beta = 0.237$), followed closely by SP ($\beta = 0.235$) and GP ($\beta = 0.221$). This suggests that in terms of future vaccination behavior, accessibility and socio-economic factors are almost equally influential. Hypotheses 1 and 4 are strongly supported here, showing that individuals from higher socio-economic backgrounds, as well as those with better access to vaccination services, are more likely to plan to adhere to future vaccination recommendations. The influence of GP was also relatively strong in this model, demonstrating that urban residents continue to show a higher likelihood of future vaccination adherence, thus supporting Hypothesis 2. The lower yet still significant effect of QP ($\beta = 0.194$) indicates that while public health campaigns are important, their influence on future vaccination plans may not be as pronounced as the direct impact of accessibility or socio-economic position.

The results of the regression analysis across all three models—VB1, VB2, and VB3—consistently support the four proposed hypotheses, revealing clear causal relationships between the independent variables and vaccination behavior. Socio-economic position (SP) is shown to have a strong influence on both actual vaccination rates and future intentions, confirming that individuals from wealthier backgrounds are more likely to engage in vaccination behavior. This could be attributed to better access to information, higher trust in medical institutions, and greater resources to prioritize health-related activities. Geographic location (GP) also proves to be a significant predictor, with urban residents demonstrating higher vaccination rates and intentions, likely due to better access to healthcare facilities, more exposure to public health campaigns, and greater convenience in receiving vaccinations.

The contribution of public health campaign quality (QP) suggests that the accuracy, comprehensibility, and thoroughness of public messaging play a crucial role in influencing vaccination behavior, though its impact is somewhat less than socio-economic or accessibility factors. Finally, the accessibility of vaccination services (VP) emerges as a critical determinant across all three models, underscoring the importance of removing logistical barriers to vaccination in order to improve both current and future vaccination behavior. Making vaccinations more accessible by increasing the number of sites, reducing waiting times, and simplifying the process will likely result in higher vaccination rates and better public health outcomes overall.

In conclusion, this regression analysis validates the theoretical assumptions outlined in the four hypotheses. It reveals that socio-economic position, geographic location, public health campaign quality, and accessibility all contribute significantly to vaccination behavior, with socio-economic factors and accessibility emerging as particularly influential. These findings not only provide valuable empirical support for public health initiatives but also offer practical

insights for policymakers aiming to improve vaccination rates by addressing socio-economic disparities, enhancing campaign quality, and removing barriers to accessibility.

4 Discussion

4.1 Strategies based on socio-economic status

To bridge the vaccination gap across socio-economic statuses, it is essential to develop targeted strategies that cater specifically to the needs of lower socio-economic groups. These strategies should focus on eliminating barriers such as financial constraints, access to reliable information, and healthcare resources. Programs offering financial aid, such as vaccine subsidies and transport vouchers, can alleviate some of the economic burdens. Information dissemination efforts should be intensified through community outreach and the use of digital platforms to ensure that correct and accessible information reaches all demographic segments. Additionally, the establishment of mobile vaccination clinics can enhance access by delivering services directly to under-served areas, making it easier for residents to get vaccinated without the need to travel far. Collaborations with local community organizations can further promote vaccination through trusted networks, providing a holistic approach to increasing vaccination rates among vulnerable populations.

4.2 Geographical-based strategies

Addressing the unique challenges faced by rural areas requires specific strategies that focus on logistical barriers and access to healthcare. Increasing the number of mobile vaccination units and temporary sites can substantially improve accessibility for rural residents, ensuring that vaccinations are available closer to home. Partnerships with local organizations can provide logistical support and facilitate the identification of strategic locations for these mobile units and sites. Additionally, leveraging technology for better scheduling and information dissemination can optimize the vaccination process, making it more efficient and accessible. Engaging with local leaders and influencers to promote vaccination benefits can also play a crucial role in building trust and encouraging community participation in vaccination programs.

4.3 Enhancing the effectiveness of public health campaigns

Research has shown that clear and precise messaging is critical for public understanding and behavior change. For instance, a study by Motta et al. (29) found that campaigns with regularly updated information maintained higher trust and engagement levels among the target audience. Ensuring the reliability of campaign content through expert reviews and regular updates is crucial. Campaigns should also aim to be understandable to people of all literacy levels by using simple language and visual aids, which help in explaining complex health information. Utilizing community feedback is vital for adapting campaign messages to

better meet the community's needs and concerns. Moreover, fostering community participation in campaign planning and execution can enhance the campaign's relevance and effectiveness, making community members more likely to engage with and support the campaign's objectives.

4.4 Improving vaccination service logistics

Streamlining the logistics of vaccination services can significantly enhance their accessibility and convenience, thereby improving vaccination rates. Expanding the number of vaccination sites, especially in underserved areas, and optimizing scheduling systems to reduce waiting times are key strategies. Simplifying the vaccination process through effective information systems can help individuals understand and navigate the process better, reducing any perceived complexities. Additionally, training staff to improve their interactions with the public can lead to a more positive vaccination experience, fostering a supportive atmosphere that encourages people to get vaccinated. Together, these strategies aim to create a more efficient and user-friendly vaccination infrastructure that can cater to the needs of diverse populations.

5 Conclusion and future work

This paper explores the influence of public health campaigns on vaccination behavior, focusing on socioeconomic status, geographical location, campaign quality, and service accessibility. The findings highlight that individuals from higher socioeconomic backgrounds are more likely to get vaccinated, emphasizing the need for targeted outreach and education to address disparities. Tailored programs for lower socioeconomic groups, aimed at removing barriers like misinformation and financial constraints, are essential for equitable vaccination uptake. Geographically, urban residents are more inclined to get vaccinated than their rural counterparts. To address this gap, mobile vaccination units, community-led initiatives, and trusted local figures can be utilized to promote vaccination in rural areas. Bringing services closer to rural populations can help overcome logistical barriers and improve vaccination rates. The research also underscores the importance of effective public health campaigns, finding that clear, culturally relevant messaging improves vaccination outcomes. Campaigns should utilize various communication channels, including social and traditional media, while collaborating with local organizations and influencers to broaden their reach. Improving the convenience of vaccination services is another crucial factor. Expanding the number of sites, reducing wait times, and simplifying the process through online appointments and transportation support can significantly increase vaccination rates. Well-equipped and staffed vaccination centers enhance the overall experience and encourage participation.

Future research should focus on misinformation and its role in vaccination hesitancy, as well as explore behavioral economics to understand how incentives influence decisions. Emerging technologies like artificial intelligence can be integrated to optimize vaccination efforts, predict behavior, and evaluate interventions. By addressing these diverse factors, vaccination rates can be increased, contributing to overall public health improvements.

Although this study provides important insights, there are still some limitations to acknowledge. First, the sample size may not be sufficient to fully represent a broader population, which could limit the generalizability of the results. Second, potential bias in survey responses may exist, such as respondents adjusting their answers due to social expectations or inaccuracies in recall. Lastly, the applicability of the findings to other regions in China may be limited, as differences in demographic characteristics, cultural backgrounds, and policy environments across regions could influence vaccination attitudes and behaviors. Therefore, future research should aim to increase the sample size and include a more diverse population to improve external validity, while also exploring the impact of regional differences on the study's conclusions. A systematic review of global COVID-19 vaccination (22) pointed out that there are significant differences in vaccine acceptance between low-income and high-income countries, with the former often facing limitations related to healthcare system capacity and the availability of information.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the study involving human data in accordance with the local legislation and institutional requirements. Written informed consent was not required, for either participation in the study or for the publication of potentially/indirectly identifying information, in accordance with the local legislation and institutional requirements. The social media data was accessed and analyzed in accordance with the platform's terms of use and all relevant institutional/national regulations.

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YY: Writing – original draft, Data curation, Investigation. AS: Conceptualization, Project administration, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work was supported by the UNIMAS.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1498296/full#supplementary-material>

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OPEN ACCESS

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RECEIVED 31 October 2024

ACCEPTED 13 January 2025

PUBLISHED 29 January 2025

CITATION

Kwella H, Schilbert J, Tessartz A and
Scheersoi A (2025) From classrooms to
real-world contexts: enhancing vaccine
education through open schooling.
Front. Public Health 13:1520395.
doi: 10.3389/fpubh.2025.1520395

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From classrooms to real-world contexts: enhancing vaccine education through open schooling

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The topic of vaccination has been a highly debated issue for many years, whether related to measles, HPV, or the recent COVID-19 pandemic. It necessitates deeper exploration, particularly in school biology classes where it is often superficially covered, with ethical considerations rarely addressed. To enable students to engage in an in-depth examination of this complex socio-scientific issue and to enhance their argumentation and decision-making skills, a vaccine educational project was implemented based on the concept of open schooling, where schools collaborate with various societal institutions. Over a three-day interdisciplinary program, secondary school students worked with scientists from diverse fields, including immunobiology, medicine, and ethics, across different career levels, providing varied perspectives. Students actively engaged in real-world learning contexts with authentic problems, fostering individual reflection. A qualitative study, which involved observations and interviews with students, scientists, and teachers, highlighted key success factors in developing student interest and engagement in the topic of vaccination: learner-centered design, interaction with experts, exposure to diverse professional environments, active science learning, and the integration of ethical aspects. This approach promoted not only student engagement with the complex subject matter but also critical thinking and argumentation, contributing to informed decision-making and public health awareness.

KEYWORDS

vaccine education, open schooling, socio-scientific issue, real-world contexts, ethical aspects

1 Introduction

Vaccination is one of humanity's greatest public health achievements, widely recognized for its effectiveness in preventing major diseases such as diphtheria, tetanus, polio, and influenza (37). Despite this, vaccine hesitancy and declining immunization rates continue to rank among the top ten global health challenges, underscoring the urgent need for better vaccine education.

Recent studies emphasize the positive impact of comprehensive educational initiatives focused on vaccination on countering vaccination hesitancy and immunization rates (1). Although these efforts can be carried out in various contexts, Schott et al. (2) found that school-based education is particularly effective in promoting HPV vaccination, as it reaches a wide audience of students and their families. Another advantage of the school setting is that students spend a significant amount of time there, and instruction is generally delivered by highly trained educators (3).

In school curricula, however, vaccination is often only treated as a secondary topic, usually connected to broader subjects like the immune system or genetics (3, 4). Most student tasks focus narrowly on scientific content, neglecting emotional and socio-cultural dimensions, which raises concerns about the adequacy of this approach in modern science education (5). When addressing contentious topics like vaccination, educational efforts must move beyond simply presenting facts. Students need to be equipped with the skills to critically assess and contextualize the information they receive (3, 6). To provide a comprehensive understanding and support public health, the scientific aspects of vaccination should be taught alongside its ethical and societal implications (3), such as personal autonomy, public health, and vaccine hesitancy.

The complexity of the vaccination topic necessitates that learners engage deeply with the material to fully understand and evaluate it. Cultivating students' interest in the content is essential for ensuring such engagement. Interest is a key motivational factor in (life-long) learning, as it fosters persistence, and voluntary engagement with learning materials, thereby making the learning experience more meaningful and effective (7, 8). However, there is a lack of research on how to foster student interest in vaccination and develop effective instructional strategies (1, 3, 9).

The open schooling approach, which emphasizes real-world contexts, interdisciplinary learning, and student-centered pedagogy, may serve as an effective framework for promoting the students' interest and engagement and thoroughly exploring the topic of vaccination while combining scientific content with ethical and social discussions. Therefore, this study investigates an open schooling program focused on vaccination to identifying key factors that foster student interest and engagement, with the goal of improving contemporary vaccine education that integrates both scientific learning and its social implications.

Our study has been conducted as part of the international open schooling project Multipliers,¹ within which students engaged with various socio-scientific issues and current challenges. In our subproject, the focus was on exploring the topic of vaccination. The study involved secondary school students participating in a three-day interdisciplinary vaccine education program alongside scientists from fields such as immunobiology, medicine, and ethics. Throughout the program, students actively engaged in discussion and argumentation processes. Afterwards, interviews were conducted with students, scientists, and teachers to explore their experiences and identify interest-enhancing factors.

The insights gathered from these interviews informed the development of recommendations for designing innovative educational projects in real-world contexts, aimed at promoting contemporary science education and improving vaccination education.

2 Background

Vaccination is a complex topic, not only due to its foundational biological principles but also because of its significant societal relevance and the diverse, often controversial attitudes associated with it. To ensure that students engage deeply and comprehensively with this topic,

it is essential to spark and maintain their interest, which in turn promotes knowledge acquisition and argumentation skills. Research indicates that students' interest and engagement with (classroom) topics are enhanced when they have the opportunity to work hands-on—ideally in authentic contexts that differ from the often theory-heavy school curriculum—when they recognize the topic's relevance to their own lives or to society, and when they can have unique and novel learning experiences [e.g., (10–14)]. Additionally, approaches tailored to students' needs are crucial for motivation and learning, ensuring they are neither under- nor over-challenged, while also taking their subject-specific knowledge and methodological skills into account (15).

A pedagogical approach that encompasses these interest-promoting aspects is the open schooling approach, which is gaining increasing importance in science education. The European Commission (16) emphasizes open schooling as a transformative approach that positions schools as collaborative agents of community well-being. This model involves diverse stakeholders—including professionals from enterprises, civil society, and the broader community—who bring real-life projects into the classroom. Open schooling employs project-based, inquiry-driven methodologies, encouraging schools to work with local stakeholders to address real-world problems and enhance community well-being (17).

By focusing on inclusive, community-focused projects, open schooling aims to address local needs while fostering global awareness and sustainability (18–20). These initiatives align educational practices with the United Nations' Agenda 2030 goals, making schools active contributors to sustainable development (21).

Within this framework, learning extends well beyond the classroom, allowing students to gain firsthand exposure to scientific practices in diverse environments, such as science labs, museums, science centers, and community projects. By connecting science to real-life applications, open schooling encourages students to view science as a meaningful and impactful field. This practical exposure enhances students' engagement with science and may positively influence their science-based career aspirations (22). Given its potential impact, the concept of open schooling and its role in shaping contemporary science education are now subjects of intensive research (e.g., (23)).

Building on this background, we investigate whether an open schooling program on vaccination impacts secondary school students' interest and engagement with the topic and which factors contribute to this.

3 Materials and methods

To describe the methods of this study in detail, we will first present the planning and implementation of the teaching module, followed by a detailed explanation of the data collection and analysis methods.

Our vaccine education program was implemented using a systematic approach, beginning with preliminary research, followed by a collaborative planning phase, and culminating in a three-day educational module.

3.1 Preliminary research

Before the planning phase, we conducted desk research on existing vaccination educational materials. Additionally,

¹ <https://multipliers-project.org/>

we carried out an interview study with secondary school students, experienced teachers, and vaccination experts to identify factors that foster student engagement and interest in immunobiology and vaccines. The findings from these studies, published by Schlopsna and Scheersoi (9), were instrumental in shaping the lesson plan, ensuring that the program addressed key pedagogical needs and interests.

3.2 Collaborative planning

The planning phase centered on collaboration between teachers and experts from various fields. Although students were not directly involved in this phase, their prior knowledge, methodological skills, and areas of interest were carefully considered based on data from our preliminary research (9). This ensured that the educational module remained relevant to students' lives and aligned with the curriculum.

In the planning of the educational program, we engaged experts from a range of disciplines, including biology, medicine, and ethics, as well as senior scientists and young researchers (PhD students and postdoctoral researchers) working on vaccine-related topics. The early involvement of these experts contributed to ensuring that the scientific content was accurate and communicated effectively to younger audiences. To better equip the experts for working with secondary school students, we organized a workshop where researchers from biology education discussed the experts' previous experiences with students and their methodological approaches. This allowed the identification of potential challenges and provided advice on suitable teaching methods for younger learners.

The planning phase was conducted through a combination of two on-site meetings and several video calls. These sessions allowed project partners to discuss key vaccination topics, explore how to best leverage scientific expertise in the educational setting, and decide on the virus to use as a central example for explaining vaccination concepts.

Table 1 summarizes the participants and their roles in the collaborative planning phase.

The primary objectives of these meetings were to establish an open and transparent communication structure and to foster a collaborative environment among all participants from the start.

3.3 Three-day educational module

The educational module was conducted at a STEM-focused secondary school over three consecutive afternoons (see Table 2). Participants included 25 students aged 16 to 17 years, all enrolled in an advanced biology course. Participation was voluntary, and all activities were held outside of school premises.

The educational module spanned three days, each dedicated to different aspects of immunology and ethics:

On the first day, students focused on immune system and vaccination facts at the local university's lecture hall. A senior immunology scientist delivered a lecture using a PowerPoint presentation, while medical students facilitated interactive, game-like activities to engage participants.

The second day provided students with practical laboratory experience at university research center laboratories. Young biomedical and immunology researchers guided students through hands-on investigations, including plasmid transfection and gel electrophoresis. Students could choose which laboratory they wished to visit based on short films recorded in advance by the experts, allowing them to explore areas aligned with their individual interests. After the laboratory activities, a question-and-answer session offered students further insights and the opportunity to interact with the researchers.

On the final day, held at a university's ethics institution, students explored ethical considerations surrounding vaccination. Prior to this session, students were provided with preparatory materials and web access to familiarize themselves with the topic. A PhD student in ethics facilitated a fictional citizens' council meeting, simulating a scenario in which participants discussed and made recommendations on public policy issues related to compulsory COVID-19 vaccination. To ensure the accuracy of the factual knowledge presented, a medical student was also present to assist. This exercise aimed to enhance students' critical thinking and argumentation skills.

3.4 Data collection

Throughout the intervention, data were collected to identify factors that enhanced student interest and engagement within the educational setting. Our study aimed to conduct an in-depth case study of a specific open schooling program to explore its impact on student learning. To achieve these objectives, qualitative research methodologies were employed, as they are particularly well-suited for

TABLE 1 Experts involved and their role in the planning phase.

Science Research Institution (University)	Researchers specializing in biomedicine and immunology contributed scientific knowledge, helping to ensure the accuracy and depth of the content on vaccines and immunology.
Non-profit Association for Vaccination Education	Medical students from a local university brought practical medical perspectives and experience from previous programs with students including interactive sessions.
Ethics Institution (University)	Researchers in ethics and philosophy provided guidance on the ethical implications of vaccination, helping to incorporate discussions on ethical decision-making into the program.
Secondary School	Two experienced teachers played a key role in aligning the program with educational curricula and ensuring the material was accessible to students.
Education Research (University)	Researchers in biology education provided pedagogical expertise, supporting the development of teaching methods and ensuring that the program effectively engaged students in scientific inquiry.

TABLE 2 Overview of the educational module.

	Theme	Goal	Short Description	Experts involved
Day 1	Content knowledge: Immune system and vaccination	Provide students with foundational knowledge about the immune system and the principles of vaccination, while fostering engagement through interactive activities	PPP presentation and game-like activities in a university lecture hall	Senior scientist in immunology; medical students
Day 2	Practical laboratory experience	Offer students hands-on experience in a research laboratory setting, allowing them to apply theoretical knowledge to practical experiments, enhance their technical skills, and explore various areas of biomedical research	Visit to university's research laboratories including hands-on investigations; Q&A session with early career researchers	Researchers in biomedicine and immunology (different career levels)
Day 3	Ethical considerations in vaccination	Encourage critical thinking and ethical reasoning	Roleplay discussion related to compulsory COVID-19 vaccination at a university's ethics institution	PhD student in ethics; medical student

exploring new research areas and generating context-specific insights [e.g., (24)]. The primary aim of our study was not to examine behavioral patterns or produce statistical generalizations. Instead, we focused on generating rich, detailed insights into how students engage with and learn about vaccination in a real-world classroom setting. Aligned with this purpose, our research emphasizes qualitative inquiry, focusing on context-specific meanings and reflexive processes that shape the learning experience.

Interviews were conducted with students, experts, and the teachers involved (see Tables 3, 4). While the teachers and experts were interviewed individually, the students participated in small group interviews (3–4 students per group). This format was chosen to reduce anxiety and foster a conversational atmosphere, encouraging more authentic responses, as students could exchange ideas and express their preferences and interests (25). To minimize the risk of influencing respondents' answer patterns through predefined response options, a standardized survey was not utilized. Instead, open-ended semi-structured interviews were conducted, maintaining flexibility, as additional questions and topics can be addressed spontaneously based on the course of the interview (25). This flexibility is particularly valuable in qualitative research, where unexpected insights can emerge during the interview process.

Purposive sampling was employed to select participants who were willing to provide insights into the research topic. This targeted sampling approach allowed us to closely examine the program, focusing on students' individual experiences and perspectives. Detailed information regarding the study's purpose, the significance of their participation, and the potential impact of their responses was communicated to both the students and their parents. Parental consent was obtained for all participants, and confidentiality was maintained throughout the process. To enhance credibility and dependability, member checking was utilized by sharing key findings with participants for validation.

During data collection, triangulation was employed to strengthen the study's validity. First, triangulation by data source (26) was used by revisiting the same themes across interviews with students, teachers, and experts. This approach facilitated comparison of participants' statements, enhancing the accuracy of interpreting recurring responses. For example, teachers and experts were asked to

TABLE 3 Data collection, interview.

Participants (N = 18)	Teachers (2), students (12), experts: science (3), ethics (1)
Timing of data collection	Data was collected during and after the educational module
Data collection method	Group interviews with students (3–4 students per group); individual interviews with the teacher and the experts

TABLE 4 Interview participants.

Expert #1: Researcher in immunology	Science Research Institution (University)
Expert #2: Medical student Expert #3: Medical student	Non-profit Association for Vaccination Education
Expert #4: PhD student in ethics	Ethics Institute (University)
Teacher #1 Teacher #2	Secondary School
Student #1–12	16–17 years, Secondary school/advanced biology course

identify the topics and activities they observed as most engaging for students. Second, triangulation by method (26) was implemented by combining interviews with participant observations conducted throughout the three-day program. This comprehensive data collection approach aimed to provide a holistic understanding of the program's effectiveness in fostering students' interest and engagement with the complex topic of vaccination.

Observations were initially conducted using minimal standardization (27), with the aim of noting instances where students demonstrated interest and engagement, such as focused work, lively idea exchanges, or enjoyment of activities. Observational notes were recorded in bullet points during the program and elaborated in detail immediately after fieldwork, including external circumstances, notable events, and key participant statements.

3.5 Data analysis

The interview data were audio recorded and subsequently transcribed into text files (28). Both the data from interviews and observations were then systematically analyzed using qualitative content analysis: Statements from the transcripts were condensed into thematic units and organized into categories, following the content-structuring approach outlined by Kuckartz (29). This method is well-suited to capturing nuanced, textual information because it allows researchers to both apply predefined categories and develop new ones inductively during the analysis process. In our case, the initial category system was informed by our research question and the study’s background (characteristics of open schooling programs and interest-promoting factors). As we engaged with the data, we refined this system by adding inductive categories to account for emerging themes that were not anticipated in the original framework (e.g., benefits of involving experts at different career levels). This systematic approach allowed us to explore the conditions, processes, and experiences that shaped students’ engagement with the topic of vaccination in a nuanced and context-sensitive manner.

To ensure transparency, the results section presents original interview quotes alongside their corresponding categorizations and interpretations (Tables 5–9). This approach allows readers to critically assess the data analysis and ensures a transparent, traceable link between the raw data and the conclusions drawn.

4 Results

The following section outlines the key factors identified from our interview and observational data that fostered students’ interest and engagement in the open schooling vaccination program.

4.1 Collaborative planning

Collaborative planning emerged as a key success factor in the development of the educational vaccination program. This approach involved the joint planning and design of educational interventions by all stakeholders, contributing to the overall effectiveness of the program. Experts noted that this method differed significantly from their typical experiences when engaging with the public, such as in school collaborations.

Science experts who participated in the collaborative planning sessions prior to implementation expressed appreciation for the feedback and insights they received from colleagues with diverse areas of expertise. For instance, they valued educational input regarding content difficulty from teachers, who are well-versed in assessing student comprehension.

Collaborative planning also played a crucial role in enhancing the alignment between experts and students, ensuring that the educational intervention was truly student-centered. As highlighted by the teacher during our interview, preparing the experts before their meetings with students, allowed them to gain valuable insights into the students’ existing knowledge of immunobiology. This preparation enabled the experts to tailor their content and approach to match the students’ current understanding, fostering a more meaningful and engaging learning experience.

Moreover, collaborative planning was recognized as essential for fostering long-term cooperation among different experts. Familiarity and shared experiences in developing a cohesive educational concept lowered barriers to future communication and collaboration, making it easier for stakeholders to reconnect and work together again.

TABLE 5 Selection of quotes from different groups of participants describing ‘Collaborative planning’ as a key success factor.

Theme	Subtheme	Example quotes
Collaborative planning	Collaboration provides valuable feedback	<i>“The day (with the students) itself was the highlight; but the planning beforehand was also quite interesting because it was different from usual. Sure, we often do school presentations, but this time we got additional input from a different perspective. (...) We received direct input from the school, or from people who might be more scientifically engaged than we are and who see things a bit differently. That’s something we usually do not experience.”</i> (Expert #2, medical student)
		<i>“None of us have any didactic or pedagogical training, and we do it based on feeling, and it’s very valuable to receive such feedback from that perspective.”</i> (Expert #3, medical student)
		<i>“Your suggestion to involve the teacher was very helpful (...). I had not even considered that they need a role at that moment. And that you can utilize the potential that is there.”</i> (Expert #4, ethics researcher)
		<i>“I had sent you the presentation beforehand, and you had given me feedback on that, which I also incorporated. So that was actually a great support, especially from people outside the subject, when there were quite a few technical terms in it, to simplify that as well.”</i> (Expert #1, researcher in immunology)
	Collaborative planning to enhance the expert-student alignment	<i>“It was a unique situation because, normally, you do not have experts readily available to discuss how to proceed together. Typically, you prepare your lessons and then seek out experts who might fit afterward. [...] Because of this, the experts were able to adjust very well to our student. I usually encounter the problem that when set up appointments with experts, they do not really understand where the students are in their learning [...]. I had the feeling that the experts were closer to the students because they already knew what to expect.”</i> (Teacher #2)
	Collaborative planning as a basis for continuing collaboration	<i>“I think it’s super important that we had personal exchange because I believe that if you do not meet directly, no long-term collaboration arises.”</i> (Expert #2, medical student)

TABLE 6 Selection of quotes from different groups of participants describing 'Interaction with experts' as a key success factor.

Theme	Subtheme	Example quotes
Interaction with experts	Difference to regular classes and interaction with teachers	<i>"Knowing that someone is coming who's an expert in that field, definitely made a difference, compared to if I had just said we'll do it in class, grade it, and that's it. It certainly had a positive effect."</i> (Teacher #1)
	Insights into professional routines and real-world activities	<i>"That gives a look into the field, into the profession, and in that sense, I could certainly imagine that it could be a guiding experience for some."</i> (Teacher #1)
		<i>"Even afterwards [...] after the lesson was officially over, they took time to show us the lab, which I found very helpful, and we could also ask people there what they were working on. I found that very helpful."</i> (Student #2)
		<i>"And now, we were behind the scenes because we talked to the people and did not just see them from the outside but had direct contact with them."</i> (Student #3)
		<i>"[Through my family] I already had a bit of contact [with scientists], but the whole biology and chemistry aspect was completely new, and I really liked that. I always thought, 'Yeah, you just do something in the lab,' and now I actually know what they do and what their daily routine is like. I thought that was really cool."</i> (Student #8)
		<i>"I also appreciated how they interacted with us, and how they kept assuring us: 'You're really doing something related to science here, something we have done before or do in our daily work.' That [...] took away the sense of distance."</i> (Student #7)
	Accessibility of experts	<i>"The scientists did not expect us to do everything perfectly; they were like: Yeah, it's okay if a mistake happens, and they were very relaxed about it. I found that it had a calming effect, that you did not have the stress of 'I have to get everything right'."</i> (Student #11)
		<i>"I really liked that because you always think, 'Oh, that's so reserved,' but there it felt really normal. You could talk, ask anything, and it was really nice."</i> (Student #8)
	Benefits of involving different career levels	<i>"I could have sent a PhD student or a post-doc, and they would have done just as well. But you likely asked for professors to attend because it might make a bigger impression."</i> (Expert #1, researcher in immunology)
		<i>"Personally, I thought it was very cool to see very young people [...]. You could really tell they were still passionate about their topic. Because I think, the older you get, the more accustomed you become, meaning you no longer have quite the enthusiasm that you can have when you are just starting out. [...]"</i> (Student #12)
		<i>"Especially the students, they were not quite experts themselves yet, you had the feeling they were still somewhat on the same level. I mean, the others had more knowledge, so you knew you could always ask them, but I always felt it was very good to work with real experts from biology and then also with students."</i> (Student #4)
		<i>I also thought the [medical students'] team was great, especially because they were so young—they were like a bridge to everything else. I was really nervous, but then I saw them, and they were so nice, which is why I think they were really important."</i> (Student #8)

4.2 Interaction with experts

One of the primary factors contributing to the success of the educational vaccination program was the facilitation of direct interactions with experts. The teacher noted that integrating expert contact into the program allowed for extraordinary learning experiences that transcended typical classroom instruction.

Through these interactions, students gained valuable insights into the professional routines and real-world activities of experts, including hands-on experiences in laboratories. This exposure provided them with a clearer understanding of the practical applications of their studies and the realities of working in science-related fields.

Students also emphasized that the experts were approachable and fostered an environment where mistakes were viewed as part of the learning process. This supportive atmosphere contributed to a

low-stress experience, encouraging students to engage more freely without fear of judgment.

Moreover, students appreciated the diversity in age among the experts. Medical students were particularly seen as accessible, creating a welcoming environment for students to ask questions and seek guidance. In contrast, older experts, who were further along in their careers, were perceived as more distant. Data from our observational study confirmed this finding from our interviews, as we noted that students interacted more frequently and intensively with the younger experts.

4.3 Exposure to diverse professional environments

Another key factor contributing to the success of the educational vaccination program was the students' exposure to various workplaces

TABLE 7 Selection of quotes from different groups of participants describing ‘Exposure to authentic workplaces’ as a key success factor.

Theme	Subtheme	Example quotes
Exposure to authentic workplaces	Leaving the classroom	<i>“I think, for example, the setting, that it took place at the university, was totally motivating for the students. [...] I think it gives the students the feeling that they are now engaging with science, which might spark a bit more interest or motivation.”</i> (Expert #3, medical student)
		<i>“Having a practical phase outside of school perhaps, [...] that’s of course another story entirely. I think that could generate significantly more momentum and engagement, simply because you go out, see something different. The visits at school are nice, and of course, it’s great when something external comes in, but seeing a lab and working there, entering an institute—that has a completely different motivational effect.”</i> (Teacher #1)
	Insights into research environments	<i>You could really see how they work there and how they analyze things. That’s why the second day was my favorite.”</i> (Student #4)
		<i>“You learn a lot of new things, and you also gain experience in the lab [...].”</i> (Student #4)
		<i>“I would actually recommend it because you not only gain the knowledge but also get a glimpse of everyday life in a lab.”</i> (Student #6)
		<i>“[...] The places we saw—we were in the lecture hall center at one point, and I actually thought it was pretty cool. So, in a way, it inspired me a bit, like, ‘Okay, so this is what it looks like at a university’”</i> (Student #9)
	Uniqueness of such insights	<i>“My highlight was the lab. You do not see that every day because labs are usually closed off to the outside world, so to speak.”</i> (Student #11)
		<i>“I think very few people have really been in a lab like we were [...].”</i> (Student #4)
		<i>“I would definitely recommend it. [...] Especially because, as a regular student [from school], you do not always get the chance, and as far as I know, most internships in those areas are given out based on ,knowing people’”</i> (Student #10)
	Career orientation	<i>Being able to go in and work there gave me a good insight into the job of a biologist or a scientist.”</i> (Student #12)
		<i>I personally want to study medicine, so I thought it was cool to see a lab and so on.”</i> (Student #10)
		<i>“And that shows you entirely new aspects, especially if you are interested in biology, whether it might be something for your future career. Whether you want to work in a lab or if you can imagine studying biology.”</i> (Student #6)
		<i>“You can then start thinking about whether this might be something for you in the future or not.”</i> (Student #5)

related to vaccination and the underlying science. Both experts and teachers emphasized that learning outside the traditional classroom setting significantly enhanced student engagement.

Through these experiences, students gained valuable insights into the work environments of professionals, as well as the specific activities associated with those settings. The program allowed students to explore concepts they had previously only heard about, providing them with a tangible understanding of what those roles entail.

Students expressed that such exclusive and authentic experiences are not typically available to them, noting that access often depends on pre-existing connections. This realization highlighted the unique opportunity presented by the program, which many students felt was not universally accessible, a sentiment also supported by our observational data, which indicated that students were more engaged and inquisitive in these authentic contexts.

Furthermore, exposure to different work environments proved beneficial for students’ career orientations. Engaging with

professionals in real-world settings helped them better understand potential career paths and informed their future decisions.

4.4 Active science learning

Active science learning was identified as another key success factor in the educational vaccination program. Students expressed that they enjoyed engaging in practical work a lot, as it made abstract concepts more tangible and relatable. The implementation of hands-on activities allowed students to grasp the experiments they conducted and understand the results they obtained, which seems not always to be given in traditional school experimental settings.

Additionally, students appreciated the integration of interactive formats beyond the laboratory. Elements such as a cup game organized by the medical students and the use of QR codes for live voting during presentations were particularly well-received. These interactive

TABLE 8 Selection of quotes from different groups of participants describing 'Active Science Learning' as a key success factor.

Theme	Subtheme	Example quotes
Active science learning	Hands-On involvement	<i>"It's not a work where you are sitting on the chair the whole time or sitting at the laptop, but it's also practical, that you are working at the microscope or experimenting or something like that."</i> (Student #2)
		<i>"And at school, we do not really do much pipetting, so I thought it was a pretty cool experience."</i> (Student #11)
	Adequate support	<i>"I found the point that we were practically taken along the best. That it was explained to us in the lab beforehand what we had to do. [...] And when we were in these small groups, they also explained what we were currently doing, what was in these solutions and so on, I found that quite good because sometimes I feel that when you do experiments, it's a bit difficult to understand everything at once and you do the experiment, but in the end, you do not really understand what the evaluation means, I found that good."</i> (Student #10)
	Interaction and Integration	<i>"It was also, well, the thing with the cups, that we were integrated like that, I also found that good."</i> (Student #2)
		<i>"I liked [...] that we were so actively involved in the presentations and so on."</i> (Student #1)
		<i>"We did some interactive things, which I thought was good. For example, with the cups [...], or when we scanned QR codes and had to vote on something—that was really great."</i> (Student #5)
		<i>"Because it was so interactive, I also found it really exciting to listen."</i> (Student #9)
	Visualization	<i>"That was a kind of completely new first contact because you simply got much closer to it, you could experience and see much more yourself and not just hear about it."</i> (Student #1)
		<i>"I especially liked the second day because we were able to experiment on something very current. I was there and essentially recreated the RNA vaccination, and that was really interesting because it was so relevant, and it helped me understand the Corona vaccination much better. Being able to do that practically myself was really cool."</i> (Student #8)
		<i>"And if you somehow see it yourself or experiment with it or recognize it in a representation or something like that, then that's of course something good."</i> (Student #3)
		<i>"For me, it was a repetition of what I theoretically did in the internship, or where I watched, so it was great for me to be able to do it myself now."</i> (Student #12)
	Autonomy	<i>"That you have completely different directions open to you regarding what you want to do. And I think you can also come up with what you would like to experiment with yourself."</i> (Student #2)
		<i>"In general, I found it very great that we in the lab did not have this being constantly observed, but that they also let us do it and allowed us to gather our own experiences."</i> (Student #12)
		<i>"I found it interesting that we were able to experiment a lot on our own."</i> (Student #7)

components made listening periods more engaging and fostered greater participation among students, as confirmed by our observational data, which indicated that students were particularly active and enthusiastic during these interactive sessions.

Ultimately, students emphasized the importance of autonomy and making their own decisions in the learning process, particularly in relation to active science learning. They highlighted that engaging in self-directed activities was meaningful. This independence and sense of ownership in completing tasks was a key aspect they appreciated about the program.

4.5 Integration of ethical aspects and discussions

The analysis revealed that the inclusion of ethical aspects and discussions was a crucial success factor in the educational vaccination program. Engaging students in a debate about

mandatory COVID-19 vaccinations significantly heightened their awareness of diverse perspectives beyond their own. By acknowledging and considering these differing viewpoints, students developed a more nuanced understanding of the issue, enriching their own perspectives in ways they had not previously contemplated.

Our observations indicated that students were particularly engaged during the session on ethical discussions, actively using the information they had collected as a basis for their argumentation. This engagement closely relates to their awareness of other perspectives and the recognition of the complexity that comes with developing a more nuanced understanding.

Ultimately, students highlighted the relevance of discussing contentious topics like vaccination, which impact everyone in society. They noted that through their engagement with various perspectives and the inherent complexities of vaccination discussions, they felt better equipped to confront arguments that diverge from their own viewpoints.

TABLE 9 Selection of quotes from different groups of participants describing 'Inclusion of ethical aspects and discussions' as a key success factor.

Theme	Subtheme	Example quotes
Inclusion of ethical aspects and discussions	Awareness of diverse perspectives	<i>"I believe two students commented on this... that they indeed received a more differentiated picture simply and realized how important it is to hear the other side. And that is also a characteristic marker for critical thinking: not only listening to one's own head."</i> (Expert #4, ethics research)
		<i>"I think especially on the third day one took away new perspectives on how to view situations and one's stance on them; one could exchange ideas well with others who might have had different opinions; thus, one learned to look at things from another perspective."</i> (Student #5)
		<i>"I thought it was particularly cool during the ethical discussion [...] because afterwards we heard other opinions and learned about things we had not even thought about."</i> (Student #9)
		<i>"I liked that we could develop all arguments ourselves and that there were opposing viewpoints on vaccination; these were very new things, too, which changed my perspective completely during the discussion."</i> (Student #7)
	Recognition of complexity	<i>"I saw this during the discussion on mandatory vaccination. The political positions became polarized. Initially, there were three positions, and in the end, there were only two. But all those who expressed themselves said: 'We see this in a more differentiated way' in their words. However, even though they see it more differentiated, they have a clearer opinion now. The opinion has taken shape, but not because it was simplified; rather, one first opened up this complex space and then had to reduce it again. And that is already a fantastic outcome."</i> (Expert #4, ethics research)
	Personal/Societal relevance	<i>"So we talked a lot about it, especially on the last day. Now we know which side the [note: vaccine opponents] might represent a bit, and because of that, we could respond to it because we have counterarguments against it, and I think we would actually be quite well equipped."</i> (Student #2)
		<i>"I think it's also important that topics are discussed which are important for general knowledge, so society can progress."</i> (Student #3)
		<i>"And the discussion at the end of the third day actually has significance for everyone in society."</i> (Student #11)
		<i>"The topic of vaccination affects everyone; whether one should get vaccinated or not affects everyone; thus, during such a project you receive many arguments and various viewpoints explained in a very illustrative way."</i> (Student #7)

5 Discussion

The findings from this study underscore the significant potential of the open schooling approach in effectively addressing complex topics such as vaccination.

Collaborative planning emerged as a crucial success factor in the development of the educational vaccination program. This inclusive process enhanced the overall effectiveness of the program and represented a departure from traditional public engagement practices. Experts valued the feedback and insights shared during collaborative sessions, particularly the contributions from teachers regarding content difficulty. This dialog ensured that educational materials were not only scientifically accurate but also accessible and engaging for students. This is also consistent with the experiences of Borchert and Deisert (30), who describe that multi-professional partnerships between schools and external experts offer numerous learning opportunities for all parties involved.

The Involvement of experts in the planning process fostered a supportive network that is essential for long-term collaboration. The

familiarity and shared experiences gained from developing a cohesive educational concept helped to lower barriers to future communication and collaboration. As a result, stakeholders felt more comfortable reconnecting and working together again, which can lead to sustained partnerships in future educational initiatives.

These findings underscore the importance of inclusive planning processes in educational programs, as they not only enhance the quality of the interventions but also build a supportive network among professionals in the field.

The findings also indicate that effective interaction with experts can significantly enhance student interest in science. Although interactions with experts can sometimes be perceived negatively—especially if content is presented in an overly complex manner—thoughtful planning and pre-intervention coaching can yield positive results. Students in this study reported increased interest and engagement, echoing findings from Laursen et al. (31) and Schlopsna and Scheersoi (9), which suggest that direct engagement with scientists can boost students' attentiveness and enthusiasm. The presence of relatable figures, such as medical students,

provided valuable role models, further enhancing students' connection to the subject matter.

The unique approach of this program—introducing students to multiple science-related settings and diverse professional environments—emerged as a crucial factor in enhancing motivation and engagement. By taking students beyond the confines of the classroom into laboratories and research facilities, the program provided authentic science experiences that are often lacking in traditional educational settings. This approach aligns with Gamse et al. (32), who noted that many educational programs fail to adequately expose students to the varied contexts within the scientific field, underscoring the value of these real-world encounters in fostering sustained interest and enthusiasm for science. Ribeiro, Pinto and Rocha (33) also stated that open schooling approaches in science education provide students with opportunities to engage in authentic, real-world challenges. They highlight the fact that collaborations with experts not only foster meaningful partnerships between schools and universities but also have the potential to enhance students' scientific attitudes and augment their scientific capital.

Active participation through hands-on activities emerged as another critical factor in fostering interest and engagement in the topic of vaccination. Authentic, hands-on experiences have been shown to significantly enhance student engagement in science education in previous studies (31, 34, 35). The program's incorporation of game-like activities provided vivid representations of complex concepts, making them more accessible and relatable for students. Participants expressed enthusiasm for this active learning approach, emphasizing how it allowed them to engage directly with scientific processes rather than passively receiving information.

The analysis revealed that incorporating ethical aspects and discussions was another key factor in the success of the educational vaccination program. Collaboration between scientists and ethicists, as recommended by Kabasenché (36), provided students with valuable education in science ethics. Engaging in debates about mandatory COVID-19 vaccinations broadened students' awareness, encouraging them to consider perspectives beyond their own. By actively exploring these differing viewpoints, students developed a more nuanced understanding of the issue, deepening their perspectives in ways they had not previously considered. This is in line with Reiss (3) who emphasizes the multifaceted ethical considerations inherent in vaccination education. He advocates for an approach that transcends purely scientific perspectives, emphasizing the value of examining the topic through various lenses (e.g., by implementation of interdisciplinary science lessons and incorporating pedagogical methods such as discussions, role-playing exercises, and debates).

Students themselves underscored the relevance of discussing contentious topics like vaccination, which have far-reaching implications for society. Through their engagement with various perspectives and the complexities inherent in vaccination discussions, they reported feeling better equipped to confront arguments that diverged from their own views. The preparation of students for the discussions proved to be important in enabling well-founded argumentation and strengthening students' capacity for informed debate. This aligns with the recommendations of (38), who identifies sufficient time and thorough preparation as central elements of a successful ethical discussion in the classroom.

Through exploring ethical questions and understanding the multifaceted nature of societal issues, students become better prepared

to engage in meaningful conversations about public health and policy. This not only fosters their personal growth but also contributes to a more informed and participatory society. In this context, the inclusion of ethical discussions in the vaccination program has proven to be a vital component for developing students' critical thinking and engagement with societal issues. This approach underscores the importance of integrating ethical aspects into science education, as it promotes a deeper understanding of the complexities surrounding critical public health topics.

6 Limitations

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted with a specific group of secondary school students within a single educational program, which limits the generalizability of the results to other contexts or student populations. Additionally, the study's reliance on qualitative data from interviews and observations provides in-depth insights but may be subject to researcher bias in data interpretation. While a carefully developed coding system was used to analyze the transcribed data, categorizing responses is not entirely free from subjective interpretation. Despite structured coding efforts to reduce bias, the researchers' perspectives inevitably influence the assignment of statements to categories. To increase transparency in this process, we included multiple original quotes from the interviews in the results section, along with their categorizations and interpretations. This allows readers to critically evaluate the data interpretation and trace the connection between the raw data and the conclusions drawn.

The open schooling program itself was also limited to a three-day timeframe, potentially restricting the extent of long-term impact assessment on student engagement and understanding. Future research with larger, more diverse samples and extended program durations could provide a broader perspective on the effectiveness of open schooling for vaccine education.

7 Conclusion

In conclusion, this study highlights the significant value of the open schooling approach as a comprehensive framework for vaccine education, providing students with meaningful engagement in both scientific and societal aspects of vaccination. While open schooling and community-based frameworks have been studied in broader contexts, their integration into formal school systems remains limited. Our findings provide valuable insights into how these approaches can be adapted for effective implementation, particularly for complex and controversial topics like vaccination. By fostering collaboration between schools, local communities, healthcare professionals, and scientists, open schooling enables authentic learning environments where students connect with real-world public health issues, cultivating informed perspectives on vaccination. This model not only deepens students' understanding of vaccination but also equips them to become active, informed citizens capable of participating in public health discussions and decision-making processes.

Open schooling demonstrates considerable potential to spark and sustain students' interest in vaccination, combining scientific rigor with social learning. Its focus on real-world contexts, interdisciplinary

collaboration, and student-centered pedagogy creates conditions for students to engage deeply with this complex topic. Through hands-on projects and community-based discussions, students analyze diverse perspectives, including ethical, biological, and societal implications of vaccination. The program's inquiry-driven approach encourages students to question, debate, and build argumentation skills, which not only enriches their grasp of vaccination but also fosters essential competencies in scientific literacy and social discourse.

The findings of this study have significant implications for various stakeholders, including educators, healthcare professionals, and policymakers. The open schooling model not only improves students' understanding of vaccination but also fosters critical thinking and ethical reasoning skills—both crucial for countering vaccine misinformation. For educators, these results underscore the necessity of integrating interdisciplinary, community-based learning into curricula to encourage a more holistic understanding of vaccination, extending beyond traditional classroom methods. Healthcare professionals can draw on these insights to advocate for educational initiatives that promote vaccine literacy among youth, equipping future generations with the knowledge and critical faculties needed to make informed health decisions. Collaborations between schools and healthcare providers could further amplify these efforts. Policymakers are urged to view the open schooling framework as a scalable and effective model for broader educational reforms aimed at improving public health goals. By prioritizing vaccine education within school systems, governments can strengthen community resilience against vaccine hesitancy, fostering a well-informed populace capable of engaging in and supporting public health initiatives.

As educational models continue to adapt to the complexities of the modern world, the open schooling approach offers a promising and adaptable model for teaching critical topics that extend beyond traditional classroom boundaries. Incorporating open schooling principles into educational programs can foster a well-rounded understanding of complex issues like vaccination, empowering students to explore, evaluate, and form nuanced viewpoints that prepare them to engage with the broader societal challenges of the future.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Eckhard Wesemann and Thomas Rütten. The studies were conducted in accordance with the local legislation and institutional requirements.

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Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

HK: Data curation, Project administration, Writing – original draft. JS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. AT: Data curation, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. AS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This publication received support under the EU project Multipliers which has received funding from the European Union's Horizon 2020 Research and Innovation Programme under the Grant Agreement No. 101006255. This work was supported by the Open Access Publication Fund of the University of Bonn.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

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OPEN ACCESS

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RECEIVED 23 August 2024

ACCEPTED 18 December 2024

PUBLISHED 29 January 2025

CITATION

Handayani EW, Perwitasari DA and
Purba FD (2025) Health belief model of
parents' COVID-19 vaccination intentions for
children: perceived benefits and barriers in
Indonesia.

Front. Public Health 12:1485416.

doi: 10.3389/fpubh.2024.1485416

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Health belief model of parents' COVID-19 vaccination intentions for children: perceived benefits and barriers in Indonesia

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Introduction: The uptake of vaccines against COVID-19 remains low. Some barriers to childhood vaccination uptake persist, such as parents' assumption that children are at lower risk of severe COVID-19 and tend to be asymptomatic carriers. This study aims to develop guidance for in-depth interviews for a future qualitative study based on a cross-sectional quantitative study of parents with school-age children.

Methods: This study adopted a cross-sectional design. The study population comprised parents of 6–11-year-old children in the Centra Java province who had received the COVID-19 vaccine or not. The data were collected from August 2023 by filling in an online questionnaire. The sample size was calculated using formulation in OpenEpi for 95% confidence levels, with a statistical power of 80%.

Results: Our study finds that perceived benefit and perceived barriers are the two domains that most significantly influenced the parents' intention to vaccinate their children. In our study, there was no significant association between parent gender and the intention to vaccinate their children. Our study shows that parents' acceptance of vaccinating their children is high. We emphasized questions related to benefits and barriers in the interview. The questions on perceived benefits explored the advantages of COVID-19 vaccination. The content on perceived barriers examined the concerns of parents, the information influencing their decision to vaccinate their child, the procedure vaccination and the effect after vaccination.

Discussion: The significant association between parents' intention to vaccinate their children and the perceived benefits and perceived barriers to vaccination generated guidance for in-depth interviews in the qualitative study. The health belief model should be further explored in Indonesia because of the potential external factors that may influence parents' intention to vaccinate their children.

KEYWORDS

guidance, parents' intention, childhood vaccination, COVID-19, qualitative study, Indonesia

1 Introduction

The COVID-19 vaccine received emergency authorization from the Food and Drug Administration (FDA) in 2020 (1). This was followed by the approval of COVID-19 vaccines in many countries. However, in some countries, the uptake of COVID-19 vaccination has remained low because of core beliefs, mainly related to religion (2). The COVID-19 vaccination received approval from the FDA in May 2021 (3). Children are considered more susceptible to COVID-19 than adults. However, several barriers to childhood vaccination programs persist, such as the parents' assumption that children face lower risk of severe COVID-19 and are asymptomatic carriers (4). Another study mentioned that doubts about efficacy, concern about vaccine content, limited information on the vaccine from physicians, and fears regarding safety are factors contributing to parents' refusal of childhood vaccination (5).

A previous study in Indonesia described parents' concern to vaccinate their daughters with the HPV vaccine; this refusal was attributed to misinformation about the vaccine and its side effects, or a lack of sufficient information on the vaccine (6). This situation is similar to the context of the COVID-19 pandemic: according to a previous study, parents' intention to vaccinate their children only reached 69%. Several predictors of parents' refusal to vaccinate their children were concerns over vaccine side effects and unknown vaccine efficacy (7). The fact that 80% of Indonesian citizens are Muslims and the important role of neighborhood and/or religious leaders may also influence parents' intention or refusal to vaccinate their children.

One theoretical framework to describe the process linking individual factors and a specific health behavior is the Health Belief Model (HBM). This model identifies six core components that may affect the likelihood of an individual performing a protective action related to health: (i) perceived susceptibility (assessment of the risk of acquiring a condition); (ii) perceived severity (assessment of the seriousness of the consequences of a condition if it is acquired); (iii) perceived benefits (assessment of the positive consequences of adopting a health behavior); (iv) perceived barriers (assessment of the influences that discourage adoption of a health behavior); (v) self-efficacy (the individual's assessment of his/her ability to successfully adopt a health behavior); and (vi) cue to action (external influences that promote the health behavior) (8, 9). The HBM has also been applied to the analysis of behaviors related to COVID-19, including various COVID-19-preventive behaviors (10–12). Based on the previous studies, there are some gaps, such as: Cultural and Religious Specificity which the impact of religion on vaccine hesitancy across diverse religious groups or in non-Muslim contexts; Regional Diversity which many studies focus on specific regions, like Malaysia and Indonesia, but lack broader Southeast Asian or global comparisons; Age and Vaccine Type Specificity which HPV and COVID-19 vaccine hesitancy are the main focal points, leaving gaps in other vaccines or age groups; Broader Socioeconomic and Misinformation Influence which some studies lack an exploration of the impact of misinformation or economic constraints, which are significant factors in vaccine hesitancy. Addressing these gaps could involve a comprehensive study that examines vaccine hesitancy across various religious, cultural, and socioeconomic contexts, with a focus on both COVID-19 and other vaccines.

Developing the guideline for in depth interview is very important. An interview guide is crucial for enhancing the consistency, depth, and relevance of data collected, making it a cornerstone of reliable and

effective qualitative research. By developing the in-depth interview guideline, we prepared the well-prepared questions and prompts ensure that the interview covers all aspects of the research topic. Although structured, a well-designed guide is also flexible, providing prompts that allow the interviewer to explore unexpected or emerging themes. This adaptability is critical in qualitative research, as it allows the interview to uncover insights that may not have been initially considered. Clear, open-ended questions in the guide encourage participants to provide detailed responses, which is essential for qualitative analysis. The guide also includes probing questions to prompt participants to expand on or clarify their answers, ensuring a richer understanding of the topic (13).

Indonesia's COVID-19 vaccination program for children faces both potential benefits and barriers influenced by parents' beliefs. Studying these factors through the HBM domains (Perceived Benefits and Perceived Barriers) allows public health officials to design interventions directly targeting parental attitudes toward vaccination. This study aims to develop guidance for in-depth interviews for a future qualitative study based on a cross-sectional quantitative study on parents with school-age children. The topic of the aforementioned qualitative study is the HBM of parents' intention to vaccinate their children with the COVID-19 vaccine.

2 Materials and methods

2.1 Study design and sampling method

This study adopted a cross-sectional design. The study population was parents with 6–11-year-old children (COVID-19-vaccinated or not) in the central region of Java province. The subjects of this study were parents in the population criteria. We recruited the parents who had children with COVID-19 vaccinated, because this situation allowed researchers to uncover the factors that solidified their decision, providing a fuller understanding of both barriers and enablers within the HBM framework. This understanding can be instrumental in designing targeted interventions to increase vaccination rates among hesitant populations. The researchers bypass potential biases associated with hypothetical intention (e.g., stating an intention but never following through). This offers a clearer view of the factors that genuinely contribute to translating intention into behavior, as opposed to what participants think they would do. Some parents may have been hesitant at first, providing an opportunity to explore how their beliefs, perceptions, and attitudes evolved. This retrospective insight can identify critical turning points in decision-making that may be key to designing targeted interventions for hesitant parents.

The data were collected from 6th July to 10th August 2024 by filling in an online questionnaire.

2.2 Data collection process and measures

The questionnaire used in this study was adopted from Almalki et al. (14) and was translated into Bahasa Indonesia. This questionnaire has been validated and passed the reliability test. The content of the questionnaire focuses on parents' intention to vaccinate their children and five domains of HBMs, namely: perceived susceptibility (3 items), perceived severity (3 items), perceived benefits (2 items), perceived barriers (4 items), and cues to action (2 items). The questionnaire used

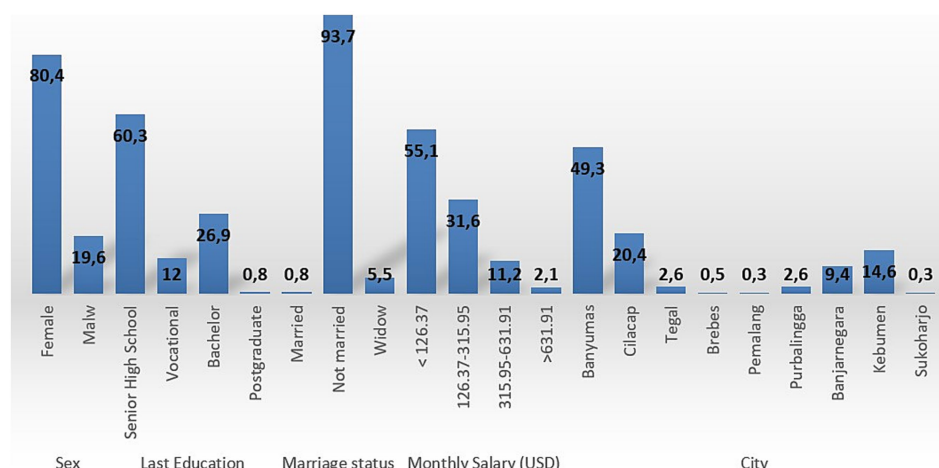


FIGURE 1
Description of respondents' characteristics (%).

the Likert Scale, with possible response options as follows: 1 (strongly disagree), 2 (disagree), 3 (agree), and 4 (strongly agree).

Sample size was calculated using formulation in OpenEpi,¹ with the following equation:

$$n = \left[\frac{\text{DEFF} \cdot N p(1-p)}{d^2 / Z^2 - \alpha / 2^* (N-1) + p^* (1-p)} \right]$$

Sample sizes were provided for 95% confidence levels, with a statistical power of 80%.

2.3 Statistical analyses

The data were descriptively analyzed. The association between parents' intention to vaccinate and domains of the HBM was assessed using Person correlation and linear regression analyses.

2.4 Ethics and consent

This study was approved by the Ethics Committee of University Muhammadiyah Gombong, under Approval Number 249.6/II.3.AU/F/KEPK/VIII/2023.

3 Results

We recruited 382 subjects from the Central Java province. Figure 1 and Table 1 presents the respondents' characteristics. Most of the respondents were female (80.4%), with the highest education level being senior high school (60.3%). Marital status was predominantly married (93.7%), and most of the respondents earned a monthly wage of below 126. Interestingly, most of the subjects mentioned that none of their family members (68.4%) or their children (95.3%) had been

infected to date. Most respondents indicated that their children had received two doses of the COVID-19 vaccine. Parents obtained information from social media (48.8%) and their commitment to provide the influenza vaccine to their children was high (55.9%). Table 2 describes the significant association among parents' intention to vaccinate their children and perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and cues to action ($p < 0.05$). These associations indicate that parents' decision to vaccinate their children is influenced by concerns relating to these five dimensions. These associations were adjusted to subjects' characteristics, described in Table 3. There was no significant association between parents' intention to vaccinate their children and their characteristics (Table 3). Owing to the objective of this study (i.e., to prepare guidance for developing in-depth interviews for a qualitative study on this topic) we continued our analysis with linear regression (Table 4). We found that the most significant association was between parents' intention to vaccinate and perceived benefits and perceived barriers ($p < 0.001$). Guidance for developing the in-depth interview in a qualitative study was developed based on the present study's findings. Table 5 lists in-depth interview points for the qualitative study.

4 Discussion

The present study aimed to develop guidance for in-depth interview for a future qualitative study based on a cross-sectional quantitative study of parents with school-age children. All parents reported that their decision on whether or not to vaccinate their children had been made taking into many considerations, including the mandatory procedures for continuing offline learning in schools. Our study finds that perceived benefit and perceived barriers were the two domains that significantly influenced parents' intention to vaccinate their children. Our results are in line with those of several previous study. The study reported that parents are concerned about the dangers of COVID-19 infection and the benefit of the vaccine. Thus, perceived severity and benefits were found to be dominant in that study (15). In our study, there was no significant association between parent

¹ www.OpenEpi.com

TABLE 1 Respondents' characteristics.

Characteristics	Mean (SD)	
Age	37.34 ± 7.394	
Characteristics	Number (N)	Percentage (%)
Have you or adults living with you been infected with SARS-CoV-2 since the beginning of the pandemic?		
Yes, I am or other family member is currently infected	105	27.4
Yes, some of us have been but are now healthy	16	4.2
No, we have not been infected by the virus	226	68.4
Have any of your children been infected with SARS-CoV-2?		
No, they have not been infected	365	95.3
Yes, they have previously been infected, but are recently healthy	10	2.6
Yes, one or more are currently infected	8	2.1
Are you vaccinated, and how many dosages did you receive?		
Yes, one dosage	17	4.4
Yes, two dosages or more	357	93.2
No, I am not	8	2.1
No, because I am exempted	1	0.3
If you have children over 12 years old and under 18 years old, have they been vaccinated at least once for COVID-19?		
Yes, they have been vaccinated once	43	11.2
Yes, they have been vaccinated twice	167	43.6
I do not have children over 12 years old	156	40.7
No, they haven't been vaccinated	13	3.4
No, because they are exempted	4	1.0
My main source of information on COVID-19 vaccine is		
Social media	187	48.8
Television	110	28.7
Friends/family	43	11.2
Others	43	11.2
How do you rate your children's health in general (aged 5–11 years old)?		
Very good	125	32.6
Good	243	63.4
Average	15	3.9
Are any of your children (5–11 years old) suffering from chronic illness that require them regular medications?		
Yes	16	4.2
No	367	95.8
I commit to giving my children (5–11 years) the annual seasonal influenza vaccine		
Yes	169	44.1
No	214	55.9

gender and the intention to vaccinate their children. A previous study mentioned that fathers had higher willingness to vaccinate their children, because of the riskier behaviors. Men are available in working area or outside of the house situation, which could be more possibility to be exposed by the virus. Mothers also had to make a decision about their children health, because they have more time spent daily (16, 17). Our study shows that parents' acceptance of vaccinating their children is high. However, another study reported that parents' acceptance of vaccination is very low, and that factor associated with this lack of acceptance included access to information, trust, and community norms. To address these concerns, education programs should be made available to enable the community to obtain accurate information (3). The role of neighborhood leaders or religion/spiritual leaders in imparting suitable information about the importance of vaccination in children is also crucial.

A systematic review and meta-analysis about parents and guardians' willingness to vaccinate their children indicated that perceived susceptibility, perceived severity, and perceived benefits had significant associations with parents' and guardians' willingness to vaccinate their children. Parents or guardians' willingness to vaccinate themselves was an important predictor of their willingness to vaccinate their children (18). A previous study in Saudi Arabia reported that all HBM domains were significantly associated with parents' intention to vaccinate their children. The most strongly associated domains were perceived benefit and perceived barriers (14). This result is in line with our finding, given the background of the two countries is similar: Saudi Arabia is a well-known Muslim country, and 80% of Indonesian citizens are Muslims. We included religion as a consideration because religious leaders have a significant role in promoting vaccination programs through collaborating the science and religion. However, some religious leaders have been reported to spread misinformation about the side effects of vaccination (19). A previous study mentioned that information from religious leaders can influence Muslims' attitudes and decisions regarding vaccination. Thus, it is important to involve religious leaders in immunization programs, as Muslims require reassurance that vaccines follow the Shariah rules (2).

The differences between our study and previous works is that our study adopted a cross-sectional design with a questionnaire to assess the association between parents' intentions to vaccinate their children, using HBM. We further developed guidance for in-depth interviews to find out more about parents' intentions to vaccinate their children and the related factors. As mentioned before, a significant association was observed for perceived benefits and barriers. Thus, we emphasized questions related to benefits and barriers in the interview guidelines. However, we planned to start the interview with questions on perceived severity for more prolonged engagement. We expect that parents will respond positively to the interview process if asked to describe their experiences during the COVID-19 pandemic: based on our experiences, it is difficult to find prospective qualitative respondents. They might refuse to participate because of their concerns regarding vaccination. Thus, strategies aimed at prolonged engagement were applied at the start of the interview. The first

TABLE 2 Association among parents' intention to vaccinate their children and domains of health belief model.

	Parents' intention (Number of subjects)				p-value
	Definitely Yes	Maybe Yes	Maybe Not	Definitely Not	
Perceived susceptibility					
Strongly agree	1	1	0	0	0.028*
Agree	42	34	5	11	
Disagree	74	98	21	30	
Strongly disagree	22	22	11	11	
Perceived severity					
Strongly agree	11	10	1	1	<0.001*
Agree	99	113	21	25	
Disagree	26	28	14	20	
Strongly disagree	3	4	1	6	
Perceived benefits					
Strongly agree	41	13	2	1	<0.001*
Agree	91	136	25	27	
Disagree	4	6	8	20	
Strongly disagree	3	0	2	4	
Perceived barriers					
Strongly agree	3	4	5	10	<0.001*
Agree	74	116	24	37	
Disagree	60	35	7	3	
Strongly disagree	2	0	1	2	
Cues to action					
Strongly agree	15	4	3	4	<0.001*
Agree	121	144	27	34	
Disagree	0	7	7	12	
Strongly disagree	1	0	0	2	

*Significant association.

qualitative study about the COVID-19 vaccine also suggested this method (20).

In our guidance for in-depth interviews, the content on perceived severity included questions about the symptoms experienced by children due to COVID-19 infection, the short term and long-term impact, and the impact on children relative to adults. Questions about parents' knowledge about COVID-19 symptoms, its impact, and the severity of impact were also explored in this domain. The content on perceived severity explored the level of severity for children, the concerns of parents about COVID-19 infection, and the steps taken by parents to protect their children. The perceived benefits explored the advantages of COVID-19 vaccination. The content on perceived barriers included concerns of parents, information influencing the decision to receive the vaccination, the procedure vaccination and the effect after vaccination. The domain of cues of action explored sources of information about vaccination and people trusted by the parents. The additional information content included questions about the government policy, especially related to the mandatory aspect of the COVID-19 vaccination for children.

We arranged these questions based on our experience during the quantitative study as well as previous reports (14, 15, 17, 20). Regarding the development of the guidance for in-depth interviews, we agree that more explicit details would benefit other researchers. While this was largely an exploratory process, our experiences allowed us to refine our questions, identify common themes, and avoid potential pitfalls in future qualitative interviews. To enhance transparency and reproducibility, we will provide a detailed outline of how our quantitative findings informed the qualitative phase, including specific challenges, adaptations made, and lessons learned.

Since parents' perceptions of vaccine benefits and barriers are likely influenced by cultural, religious, and socioeconomic contexts, findings may not automatically transfer across diverse populations. Generalizability could be improved by detailing these factors within the study, allowing others to judge the applicability of the results to their own populations or settings. The Health Belief Model (HBM) provides a structured framework (e.g., perceived benefits, perceived barriers, cues to action), making it easier to adapt findings to other studies. While specific findings

TABLE 3 Description of parents' intention to vaccinate their children based on their characteristics.

	Parents' intention (Number of subjects)				p-value
	Definitely Yes	Maybe Yes	Maybe Not	Definitely Not	
Sex					
Male	31	27	6	11	0.664
Female	108	128	31	41	
Marriage status					
Married	131	148	34	46	0.078
Widow	8	6	2	5	
Not married	0	1	1	1	
Last education					
Up to Senior high school	81	95	20	35	0.676
Vocational	18	21	4	3	
Bachelor	38	39	13	13	
Postgraduate	2	0	0	1	
Monthly salary (IDR)					
<2.000.000	74	87	18	32	0.313
2.000.000–5.000.000	41	52	16	12	
5.000.000–10.000.000	19	14	52	7	
>10.000.000	5	2	41	1	
	Definitely Yes (Mean ± SD)	Maybe Yes (Mean ± SD)	Maybe Not (Mean ± SD)	Definitely Not (Mean ± SD)	
Age	37.81 ± 7.100	37.12 ± 7.643	36.24 ± 8.060	37.51 ± 7.001	0.678

TABLE 4 Linear regression results of the parents' intention to vaccine COVID-19.

Independent variable	B	Beta	t	Sig
(Constant)	1.796		4.293	0.000
Perceived susceptibility	0.025	0.045	0.925	0.356
Perceived severity	0.532	0.094	1.677	0.094
Perceived benefits	0.301	0.343	6.346	0.000
Perceived barriers	−0.157	−0.313	−7.190	0.000
Cues to action	0.002	0.002	0.037	0.970

on barriers and benefits may vary, the core HBM domains offer a transferable structure. Emphasizing these core domains can aid in the study's adaptation to different regions, cultures, or vaccines. The in-depth interview guidelines developed in the study can be made more widely applicable by including flexible prompts that allow researchers to explore culturally specific or context-specific factors related to vaccine hesitancy. By doing so, the guidelines could serve as a useful tool for conducting qualitative research on vaccine intention in different settings. We also still used some questions in the interview guideline which is related to the HBM, because, the parents' intention to do the vaccination for their children could influence by complex constructs.

The strength of our study was that we used a quantitative study with large number of respondents and experience of the researcher during the quantitative study to develop a guidance of an in-depth

interview of the qualitative study. The limitation of this study is that, we cannot include religion aspect in the guidance, because we will select the subject randomly, not based on religion. Thus, the exploration about religion could be mentioned by the subjects, if they have experience about the influence of religion in decision making. The role of religion leader, is one of the important factors which influenced the decision maker about the use of drug, including vaccine. In Indonesia, there is a Muslim Board, namely Majelis Ulama Indonesia (MUI) which has responsibility in the recognition of halal products, including food and drinks, cosmetics, drugs and vaccine. Most of the muslim' people will comply with the decision of MUI regarding the use of some products. MUI was formed by the government and the main role is conducting the comprehensive review and analysis about the halal of product. Thus, it is important to add the religion leaders as part of the interview.

In the future, it is important to implement some programs, such as health promotion and cadres' education to increase the community awareness about the vaccination. The interview guideline also can be implemented in the intervention study to explore the HBM before and after the intervention.

5 Conclusion

The significant association observed between parents' intention in some cities of Central of Java, to vaccinate their children and perceived benefits and perceived barriers yielded guidance for in-depth interviews in the qualitative study. We belief that the interview guideline can be implemented in Central of java area, because

TABLE 5 List of questions in the in-depth interview of qualitative study.

Dimensions	Questions
Introduction	How was your experience during the COVID-19 pandemic?
	Have any of your family members been infected with COVID-19?
	Who were they and when? Has your child ever been diagnosed with COVID-19?
	IF YES
Perceived severity	What happened to your child when he or she got COVID-19? What were the symptoms? What was the impact on his physical/emotional/social/school?
	When your child experienced COVID-19, what was the impact on your family and people around you? (for example, parents cannot work because they have to take care of them, siblings have to move temporarily, etc.)
	Are there any long-term impacts experienced by your children as a result of COVID-19 that they have experienced (long-Covid)?
	Was the impact of COVID-19 on children different from the impact on adults? (the same/worse/lighter, please explain?)
	IF YES
	What do you know about the symptoms of COVID-19 in children? What is the impact on the physical/emotional/social/school of children affected by COVID-19?
	What do you know about the impact of a child diagnosed with COVID-19 on the family and people around them? (for example, parents cannot work because they have to take care of them, siblings have to move temporarily, etc.)
	What do you know about the long-term impact experienced by children affected by COVID-19 (long-Covid)?
Perceived susceptibility	Is the impact of COVID-19 on children different from the impact on adults? (the same/worse/lighter, please explain?)
	In your opinion, how vulnerable are your children to COVID-19?
	What is the reason? Compared to adults, who is more vulnerable?
	Are you worried that your child will get COVID-19?
Perceived benefits	Are you taking special measures to protect your children from COVID-19? If so, what are they?
	Has your child been vaccinated against COVID-19? How many times? When was that?
	What do you know in general about vaccines? What are the benefits of vaccines?
	What do you think are the main benefits of the COVID-19 vaccine for children?
	Has the COVID-19 vaccine that your child has received had a good impact on him so far? If so, what are the outcome (e.g., mild symptoms, no longer getting a second covid, etc)? What is the reason if there are no outcomes?
Perceived barriers	Do you see vaccines as an effective way to protect your child from COVID-19?
	Do you have any specific concerns about COVID-19 vaccines for children?
	What are the main considerations for you in deciding whether or not to vaccinate your child related to COVID-19?
	Are there certain events or information that affect your decision regarding the administration of the COVID-19 vaccine for children? Suppose there is influence from family or neighbors
	What are the obstacles or obstacles that you feel in deciding to give the COVID-19 vaccine to your child?
Cues to action	If your child has been vaccinated, what is the process? Are there any side effects experienced? or what symptoms occur after your child is vaccinated?
	Where do you get information about COVID-19 vaccines for children? What form of information about COVID-19 and the COVID-19 vaccine is the easiest for you to accept and understand? (e.g., TV advertisements, flyers, lectures at ibvadah's house, discussions with health workers, etc.)
Additional questions	Regarding the administration of the COVID-19 vaccine to your children, who is the party that you trust their opinions/suggestions so that you will be willing to give vaccines to your children? (ex: government, doctors, pharmacists, religious experts, celebrities, etc.) Why are these people you trust?
	What do you think about the government's policy regarding COVID-19 vaccination for children?
	Do you think vaccination should be mandatory for children?
	If the COVID-19 vaccine is not mandatory, will you continue to give the COVID-19 vaccine for children?

we selected respondents from big cities in Central of java, randomly. The Health Belief Model should be further explored in Indonesia because several external factors may influence parents' intention to vaccinate their children.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of University Muhammadiyah Gombong. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

EH: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing, Formal analysis, Data curation, Project administration. DP: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing, Funding acquisition, Supervision, Validation. FP: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work was supported by the Directorate of Research, Technology and Community Services, Ministry of Education, Culture, Research and Technology, Indonesia (grant numbers: 107/E5/PG.02.00.PL/2024, 11

June 2024; 0609.12/LL5-INT/AL.04/2024, 14 June 2024; and 041/PDD/LPPM UAD/VI/2024, 15 June 2024).

Acknowledgments

We thank the Directorate of Research, Technology and Community Services, Ministry of Education, Culture, Research and Technology for their financial support.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

EDITED BY

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RECEIVED 12 October 2024

ACCEPTED 16 December 2024

PUBLISHED 30 January 2025

CITATION

Song S-Y, Guo Y, Li Y-H, Wang Z and
Gao W (2025) Analysis of factors influencing
HPV vaccination intention among Chinese
college students: structural equation
modeling based on health belief theory.
Front. Public Health 12:1510193.
doi: 10.3389/fpubh.2024.1510193

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Analysis of factors influencing HPV vaccination intention among Chinese college students: structural equation modeling based on health belief theory

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Background: Increasing human papillomavirus (HPV) vaccination rates is vital for achieving society-wide public health goals, yet current research on HPV vaccine-related knowledge, vaccination intentions, and behaviors among college students in ethnic minority regions is inadequate. This investigation sought to explore the present circumstances of college students in China's ethnic minority regions concerning their awareness, attitudes, and practices related to the HPV vaccine. This study also aimed to provide a scientific basis for future health education and HPV vaccine promotion in China's college student population.

Methods: Based on health belief theory, 1,388 valid questionnaires were collected online to investigate college students' knowledge, beliefs, and behaviors related to HPV vaccination and the factors influencing their willingness to be vaccinated. The data were analyzed via SPSS 26.0 for descriptive analysis and Amos 24.0 for structural equation modeling, factor analysis and path analysis.

Results: The overall HPV vaccine awareness rate was 77.9%. In terms of health attitudes, the positive intention rate was 50.4%, with females having more positive attitudes than males (OR = 2.242, 95% CI = 1.777–2.829). In terms of health behaviors, the rate of positive behaviors was low (40.0%), and the probability of positive behaviors was significantly lower for students with nonmedical-related majors than for those with medical majors (OR = 0.579, 95% CI = 0.442–0.759). The results of the structural equation modeling analysis revealed that college students' perceptions of the perceived benefits of the HPV vaccine positively and directly affect their willingness to be vaccinated ($\beta = 0.290$, $p < 0.001$), and perceived severity has an indirect effect on their willingness to be vaccinated ($\beta = 0.198$, $p < 0.05$).

Conclusion: Although college students in ethnic minority areas have a high rate of HPV-related knowledge, their willingness to be actively vaccinated and their positive behaviors need to be improved. In addition, enhancing the levels of perceived severity and perceived efficacy among college students can help increase their willingness to receive the HPV vaccine.

KEYWORDS

HPV vaccine, vaccination intentions, health belief model, structural equation modeling, minority area

1 Introduction

Cervical cancer is the 4th most common malignant tumor threatening the health of the female reproductive system after breast, colorectal, and lung cancers (1). It is estimated that more than 58% of global cervical cancer cases occur in Asia, of which 18% occur in China (2). In 2020, there were 110,000 new cases of cervical cancer in China, with 60,000 fatalities (3). This makes the disease a major public health concern that endangers health of women in the country. Reports indicate a close relationship between high-risk human papillomavirus infection and the occurrence of cervical cancer (4). Sexual contact, including vaginal intercourse, oral sex, and anal sex, primarily transmits HPV and is a necessary condition for cervical cancer. Therefore, preventing HPV infection has become a key measure to reduce the risk of cervical cancer. In recent years, a number of studies have confirmed that vaccination against HPV vaccination can effectively prevent such infection, thus significantly reducing the risk of cervical cancer (5, 6). Studies have suggested that vaccination rates can reach more than 75% in some high-level-income countries; however, many countries still have low vaccination rates (6).

In China, the knowledge and vaccination rate of the HPV vaccine among school-aged college students in inland areas are generally low, with only 46.7% of college students having a good level of knowledge of cervical cancer prevention and treatment (7) and only 10.4% of students indicating that they have received the HPV vaccine (8). As a group with a high level of education, college students have more autonomy in terms of whether to receive the HPV vaccine (9). Studies have also confirmed that 68.8% of students regard a university education as one of the main ways to obtain information about vaccines (10). Therefore, the level of knowledge, willingness, and behavior of vaccination during university years plays an important role in promoting the popularization of HPV vaccines. In addition, premarital sex among college students is increasing, further exacerbating the potential risk of HPV infection. Understanding the level of HPV knowledge among college students and its impact on their vaccination willingness and behavior is of great public health significance. Factors are of enormous significance for the prevention and control of cervical cancer in China.

A variety of demographic factors may influence HPV knowledge, vaccination willingness, and vaccination behavior. Research indicates that various factors such as gender (11), grade (11), ethnicity (12), major (13), financial burden of vaccine costs (14), concerns about vaccine side effects (14), sexual behavior (14), and whether family members have a history of cervical cancer (12) significantly influence HPV-related knowledge, vaccination willingness, and vaccination behavior. Therefore, exploring the differences in HPV-related knowledge, willingness, and behavior among college students based on demographic factors is of great significance for formulating targeted strategies to promote cervical cancer prevention and control.

The health belief model (HBM) is a prevalent theoretical framework for evaluating and forecasting individual health behaviors. The model posits that an individual's readiness to engage in preventive health behaviors through both direct and indirect pathways (15). Perceived susceptibility, perceived severity, perceived barriers, and perceived benefits directly influence the direct pathway, which in turn influences the implementation of health behaviors. Perceived susceptibility refers to an individual's subjective assessment of the risk of a health problem or disease occurring; perceived severity refers to an

individual's subjective judgment of the possible harmful consequences of the health problem or disease; perceived barriers refers to the obstacles or difficulties an individual faces in adopting a health behavior; perceived benefits refers to the positive effects or benefits an individual believes may result from adopting a particular health behavior; and perceived benefits refers to the positive effects or benefits an individual believes may result from adopting a particular health behavior. Perceived barriers refers to the obstacles or difficulties faced by individuals in adopting health behaviors; perceived benefits refers to the positive impacts or benefits that individuals believe may be brought about by adopting specific health behaviors. Perceived severity indirectly influences the willingness to engage in health behaviors through mediating variables like perceived benefits or self-efficacy, forming the indirect pathway. Therefore, the health belief model not only focuses on direct cause-and-effect relationships but also reveals the complex interactions between constructs. In recent years, the HBM has shown to be a valid and reliable tool for assessing health beliefs, and it has been used in studies related to HPV vaccination intentions in several regions. A previous study in Italy showed that students are more likely to complete the vaccination program when they have a greater awareness of the benefits of the HPV vaccine (16); other studies have also indicated that there is a direct relationship between willingness to vaccinate, perceived sensitivity, and self-efficacy, with a negative correlation with perceived handicap (17). Thus, good health behaviors under the HBM framework are crucial for increasing the willingness to receive HPV vaccination and vaccine coverage and thus improving the level of public health awareness (18–20).

Studies have shown that due to cultural background, lifestyle, and socioeconomic conditions, the health awareness and behaviors of people in minority areas often differ significantly from those in other areas (21–23). In addition, medical resources in minority areas are relatively limited (24), and the health literacy rate is low, which may further affect the awareness and willingness to vaccinate against HPV.

The institution examined is situated in Yanbian Korean Autonomous Prefecture, a region in China characterized by a minority population, and operates as a full-time comprehensive public university. It is one of the colleges and universities previously established by the Communist Party of China in ethnic minority areas; thus, it has a large population of ethnic minority students and strong ethnic regional characteristics. Furthermore, it possesses the typical attributes of a comprehensive university and exhibits significant universality and representativeness, and can better represent the characteristics of the group of college students from minority universities in China. Thus, investigating the positive level of college students' knowledge, attitudes, and behaviors related to the HPV vaccine at this university is conducive to further understanding the status of college students in ethnic minority colleges and universities in China regarding HPV vaccination and its influencing factors in carrying out health education in a targeted manner.

Although in recent years, there have been a large number of studies on the factors affecting the willingness of Chinese college students to receive the HPV vaccine. However, most of the existing studies focus on urban areas or mainstream groups (10, 25–27), and there is limited research on the willingness of college students in ethnic minority areas to receive the HPV vaccine. On the basis of the above background, the current study aimed to not only investigate the knowledge, willingness to vaccinate, and positive behaviors of college students in ethnic minority areas in China with respect to the HPV vaccine and the related influencing factors, in order to fill the research

gap in this field. In addition, previous studies have mainly focused on the analysis of a single factor, while this study is based on the Health Belief Model, which comprehensively considers the impact of multiple factors on vaccination intentions. It uses a structural equation model to conduct an in-depth analysis, so as to provide a scientific basis for formulating more targeted vaccine promotion strategies and for future health education and HPV vaccine promotion among college students from minority groups in China.

2 Materials and methods

2.1 Study population and data collection

The target population of this study is full-time college students at a university in an ethnic minority area in China. Considering the limitations of the actual situation at the implementation stage of the sample survey, nonprobability sampling (convenience sampling) was used for the present investigation (27, 28). Nonprobability sampling transpires when the researcher chooses a subject for which information is readily accessible, reflecting the current circumstances. This implies that increasing the sample size can mitigate data bias stemming from individual differences, thereby enhancing the credibility and validity of the research findings. As a result, the survey collected data from a large sample of 1,388 respondents, with a valid response rate of 100%. There were no missing values in this study.

The online platform “Questionnaire Star” was used to create an electronic questionnaire, a presurvey was conducted (300 people), and after the questionnaire was refined, the investigators conducted a formal face-to-face survey from May 27 to June 27, 2024. The criteria for including study subjects were as follows: (1) full-time college students aged 18–26 years and (2) obtaining informed consent for participation in this research study and voluntary involvement in this survey. The exclusion criteria were delineated as follows: (1) people with allergic reactions to vaccines and (2) patients who were diagnosed with severe cognitive disorders.

This study set individuals aged 18–26 as the target population for the study, based on the following considerations: individuals in this age group are usually in an important period of sexual health education, and HPV vaccination still has a high preventive benefit. In addition, excluding individuals who have been diagnosed with severe cognitive impairment is to ensure that the questionnaire can be accurately understood and completed, thereby reducing potential data bias and improving the scientific nature of the research results.

2.2 Survey instruments and quality control

2.2.1 General information questionnaire

These factors include gender, ethnicity, urban/rural status, specialty, grade level, monthly living expenses, parents' education level, history of cervical cancer in family members or close friends, and history of sexual behavior.

2.2.2 Self-administered HPV and HPV vaccination knowledge and beliefs questionnaire

The questionnaires used to assess HPV-related knowledge, willingness, and behaviors were designed based on previous studies

and authoritative guidelines (29–31) and were finalized under expert review and guidance. This questionnaire consisted of 28 questions. There were 15 questions on HPV-related knowledge, all of which were single-choice, with one point given for a correct answer and no points given for an incorrect answer, for a maximum possible total of 15 points. The HPV vaccination willingness questionnaire had nine questions. A 5-point Likert scale was used to assign scores to the nine entries (very reluctant/strongly disagree = 1 point, very willing/strongly agree = 5 points), with a maximum possible score of 45 points. The Cronbach's α for this part of the scale was 0.924, indicating that it has good internal consistency. HPV vaccine-related behaviors were assigned a score (yes = 1 point, no = 0 points) for four questions, with a maximum possible score of 4 points. To more clearly distinguish between different levels of cognition, willingness, and behavior, this study divided continuous variables into dichotomous variables during data analysis (12, 14). We used the 80% quartile as a threshold and the percentile as a criterion for division. Health-related research has widely used this method (12, 28). In this study, a score of ≥ 12 on the knowledge level was defined as a high-awareness situation, with 80% used as the cutoff, and this population was defined as the aware population; a score of ≥ 36 on the health intention dimension was defined as positive intention; and a score of ≥ 3 on the health behavior dimension was defined as positive behavior. This dichotomous categorization helps classify the study population into high- and low-risk categories, which facilitates more targeted intervention designs for high- and low-risk groups at a later date.

2.2.3 Health beliefs scale

The Health Belief Model (HBM)-based study used structural equation modeling (SEM) to analyze the direct and indirect pathways of influence of the constructs (perceived benefits, perceived severity, perceived barriers, self-efficacy, etc.) on vaccination intentions. The main goal of SEM modeling is to explore the relationships among the core constructs of the HBM theory as well as their pathways of influence. Therefore, we limited the scope of the SEM analysis to the Health Belief Model's theoretical framework and excluded demographic variables. In descriptive and logistic regression analyses, demographic variables had big impacts on HPV knowledge, vaccination intentions, and behaviors. However, these impacts did not directly show how the HBM constructs were related to each other. Therefore, to avoid overly complex models or deviation from the HBM theoretical framework, we did not include demographic variables in the SEM model.

Therefore, this section extracts model entries of health beliefs associated with HPV vaccination through a systematic review of previous studies (32–35). Five dimensions were examined in terms of perceived susceptibility (2 entries), perceived severity (5 entries), perceived handicap (3 entries), self-efficacy (3 entries), and perceived benefit (3 entries). Each question was scored on a 5-point Likert scale ranging from “strongly disagree” to “strongly agree,” with higher scores indicating stronger beliefs about the individual's health (the “perceived obstructiveness” section was reverse scored, with “strongly disagree” scored as 5 and “strongly agree” scored as 1). We invited two epidemiologists to evaluate the applicability and scientific validity of the entries' content, and we conducted a pre-test among 300 students. The Cronbach's alpha values for the five dimensions of the scale were 0.716, 0.912, 0.779, 0.791, and 0.959, all of which indicated good reliability.

2.3 Data analysis methods

SPSS 26.0 software and Amos 24.0 software were used to organize and analyze the data. Descriptive analyses of the respondents were carried out via SPSS, and count data were expressed as component ratios. The influencing factors were examined using one-way analysis of variance and binary logistic regression. Structural equation modeling (SEM) via Amos was used for confirmatory factor analysis (CFA), path analysis, and mediation tests. A two-sided test was used, with a test level of $\alpha = 0.05$.

2.4 Ethical reflections

Informed consent was secured from all study participants; they were apprised of their right to withdraw from the study and assured that their data would remain strictly confidential and utilized solely for scientific analysis. The research was executed in accordance with the principles of the Declaration of Helsinki and received approval from the Institutional Review Board of Yanbian University (Ethics Code: 10187).

3 Results

3.1 General demographic characteristics

This study distributed 1,388 questionnaires, receiving 1,388 valid responses, resulting in a validity rate of 100%. Male and female students accounted for 38.83% (539) and 61.17% (849) of the sample, respectively. The vast majority of the students were Han Chinese (76.37%), with the type of residence being urban (72.05%) and nonmedically related (76.08%). A total of 30.12% were in their freshman year, and 26.01% were in their sophomore year; the monthly living expenses were predominantly 1,000–1999 RMB (47.41%). The literacy level of both parents was predominantly middle school (30.33, 29.32%). The vast majority of the students had family members who did not practice a medical-related profession (79.32%), had no family members with cervical cancer (89.19%), and were not sexually active (83.36%). The distribution of basic details is shown in [Table 1](#).

3.2 Current status of HPV in college students

3.2.1 Knowledge of HPV-related knowledge among college students

The total knowledge rate of the 1,388 university students with regard to HPV was 77.9%, and the mean knowledge score was 12.44 ± 2.237 , which suggests an excellent overall knowledge rate. The knowledge rates of the different questions ranged from 39.99 to 93.66%, as shown in [Table 2](#). Knowledge of the entry “HPV types 6 and 11 are not high-risk types” was the lowest, at 39.99%. While the knowledge rates of the “HPV infection may be asymptomatic” (60.73%) and “Man can also be vaccinated against HPV” (75.36%) entries were low, the knowledge rates of the remaining entries were good.

The overall rate of knowledge about HPV was good, with 77.95% of the total number of people being considered qualified in terms of knowledge. The results of the univariate analysis revealed differences in HPV-related knowledge among college students of different genders, ethnicities, majors, grades, monthly living expenses, parental literacy, family history of cervical cancer, and sex status. The results are shown in [Table 3](#). Among them, the rate of awareness was found to be significantly higher among women than among men; the knowledge rate of Han Chinese was determined to be markedly superior to that of other ethnic groups; the awareness rate was found to be higher among students with medical-related majors than among nonmedical students; knowledge rates were found to be higher among first-year research students than among students in the remaining grades; students with a monthly living wage of 2,000–2,999 were found to be more aware than the remaining class-living wage students; the knowledge rate of students whose parents' education level is specialized was found to be higher than that of students whose parents have other academic qualifications; and knowledge rates were found to be highest among students whose family members did not have cervical cancer (all p values < 0.05).

When we looked at the variables that were significantly different in the univariate analysis, we observed that being female and having a high level of knowledge about HPV were linked (OR = 1.824, 95% CI = 1.389–2.395). Moreover, there was an inverse relationship found between Korean ethnicity and a good level of knowledge compared with the findings for Han Chinese ethnicity (OR = 0.527, 95% CI = 0.368–0.754). There was an inverse relationship found between the population of nonmedically related specialties and knowledge (OR = 0.589, 95% CI = 0.415–0.835). In addition, there was a positive association found between those with monthly living expenses of 2,000–2,999 RMB and a good level of HPV knowledge compared with those with monthly living expenses of $< 1,000$ RMB (OR = 1.901, 95% CI = 1.008–3.585). There was a positive relationship found between those whose family members did not have cervical cancer and knowledge (OR = 3.094, 95% CI = 1.414–6.770), as shown in [Table 4](#).

3.2.2 College students' willingness to be vaccinated against HPV

The total positive willingness rate of college students to receive the HPV vaccine was 50.4%. The mean score of willingness to be vaccinated was 34.96 ± 7.187 , and the details of willingness to be vaccinated for each entry are shown in [Table 5](#).

According to the univariate analysis findings, there were variations found in university students' willingness to receive the HPV vaccine depending on their sex, ethnicity, type of residence, major, monthly living expenses, parents' literacy levels, family members' employment status in the medical field, and family members' cervical cancer status, as shown in [Table 6](#). In particular, female students were found to have higher attitude scores than male students; students living in towns were found to have higher attitude scores than those living in rural areas; the attitude scores of medical-related majors were found to be higher than those of nonmedical-related majors; the willingness to be vaccinated was found to be lowest among students with monthly living expenses $< 1,000$ RMB; the willingness to be vaccinated was found to be highest among students whose parents' education level was specialized; the willingness to be vaccinated was found to be higher among students whose family members were in medically related occupations than among those whose parents were in nonmedically related occupations;

TABLE 1 General demographic characteristics of survey respondents.

Participants		Frequency (n)	Percent (%)
Gender	Male	539	38.83
	Female	849	61.17
Ethnic group	Han	1,060	76.37
	Korean	202	14.55
	Other nationality	126	9.08
Town and country	Town	1,000	72.05
	Country	388	27.95
Major	Medical major	332	23.92
	Non-medical major	1,056	76.08
Grade	Freshman	418	30.12
	Sophomore	361	26.01
	Junior	287	20.68
	Senior	111	8.00
	Five-grade	14	1.01
	First-year graduate students	100	7.20
	Second-year graduate student	52	3.75
	Third-year graduate student	40	2.88
	Doctoral student	5	0.36
Monthly living expenses	<1,000	58	4.18
	1,000–1,999	658	47.41
	2,000–2,999	539	38.83
	3,000–3,999	87	6.27
	≥4,000	46	3.31
Father's education level	Illiteracy	25	1.80
	Secondary school	163	11.74
	Junior high school	421	30.33
	Senior high school	285	20.53
	Specialized training school	190	13.69
	Undergraduate	244	17.58
	Graduate student and above	60	4.32
Mother's education level	Illiteracy	35	2.52
	Secondary school	209	15.06
	Junior high school	407	29.32
	Senior high school	284	20.46
	Specialized training school	174	12.54
	Undergraduate	221	15.92
	Graduate student and above	58	4.18
Family members in medical-related professions	Yes	287	20.68
	No	1,101	79.32
Family member with cervical cancer	Yes	30	2.16
	No	1,238	89.19
	Currently unknown	120	8.65
Sexually active	Yes	231	16.64
	No	1,157	83.36

TABLE 2 Knowledge about HPV among college students in higher education.

Item	Number of people aware (n)	Awareness rate (%)
HPV infection may have no symptoms	843	60.73
HPV infection can cause diseases other than cervical cancer	1,237	89.12
HPV can be detected through screening	1,222	88.04
Proper condom use reduces HPV infections	1,291	93.01
Men do not get HPV	1,272	91.64
If you have never had sex, you do not have a chance of getting cervical cancer	1,265	91.14
HPV types 16 and 18 are high-risk types	1,193	85.95
HPV types 6 and 11 are not high-risk types	555	39.99
Do you know the meaning of “price”?	1,250	90.06
HPV vaccination can help prevent cervical cancer	1,288	92.80
Cervical screening is still needed after HPV vaccination	1,300	93.66
The best time to get the HPV vaccine is before first sex	1,184	85.30
HPV Vaccination Prevents 100% Cervical Cancer	1,119	80.62
The nine-valent vaccine protects against more types of HPV than the bivalent and quadrivalent vaccines	1,196	86.17
Men can also get the HPV vaccine	1,046	75.36

and the willingness to be vaccinated was found to be highest among students whose family members were suffering from cervical cancer.

Logistic regression analysis of the variables that were significantly different in the univariate analysis of HPV vaccination willingness revealed a significant positive relationship between females and the willingness to be actively vaccinated with the HPV vaccine (OR = 2.242, 95% CI = 1.777–2.829). Compared with the medically related population, the nonmedically related population was found to have an inverse relationship with the willingness to vaccinate (OR = 0.744, 95% CI = 0.570–0.970). In addition, compared with the population with monthly living expenses <1,000 RMB, the population with monthly living expenses of 2,000–2,999 RMB and 3,000–3,999 RMB were found to have a positive relationship with the willingness to receive the vaccination (OR = 1.926, 95% CI = 1.005–3.689; OR = 3.245, 95% CI = 1.488–7.077). Finally, having no family member in a medically related occupation was inversely associated with vaccination intentions (OR = 0.660, 95% CI = 0.493–0.883). All the above results were statistically significant, as shown in Table 7.

3.2.3 HPV vaccine-related behaviors of college students

The total positive behavior rate of college students toward the HPV vaccine was found to be 40.0%, with a mean score of 1.895 ± 1.456 for related behaviors, and only 25.43% (353) of those surveyed had already been vaccinated against HPV. A total of 62.18% (863) of the students said that they would publicize and recommend the HPV vaccine to others, and 52.81% (733) of the students said that they had inquired about the HPV vaccine; however, only 49.06% (681) had previously participated in HPV vaccine-related publicity activities (listening to lectures, watching videos).

The results of the univariate analysis revealed differences in the positive behavioral dimensions of the HPV vaccine among college students of different genders, types of residence, majors, grades, monthly living expenses, parental literacy, family members' status in

medically related occupations, family members' status of cervical cancer, and sexual behavior, as shown in Table 8. Logistic regression analysis of the variables that exhibited significant differences in the univariate analysis indicated that females were positively correlated with favorable HPV vaccine behavior (OR = 2.687, 95% CI = 2.088–3.457), and nonmedically related professions were found to be inversely associated with positive vaccination behavior (OR = 0.579, 95% CI = 0.442–0.759). In addition, compared with the presence of family members in medically related occupations, those without family members in medically related occupations were inversely associated with positive vaccination behavior (OR = 0.693, 95% CI = 0.518–0.926). Compared with those who had family members with cervical cancer, those who had no family members with cervical cancer and those who were unsure about the presence of cervical cancer were found to be inversely associated with positive vaccination behavior (OR = 0.363, 95% CI = 0.160–0.824; OR = 0.346, 95% CI = 0.140–0.852). Finally, those who had not had sexual intercourse were found to have an inverse relationship positive vaccination behavior (OR = 0.651, 95% CI = 0.470–0.902). The results are shown in Table 9.

3.2.4 Status of the health belief model

The evaluation of participants in this study utilized the five dimensions of the health belief model: perceived benefit, perceived severity, self-efficacy, perceived handicap, and perceived susceptibility.

The scores for each dimension of willingness to receive the vaccination were in the same order as the overall perceptions. The scores of perceived severity (3.58 ± 1.09), self-efficacy (3.32 ± 1.00), and perceived benefit (3.86 ± 1.14) were greater for those with positive vaccination attitudes than for those with negative attitudes (3.38 ± 0.76 ; 3.13 ± 0.65 ; and 3.51 ± 0.78 , respectively), and the differences were statistically significant (all $p < 0.05$). The score of negative vaccination willingness (3.14 ± 0.73) was greater than that of cheerful vaccination willingness (2.96 ± 1.08) for the perceptual obstructive dimension, and

TABLE 3 Univariate analysis of knowledge about HPV among college students with different demographic characteristics.

Participants		Number of people aware (%)	χ^2	p	Partial eta squared
Gender	Male	383 (71.06)	24.386	<0.001*	0.018
	Female	699 (82.33)	–	–	–
Ethnic group	Han	854 (80.57)	18.684	<0.001*	0.013
	Korean	137 (67.82)	–	–	–
	Other nationality	91 (72.22)	–	–	–
Town and country	Town	781 (56.27)	0.044	0.833	0.000
	Country	301 (21.69)	–	–	–
Major	Medical major	278 (83.73)	8.486	0.004*	0.006
	Non-medical major	804 (76.14)	–	–	–
Grade	Freshman	323 (77.27)	16.020	0.042*	0.012
	Sophomore	270 (74.79)	–	–	–
	Junior	218 (75.96)	–	–	–
	Senior	93 (83.78)	–	–	–
	Five-grade	12 (85.71)	–	–	–
	First-year graduate students	86 (86.00)	–	–	–
	Second-year graduate student	44 (84.62)	–	–	–
	Third-year graduate student	34 (85.00)	–	–	–
	Doctoral student	2 (40.00)	–	–	–
Monthly living expenses	<1,000	34 (58.62)	22.571	<0.001*	0.016
	1,000–1,999	519 (78.88)	–	–	–
	2,000–2,999	436 (80.89)	–	–	–
	3,000–3,999	64 (73.56)	–	–	–
	≥4,000	29 (63.04)	–	–	–
Father's education level	Illiteracy	13 (52.00)	23.108	<0.001*	0.017
	Secondary school	130 (79.75)	–	–	–
	Junior high school	336 (79.81)	–	–	–
	Senior high school	215 (75.44)	–	–	–
	Specialized training school	159 (83.68)	–	–	–
	Undergraduate	191 (78.28)	–	–	–
	Graduate student and above	38 (63.33)	–	–	–
Mother's education level	Illiteracy	19 (54.29)	35.135	<0.001*	0.025
	Secondary school	165 (78.95)	–	–	–
	Junior high school	321 (78.87)	–	–	–
	Senior high school	224 (78.87)	–	–	–
	Specialized training school	143 (82.18)	–	–	–
	Undergraduate	179 (81.00)	–	–	–
	Graduate student and above	31 (53.45)	–	–	–
Family members in medical-related professions	Yes	224 (16.14)	0.002	0.965	0.000
	No	858 (61.82)	–	–	–
Family member with cervical cancer	Yes	16 (53.33)	14.389	<0.001*	0.010
	No	980 (79.16)	–	–	–
	Currently unknown	86 (71.66)	–	–	–
Sexually active	Yes	176 (12.68)	0.501	0.479	0.000
	No	906 (65.27)	–	–	–

* $p < 0.05$.

TABLE 4 Multifactorial logistic regression analysis of HPV-related knowledge among college students in higher education.

Participants		β value	SE value	Wald χ^2 value	p value	OR value (95%CI)
Gender	Male	–	–	–	–	1.00
	Female	0.601	0.139	18.677	<0.001*	1.824 (1.389 ~ 2.395)
Ethnic group	Han	–	–	–	–	1.00
	Korean	–0.641	0.183	12.281	<0.001*	0.527 (0.368 ~ 0.754)
	Other nationality	–0.418	0.228	3.344	0.067	0.659 (0.421 ~ 1.03)
Major	Medical major	–	–	–	–	1.00
	Non–medical major	–0.529	0.178	8.832	0.003*	0.589 (0.415 ~ 0.835)
Monthly living expenses	<1,000	–	–	–	–	1.00
	1,000–1,999	0.559	0.314	3.172	0.075	1.748 (0.945 ~ 3.233)
	2,000–2,999	0.642	0.324	3.935	0.047*	1.901 (1.008 ~ 3.585)
	3,000–3,999	0.531	0.4	1.757	0.185	1.700 (0.776 ~ 3.725)
	≥4,000	0.228	0.46	0.245	0.621	1.256 (0.510 ~ 3.091)
Father's education level	Illiteracy	–	–	–	–	1.00
	Secondary school	0.3	0.574	0.273	0.601	1.350 (0.438 ~ 4.161)
	Junior high school	0.158	0.563	0.079	0.779	1.172 (0.389 ~ 3.533)
	Senior high school	0.299	0.577	0.268	0.605	1.348 (0.435 ~ 4.176)
	Specialized training school	–0.035	0.595	0.003	0.954	0.966 (0.301 ~ 3.103)
	Undergraduate	–0.021	0.596	0.001	0.972	0.980 (0.305 ~ 3.148)
	Graduate student and above	0.755	0.687	1.208	0.272	2.128 (0.553 ~ 8.188)
Mother's education level	Illiteracy	–	–	–	–	1.00
	Secondary school	0.016	0.493	0.001	0.973	1.017 (0.387 ~ 2.673)
	Junior high school	–0.558	0.483	1.338	0.247	0.572 (0.222 ~ 1.474)
	Senior high school	–0.535	0.499	1.152	0.283	0.586 (0.220 ~ 1.556)
	Specialized training school	–0.814	0.519	2.46	0.117	0.443 (0.160 ~ 1.225)
	Undergraduate	–0.821	0.52	2.493	0.114	0.440 (0.159 ~ 1.219)
	Graduate student and above	–1.117	0.629	3.152	0.076	0.327 (0.095 ~ 1.123)
Family member with cervical cancer	Yes	–	–	–	–	1.00
	No	1.13	0.399	7.995	0.005*	3.094 (1.414 ~ 6.770)
	Currently unknown	0.817	0.447	3.332	0.068	2.263 (0.942 ~ 5.439)

* $p < 0.05$.

TABLE 5 HPV vaccination willingness of college students in tertiary institutions.

Item	Number of negative attitudes (%)
Are you interested in learning about the HPV vaccine	511 (36.82)
Do you believe in the preventive effects of the HPV vaccine?	337 (24.28)
Do you believe in the safety of the HPV vaccine?	368 (26.51)
Your acceptance of the price of imported bivalent HPV vaccine (about 2,000)	672 (48.41)
Your acceptance of the price of imported quadrivalent HPV vaccine (about 3,000)	709 (51.08)
Your acceptance of the price of imported 9-valent HPV vaccine (about 4,000)	721 (51.95)
Would you like to be vaccinated against HPV	440 (31.70)
Would you like your friends and relatives to be vaccinated against HPV?	347 (25.00)
Would you be willing to get the HPV vaccine if it were included in the national health insurance?	300 (21.61)

TABLE 6 Univariate analysis of HPV vaccination intention among college students with different demographic characteristics.

Participants		Mean score $\pm$ SD value	T/F value	p value	Cohen's d/ η^2
Gender	Male	33.07 $\pm$ 6.990	-7.985	<0.001*	-0.440
	Female	36.16 $\pm$ 7.055	-	-	-
Ethnic group	Han	35.18 $\pm$ 7.129	5.062	0.006*	0.007
	Korean	33.49 $\pm$ 7.384	-	-	-
	Other nationality	35.47 $\pm$ 7.128	-	-	-
Town and country	Town	35.29 $\pm$ 7.326	2.883	0.004*	0.166
	Country	34.10 $\pm$ 6.749	-	-	-
Major	Medical major	35.68 $\pm$ 7.292	2.090	0.037*	0.131
	Non-medical major	34.73 $\pm$ 7.142	-	-	-
Grade	Freshman	35.20 $\pm$ 7.513	0.659	0.728	0.004
	Sophomore	34.53 $\pm$ 7.196	-	-	-
	Junior	35.30 $\pm$ 7.164	-	-	-
	Senior	34.91 $\pm$ 6.907	-	-	-
	Five-grade	33.36 $\pm$ 6.008	-	-	-
	First-year graduate students	35.40 $\pm$ 6.208	-	-	-
	Second-year graduate student	34.62 $\pm$ 5.852	-	-	-
	Third-year graduate student	34.48 $\pm$ 7.693	-	-	-
	Doctoral student	31.00 $\pm$ 15.232	-	-	-
Monthly living expenses	<1,000	30.74 $\pm$ 9.128	10.056	<0.001*	0.028
	1,000-1,999	34.39 $\pm$ 6.588	-	-	-
	2,000-2,999	35.82 $\pm$ 7.060	-	-	-
	3,000-3,999	37.01 $\pm$ 7.679	-	-	-
	$\geq$ 4,000	34.46 $\pm$ 9.968	-	-	-
Father's education level	Illiteracy	31.36 $\pm$ 11.011	4.658	<0.001*	0.020
	Secondary school	34.26 $\pm$ 6.707	-	-	-
	Junior high school	34.40 $\pm$ 6.650	-	-	-
	Senior high school	34.77 $\pm$ 7.074	-	-	-
	Specialized training school	36.88 $\pm$ 6.617	-	-	-
	Undergraduate	35.70 $\pm$ 7.570	-	-	-
	Graduate student and above	34.10 $\pm$ 9.244	-	-	-
Mother's education level	Illiteracy	31.46 $\pm$ 9.736	4.754	<0.001*	0.020
	Secondary school	33.76 $\pm$ 6.644	-	-	-
	Junior high school	35.00 $\pm$ 6.662	-	-	-
	Senior high school	34.43 $\pm$ 7.081	-	-	-
	Specialized training school	36.23 $\pm$ 6.648	-	-	-
	Undergraduate	36.23 $\pm$ 7.644	-	-	-
	Graduate student and above	35.05 $\pm$ 9.441	-	-	-
Family members in medical-related professions	Yes	36.49 $\pm$ 7.185	4.086	<0.001*	0.271
	No	34.56 $\pm$ 7.137	-	-	-
Family member with cervical cancer	Yes	36.00 $\pm$ 8.542	5.256	0.005*	0.008
	No	35.13 $\pm$ 7.033	-	-	-
	Currently unknown	32.98 $\pm$ 8.094	-	-	-
Sexually active	Yes	34.71 $\pm$ 7.113	-0.588	0.556	-0.042
	No	35.01 $\pm$ 7.204	-	-	-

* $p < 0.05$.

TABLE 7 Multifactorial logistic regression analysis of HPV vaccination willingness among college students in higher education.

Participants		β value	SE value	Wald χ^2 value	p value	OR value (95%CI)
Gender	Male	–	–	–	–	1.00
	Female	0.807	0.119	46.354	<0.001*	2.242 (1.777 ~ 2.829)
Town and country	Town	–	–	–	–	1.00
	Country	–0.057	0.144	0.157	0.692	0.944 (0.712 ~ 1.253)
Major	Medical major	–	–	–	–	1.00
	Non-medical major	–0.296	0.135	4.777	0.029*	0.744 (0.570 ~ 0.970)
Monthly living expenses	<1,000	–	–	–	–	1.00
	1,000–1,999	0.616	0.325	3.584	0.058	1.851 (0.979 ~ 3.501)
	2,000–2,999	0.655	0.332	3.903	0.048*	1.926 (1.005 ~ 3.689)
	3,000–3,999	1.177	0.398	8.755	0.003*	3.245 (1.488 ~ 7.077)
	≥4,000	0.859	0.45	3.637	0.057	2.361 (0.976 ~ 5.708)
Father's education level	Illiteracy	–	–	–	–	1.00
	Secondary school	–0.263	0.573	0.21	0.647	0.769 (0.250 ~ 2.364)
	Junior high school	–0.135	0.561	0.058	0.81	0.874 (0.291 ~ 2.625)
	Senior high school	–0.301	0.575	0.275	0.6	0.740 (0.240 ~ 2.283)
	Specialized training school	0.073	0.594	0.015	0.902	1.076 (0.336 ~ 3.443)
	Undergraduate	0.038	0.593	0.004	0.948	1.039 (0.325 ~ 3.322)
	Graduate student and above	–0.8	0.685	1.364	0.243	0.450 (0.118 ~ 1.720)
Mother's education level	Illiteracy	–	–	–	–	1.00
	Secondary school	–0.086	0.491	0.031	0.861	0.917 (0.350 ~ 2.401)
	Junior high school	0.462	0.48	0.924	0.336	1.587 (0.619 ~ 4.070)
	Senior high school	0.411	0.497	0.683	0.408	1.508 (0.569 ~ 3.993)
	Specialized training school	0.601	0.519	1.345	0.246	1.825 (0.660 ~ 5.042)
	Undergraduate	0.662	0.52	1.62	0.203	1.938 (0.700 ~ 5.369)
	Graduate student and above	0.857	0.629	1.856	0.173	2.355 (0.687 ~ 8.078)
Family member with cervical cancer	Yes	–	–	–	–	1.00
	No	–0.150	0.396	0.143	0.705	0.861 (0.396 ~ 1.870)
	Currently unknown	–0.645	0.438	2.168	0.141	0.525 (0.222 ~ 1.238)
Family members in medical-related professions	Yes	–	–	–	–	1.00
	No	–0.416	0.149	7.828	0.005*	0.660 (0.493 ~ 0.883)

* $p < 0.05$.

the difference was statistically significant ($p < 0.05$). There was no statistically significant difference found between the two scores on the perceived susceptibility dimension ($p > 0.05$) (see Table 10).

3.3 Confirmatory factor analysis

This research investigated six variables: willingness to vaccinate, perceived susceptibility, perceived severity, perceived disability, self-efficacy, and perceived benefit. The model had a KMO value of 0.915 and a Bartlett test of sphericity value of <0.01, which was statistically

significant at the $\alpha = 0.05$ level, indicating that it was possible to perform a factor analysis. Perceived severity (with five observations) was the exogenous latent variable in this survey. Perceived susceptibility (with five observations), perceived handicap (with two observations), self-efficacy (with three observations), perceived benefit (with three observations), and willingness to be vaccinated (with six observations) were the endogenous latent variables. A validated factor analysis was conducted via AMOS 24.0 software. The mean of the six factors corresponding to the variance extraction (AVE) values was more significant than 0.5. The combined reliability (CR) values were higher than 0.7, and the current data had good convergent validity.

TABLE 8 Univariate analysis of HPV vaccine-related behaviors among college students with different demographic characteristics.

Participants		Number of positive behaviors (%)	χ^2	p	Partial eta squared
Gender	Male	149 (27.64)	56.554	<0.001*	0.041
	Female	407 (47.94)	–	–	–
Ethnic group	Han	429 (30.91)	0.399	0.819	0.000
	Korean	77 (5.55)	–	–	–
	Other nationality	50 (3.60)	–	–	–
Town and country	Town	422 (42.20)	6.838	0.009*	0.005
	Country	134 (34.54)	–	–	–
Major	Medical major	172 (51.81)	25.089	<0.001*	0.018
	Non-medical major	384 (36.36)	–	–	–
Grade	Freshman	172 (41.15)	17.299	0.027*	0.012
	Sophomore	123 (34.07)	–	–	–
	Junior	117 (40.77)	–	–	–
	Senior	40 (36.04)	–	–	–
	Five-grade	8 (57.14)	–	–	–
	First-year graduate students	50 (50.00)	–	–	–
	Second-year graduate student	22 (42.31)	–	–	–
	Third-year graduate student	20 (50.00)	–	–	–
	Doctoral student	4 (80.00)	–	–	–
Monthly living expenses	<1,000	16 (27.59)	17.534	0.002*	0.013
	1,000–1,999	238 (36.17)	–	–	–
	2,000–2,999	234 (43.41)	–	–	–
	3,000–3,999	46 (52.87)	–	–	–
	≥4,000	22 (47.83)	–	–	–
Father's education level	Illiteracy	9 (36.00)	28.982	<0.001*	0.021
	Secondary school	42 (25.77)	–	–	–
	Junior high school	153 (36.34)	–	–	–
	Senior high school	116 (40.70)	–	–	–
	Specialized training school	93 (48.95)	–	–	–
	Undergraduate	114 (46.72)	–	–	–
	Graduate student and above	29 (48.33)	–	–	–
Mother's education level	Illiteracy	12 (34.29)	23.416	<0.001*	0.017
	Secondary school	65 (31.10)	–	–	–
	Junior high school	148 (36.36)	–	–	–
	Senior high school	115 (40.49)	–	–	–
	Specialized training school	78 (44.83)	–	–	–
	Undergraduate	105 (47.51)	–	–	–
	Graduate student and above	33 (56.90)	–	–	–
Family members in medical-related professions	Yes	149 (51.92)	21.191	<0.001*	0.015
	No	407 (36.97)	–	–	–
Family member with cervical cancer	Yes	20 (66.67)	10.583	0.005*	0.008
	No	495 (39.98)	–	–	–
	Currently unknown	41 (34.17)	–	–	–
Sexually active	Yes	110 (47.62)	6.599	0.010*	0.005
	No	446 (38.55)	–	–	–

* $p < 0.05$.

TABLE 9 Multifactorial logistic regression analysis of HPV vaccine-related behaviors among college students in higher education.

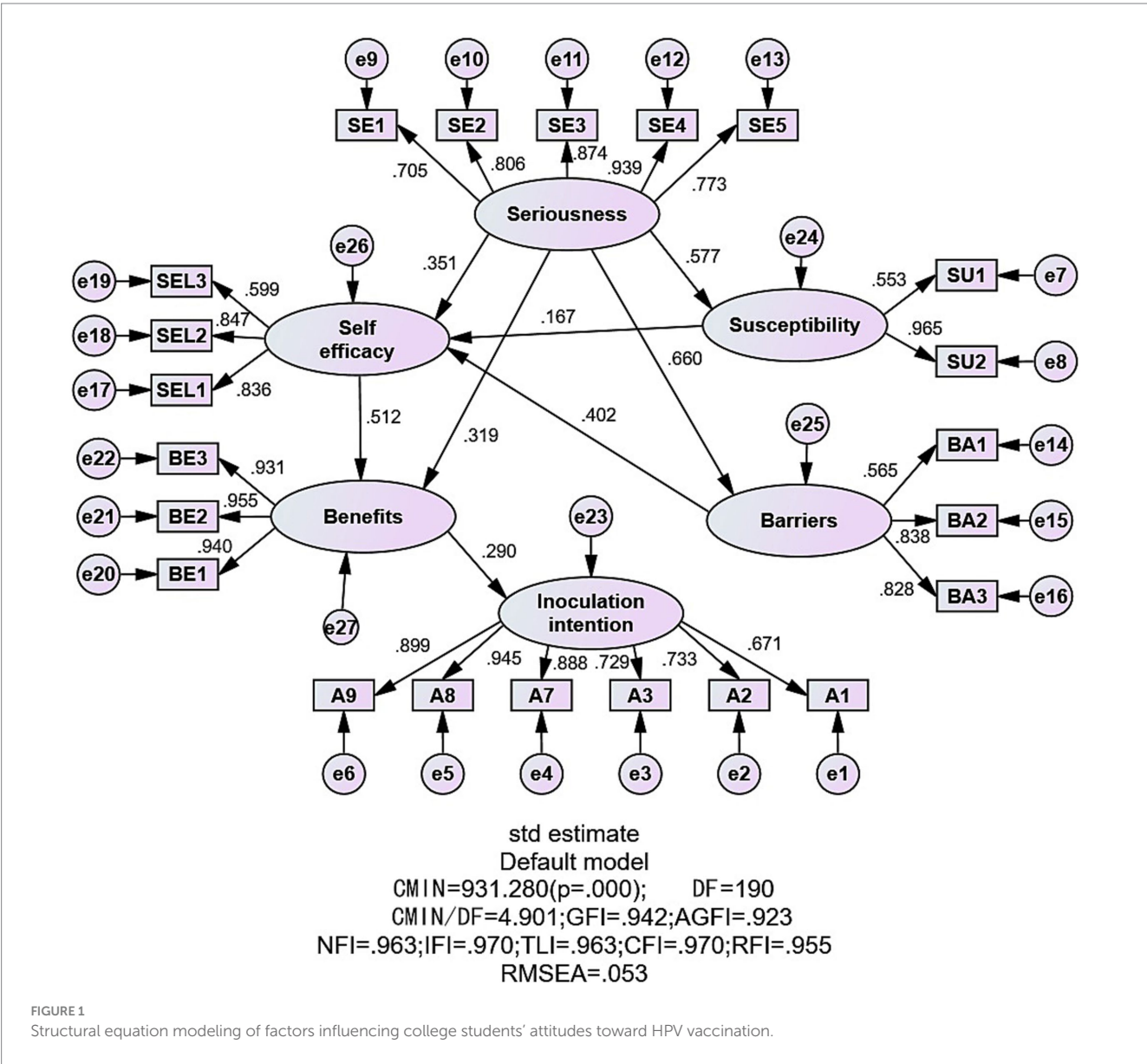
Participants		β value	SE value	Wald χ^2 value	p value	OR value (95%CI)
Gender	Male	–	–	–	–	1.00
	Female	0.988	0.129	58.981	<0.001*	2.687 (2.088 ~ 3.457)
Town and country	Town	–	–	–	–	1.00
	Country	0.079	0.15	0.274	0.601	1.082 (0.806 ~ 1.453)
Major	Medical major	–	–	–	–	1.00
	Non-medical major	–0.546	0.138	15.597	<0.001*	0.579 (0.442 ~ 0.759)
Grade	Freshman	–	–	–	–	1.00
	Sophomore	–0.254	0.158	2.574	0.109	0.776 (0.569 ~ 1.058)
	Junior	0.072	0.166	0.187	0.666	1.075 (0.776 ~ 1.489)
	Senior	–0.146	0.236	0.384	0.536	0.864 (0.544 ~ 1.373)
	Five-grade	0.344	0.584	0.346	0.556	1.41 (0.449 ~ 4.430)
	First-year graduate students	0.395	0.243	2.636	0.104	1.485 (0.921 ~ 2.393)
	Second-year graduate student	–0.049	0.317	0.023	0.878	0.953 (0.511 ~ 1.775)
	Third-year graduate student	0.031	0.356	0.008	0.931	1.031 (0.514 ~ 2.070)
	Doctoral student	1.158	1.189	0.949	0.330	3.183 (0.310 ~ 32.715)
Monthly living expenses	<1,000	–	–	–	–	1.00
	1,000–1,999	0.314	0.338	0.864	0.352	1.369 (0.706 ~ 2.655)
	2,000–2,999	0.408	0.345	1.399	0.237	1.503 (0.765 ~ 2.954)
	3,000–3,999	0.699	0.405	2.982	0.084	2.011 (0.910 ~ 4.444)
	≥4,000	0.286	0.465	0.379	0.538	1.331 (0.535 ~ 3.310)
Father's education level	Illiteracy	–	–	–	–	1.00
	Secondary school	–0.546	0.603	0.821	0.365	0.579 (0.178 ~ 1.888)
	Junior high school	–0.019	0.587	0.001	0.974	0.981 (0.310 ~ 3.100)
	Senior high school	0.166	0.601	0.076	0.782	1.181 (0.363 ~ 3.836)
	Specialized training school	0.451	0.62	0.53	0.467	1.570 (0.466 ~ 5.292)
	Undergraduate	0.254	0.619	0.168	0.682	1.289 (0.383 ~ 4.332)
	Graduate student and above	–0.442	0.714	0.382	0.536	0.643 (0.159 ~ 2.607)
Mother's education level	Illiteracy	–	–	–	–	1.00
	Secondary school	0.143	0.514	0.078	0.78	1.154 (0.422 ~ 3.158)
	Junior high school	0.031	0.504	0.004	0.951	1.032 (0.384 ~ 2.772)
	Senior high school	0.130	0.520	0.063	0.802	1.139 (0.411 ~ 3.159)
	Specialized training school	0.039	0.543	0.005	0.943	1.040 (0.359 ~ 3.012)
	Undergraduate	0.187	0.542	0.119	0.730	1.205 (0.417 ~ 3.484)
	Graduate student and above	1.092	0.653	2.793	0.095	2.98 (0.828 ~ 10.721)
Family member with cervical cancer	Yes	–	–	–	–	1.00
	No	–0.367	0.148	6.133	0.013*	0.693 (0.518 ~ 0.926)
	Currently unknown	–	–	–	–	1.00
Sexually active	Yes	–1.012	0.418	5.865	0.015*	0.363 (0.160 ~ 0.824)
	No	–1.063	0.46	5.329	0.021*	0.346 (0.140 ~ 0.852)
Family member with cervical cancer	Yes	–	–	–	–	1.00
	No	–0.429	0.166	6.653	0.010*	0.651 (0.470 ~ 0.902)

* $p < 0.05$.

TABLE 10 Comparison of health belief dimension scores of different HPV vaccination intendants.

	Overall score	Negative intentions score (<36)	Active volunteer score (≥36)	T/F	p
Susceptibility	2.79 ± 1.04	2.76 ± 0.89	2.83 ± 1.16	1.217	0.224
Perceived severity	3.48 ± 0.95	3.38 ± 0.76	3.58 ± 1.09	3.915	<0.001*
Perceptual disability	3.05 ± 0.93	3.14 ± 0.73	2.96 ± 1.08	−3.615	<0.001*
Self-efficacy	3.23 ± 0.85	3.13 ± 0.65	3.32 ± 1.00	4.173	<0.001*
Perceived benefits	3.69 ± 1.00	3.51 ± 0.78	3.86 ± 1.14	6.680	<0.001*

**p* < 0.05.



3.4 Construction of structural equation modeling

Based on the theoretical framework of the health belief model, the six factors obtained from the exploratory factor analysis were used as latent variables to construct a structural equation model. The model

was continuously revised and fitted via the excellent likelihood method until the constructed model fit the measurement data better. The model was finalized as shown in Figure 1. The modified model fit indices all met the corresponding reference standards, $\chi^2/df = 4.901$ (<5); GFI = 0.942, AGFI = 0.923, NFI = 0.963, IFI = 0.970, TLI = 0.963, CFI = 0.970, RFI = 0.955 (All>0.90); RMSEA = 0.053 (<0.08). The

TABLE 11 Structural equation modeling path coefficients.

Pathway			Unstandardized path coefficient estimates	SE	CR	<i>p</i> value	Standardized path coefficient estimates
Susceptibility	<---	Seriousness	0.502	0.038	13.539	<0.001*	0.577
Barriers	<---	Seriousness	0.562	0.034	16.357	<0.001*	0.660
Benefits	<---	Seriousness	0.228	0.038	6.020	<0.001*	0.167
Self_efficacy	<---	Seriousness	0.559	0.052	10.749	<0.001*	0.402
Self_efficacy	<---	Susceptibility	0.416	0.044	9.420	<0.001*	0.351
Self_efficacy	<---	Barriers	0.566	0.041	13.783	<0.001*	0.512
Benefits	<---	Self_efficacy	0.419	0.046	9.193	<0.001*	0.319
Inoculation_intention	<---	Benefits	0.203	0.020	10.169	<0.001*	0.290

**p* < 0.05.

TABLE 12 Intermediary test results.

Typology	Intermediary path	Standardized estimates	Efficiency ratio	SE	Boot 95%CI	<i>p</i>
Intermediary effect	Seriousness – Self_efficacy – Benefits – Inoculation_intention	0.052	26.26%	0.012	0.033–0.082	<0.001*
	Seriousness – Benefits – Inoculation_intention	0.092	46.46%	0.018	0.059–0.131	<0.001*
	Seriousness – Susceptibility – Self_efficacy – Benefits – Inoculation_intention	0.014	7.07%	0.004	0.008–0.023	<0.001*
	Seriousness – Barriers – Self_efficacy – Benefits – Inoculation_intention	0.039	19.70%	0.007	0.028–0.056	<0.001*
Total effect	–	0.198	100.00%	–	–	–

**p* < 0.05.

model was subjected to path analysis; the results are shown in Table 11. The factor that directly influences the willingness to vaccinate against HPV is the perceived benefit, which increases by 0.29 standard units for every 1 standard unit increase in perceived benefit.

In addition, perceived severity does not directly affect willingness to vaccinate but can indirectly affect perceived susceptibility, perceived handicap, self-efficacy, and perceived benefit. Based on the identified model, the mediating roles of perceived ease of use, perceived barriers, self-efficacy, and perceived benefits in the model were analyzed via the bias-corrected bootstrap procedure, with 5,000 repetitive samples and mediation effect tests and confidence interval estimation performed, which indicated a significant indirect effect as the 95% confidence interval did not include zero. As shown in Table 12, the indirect and total effects of perceived severity on willingness to vaccinate had *p* values <0.05, with perceived benefit (95% CI = 0.059–0.131) playing a partial mediating role and self-efficacy-perceived benefit (95% CI = 0.033–0.082) and perceived susceptibility-self-efficacy-perceived benefit (95% CI = 0.008–0.023) and perceived handicap-self-efficacy-perceived benefit (95% CI = 0.028–0.056) acting as chain mediators.

4 Discussion

4.1 College students' knowledge, willingness to vaccinate, and behavior regarding HPV and the HPV vaccine

In recent years, cervical cancer has been a significant public health problem that threatens women's health globally, and the usage of the HPV vaccine is the key to preventing cervical cancer. Thus, our study conducted an in-depth investigation of the current status of HPV vaccination among college students in ethnic minority areas.

The results of this study revealed that the participants' overall knowledge about HPV was good. Most of the students had a good grasp of vaccine-related knowledge but poor knowledge about the symptoms of HPV infection and the high-risk types of the virus. The reason for this phenomenon may be that the type of information disseminated on the internet is mainly at the level of vaccination and modes of infection, with a relative scarcity of pertinent academic knowledge being disseminated; thus, the general public does not have sufficient awareness of more in-depth academic knowledge (36, 37).

Studies have shown that overall knowledge is greater in women than in men, which is consistent with the findings of many national studies (38, 39); this difference may stem from a greater level of concern about health issues among women. Considering that HPV infection is associated mainly with cervical cancer, which occurs predominantly in women, this may explain the greater level of concern for such knowledge among women. The results revealed that students of Korean ethnicity had a lower level of positive HPV knowledge than did students of Han Chinese ethnicity. This result may be related to differences in the ethnic cultures. Some studies have suggested that cultural factors may hinder the discussion and acceptance of HPV (40). Moreover, China's publicity for HPV-related knowledge is generally in the form of the Chinese language, which is a nonnative language for Korean college students; thus, Korean college students may have poorer comprehension level of the language, which may also be a potential reason for the significantly lower knowledge rate of Koreans than that of Han Chinese regarding HPV knowledge. The knowledge rate of college students in medical-related majors was found to be higher than that of students in nonmedical-related majors, possibly because medical majors have more corresponding access to information, which can make it easier for them to learn the corresponding medical-related knowledge; this is consistent with the results of other studies (41, 42). Compared with monthly living expenses of <1,000 RMB, living expenses of 2,000–2,999 RMB had a positive effect on HPV knowledge among college students; previous evidence (43) has suggested that family income is an essential factor influencing young people's acceptance of the HPV vaccine, which suggests that better-off students may be more concerned about their health due to family support and richer educational resources and are more likely to have access to HPV-related information sources and thus have higher HPV knowledge rates than their counterparts. Therefore, it is essential to focus on specific groups, such as men, Korean individuals, people who do not work in medicine, and people whose monthly living costs are less than 1,000 RMB, when making health education and promotion plans to help these individuals learn more about HPV.

The survey results revealed that the rate of cheerful willingness of college students to be vaccinated against HPV was moderate. Approximately half of these college students had negative attitudes about the import prices of HPV vaccines (including bivalent, quadrivalent, and nine-valent). A previous study of Chinese female college students revealed that the vaccine price is an essential factor affecting vaccination rates (44), which suggests that high vaccine prices may be one of the reasons hindering college students' willingness to be actively vaccinated. In addition, college students may have less knowledge about the importance and long-term benefits of the HPV vaccine, and a lack of proper understanding of the price of the vaccine investment may also contribute to the low rate of positive intentions. It was found that females had significantly higher positive willingness scores than males and were 2.242 times more likely to be positively willing to be vaccinated with the HPV vaccine than males were; these results show that female students are more interested in vaccination, which is in line with the results of other studies (45). The fact that nonmedical students lack a background in medical knowledge and do not have easy access to pertinent vaccine information (41), which in turn causes them to have doubts about the efficacy and safety of vaccines, may help explain why having a nonmedical major negatively affects one's positive intention. The study indicated that college students with higher living expenses

(2,000–2,999 RMB and 3,000–3,999 RMB per month) had a greater willingness to be vaccinated against HPV than did those with living expenses of <1,000 RMB; this result that is consistent with findings from other studies (31). There is existing evidence that the cost of vaccination is one of the most common barriers to receiving the vaccine (46). In the present study, the probability of positive vaccination intention was found to be significantly lower among those with no family members in medically related occupations than among those with family members in medically related occupations. Healthcare workers and family members are the most influential sources of information (47); thus, family members who work in medically related occupations may be trusted more highly because of their medical background and professional status. The information and opinions that these individuals convey may have a more positive effect on family members. Therefore, improving attitudes toward immunization interventions in different social roles is necessary.

The results revealed that the examined college students had a poor rate of total positive behavior toward the HPV vaccine, with only 25.43% having already received the HPV vaccine. Among them, women's positive behavior regarding the HPV vaccine was 2.687 times greater than men's positive behavior. Previous studies have noted that men are less receptive to the 9-valent HPV vaccine, with approximately 54.95% of them expressing reluctance to receive it (48). Sociocultural factors related to gender may be responsible for this phenomenon. Given that cervical cancer is the primary health risk women may encounter, men typically perceive a lower risk of HPV infection than women, leading to a generally lower willingness and behavior for vaccination. Further research is necessary to validate this relationship, even though these results align with sociocultural factors associated with gender differences. The probability of positive behavior was found to be significantly lower among those who did not have or were unsure if they had friends of family members with cervical cancer than among college students with friends or relatives who had cervical cancer. It has been shown previously that having a relative or friend with cervical cancer is a positive influencing factor for HPV vaccination (31), which suggests that the probability of adopting positive behaviors is more significant when its severity is recognized. The results indicated that sexually active college students are more inclined to engage in positive behaviors, such as vaccination, aligning with the conclusions of other studies (27, 31). Other studies have indicated that women who have never been sexually active are less likely to receive vaccinations than sexually active women are (49), which may suggest that receiving sex education may be an essential way to increase positive behaviors. Therefore, there is a need to emphasize the importance of vaccination through such education.

4.2 Influence of health belief patterns on positive vaccination intentions

We used the situation of university students' willingness to be vaccinated in ethnic minority areas in China, combined it with the health belief model, and developed structural equation modeling to explore the pathways influencing the willingness to receive HPV vaccination. The current study revealed that the health belief of college students is in a good state and that there is a positive association between the level of health belief and the willingness to receive HPV vaccination; this means that those who have a cheerful desire to receive vaccination also have stronger health beliefs.

According to this study, perceived benefits directly impact willingness to vaccinate, and both factors change in the same direction. As a result, college students are more likely to demonstrate a cheerful desire to vaccinate, and the perceived benefits are more substantial (50). One previous study found that a video-based behavioral intervention effectively increased parents' and children's willingness to be vaccinated against HPV (51). Therefore, to increase the willingness to vaccinate, we suggest increasing the efforts of public education and increasing the forms of video education, including health talks, the production of multilingual promotional videos, and media reports, to convey upbeat messages to the public, all of which will augment the public's perception of the advantages of the HPV vaccine, thereby elevating the propensity to vaccinate.

Perceived severity indirectly affects the willingness to vaccinate through other factors; thus, increasing the perceived severity of college students can effectively increase the willingness to vaccinate. Notably, increasing an individual's perception of disease severity can increase their motivation to protect, thereby promoting willingness to change behavior (30). In addition, it has been shown that HPV can cause almost all types of cervical cancer, as well as many cancers at other anatomical sites in both men and women (52); thus, HPV education should focus on highlighting the high prevalence and severity of HPV-associated diseases to increase the level of perceived risk for educated individuals.

This study revealed that perceived susceptibility mediates one's willingness to be vaccinated and influences one's willingness to vaccinate in the same direction. That is, the stronger the perceived susceptibility is, the greater the willingness to vaccinate is; this finding is similar to the results found by other studies (53). The greater the individual's perceived risk of HPV infection is, the greater their confidence in the efficacy of the HPV vaccine is, and the greater their willingness to be vaccinated is (54). These findings suggest that increasing college students' perceived risk of HPV infection facilitates their willingness to vaccinate. Consequently, healthcare professionals should be motivated to proactively educate the public regarding HPV and its vaccine, as well as to advocate for familial education, encouraging parents to engage in more dialogues with their children about the risks associated with HPV and the significance of vaccination to enhance the willingness to receive the vaccine.

The study's results showed that perceived barriers mediate the effect on willingness to vaccinate, such that the more potent the perception of barriers is, the lower the level of willingness to vaccinate is; this is consistent with the results found by other studies (55). Notably, cost, safety, and side effects have been frequently reported as significant barriers to accessing vaccines (46). Other studies have emphasized that despite the public awareness of the safety and efficacy of HPV vaccines, these factors remain essential barriers to vaccine acceptance (56). This highlights the need to convey HPV vaccine safety data and relevant research results to the public through various communication channels, such as popularization activities, special lectures, and social media, which will help the public dispel misconceptions about the vaccine. In addition, the government should consider introducing a subsidy policy for HPV vaccines to lower the cost of vaccination so that people of the right age from low-income families can also afford the cost of vaccination, thus lowering the barriers to vaccination.

In the health belief model, self-efficacy positively mediated HPV vaccination intentions, similar to previous findings (57). It suggests that increasing college students' self-efficacy will help increase their willingness to vaccinate by providing a deeper understanding of the convenience and effectiveness of vaccination. Improving self-efficacy

can be done through knowledge about HPV, peer education, or by attending relevant seminars, getting advice and support from healthcare practitioners, and increasing confidence in vaccination.

Despite this study's theoretical value and practical significance, several limitations remain. First, the sample chosen for this study included only a subset of students enrolled at a comprehensive public university, rather than the entire population of college students at the institution. Therefore, the ability of the findings to accurately reflect the perceptions and behaviors of a larger population of college students may be controversial. In the future, the sample size can be enlarged on the basis of the current study so that the study can be conducted from a broader perspective. Second, the online questionnaire format used in this study may have led to some recall bias among the participants, which may have affected the accuracy of the findings. Finally, this study has a cross-sectional research design that uses structural equation modeling to demonstrate direct and indirect effects between variables. However, it focuses primarily on modeling relationships, which does not allow causal inferences to be made.

5 Conclusion

College students in China's ethnic minority areas were found to have better knowledge about HPV and its vaccine but showed an average level of willingness to be vaccinated and a lower proportion of positive behaviors. From the perspective of the health belief model, perceived benefits were found to have a significant positive direct effect on the willingness to vaccinate, and perceived severity were found to have a positive indirect effect on the desire to vaccinate. Furthermore, the chain mediating effects of perceived susceptibility, perceived impediment, and self-efficacy were found to play an essential role in increasing the willingness to vaccinate. On this basis, it is recommended that schools and departments implement targeted interventions for special populations; strengthen publicity and education efforts; and improve college students' level of knowledge, willingness to be vaccinated, and behavior toward HPV vaccination to promote HPV vaccination and thus help reduce the potential health hazards of HPV.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Institutional Review Board of Yanbian University. (Ethics Code: 10187). The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Informed consent was secured from all

study participants; they were apprised of their right to withdraw from the study and assured that their data would remain strictly confidential and utilized solely for scientific analysis.

Author contributions

SS: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software. YG: Writing – original draft, Data curation, Methodology, Validation, Investigation, Visualization, Software. YL: Conceptualization, Formal analysis, Supervision, Validation, Writing – review & editing. ZW: Writing – original draft, Data curation, Methodology, Validation, Investigation. WG: Data curation, Methodology, Software, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded by two Yanbian University educational science planning programs: “Key Project+ Exploration of Teaching Reform and Practice Path of Epidemiology Course+ ZD2024001”, “General Project+

Innovation of Blended Teaching Reform of Epidemiology Course under the Perspective of ‘Golden Class’+ GJ2021012”.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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OPEN ACCESS

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RECEIVED 02 August 2024

ACCEPTED 27 January 2025

PUBLISHED 07 February 2025

CITATION

Tao H, Chen J, Zhang X, Wang T, Jiang N and
Jia Y (2025) Sociodemographic disparities in
influenza vaccination among older adults in
United States.
Front. Public Health 13:1474677.
doi: 10.3389/fpubh.2025.1474677

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Sociodemographic disparities in influenza vaccination among older adults in United States

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Background: Influenza vaccination uptake among United States adults aged 65 years or older remains suboptimal and stagnant. This study aims to evaluate the prevalence of influenza vaccination and examine sociodemographic disparities within a nationally representative sample.

Methods: This study is a cross-sectional study. We used the data from the Behavioral Risk Factor Surveillance System spanning the years 2011 to 2022. Logistic regression models were used to assess potential associations between influenza vaccination uptake and sociodemographic characteristics. Concentration indexes were also calculated to measure the socioeconomic inequalities on influenza vaccination uptake.

Results: The study included 1,391,440 adults aged 65 years and older, with 62.87% reporting having received an influenza vaccination. The weighted prevalence of influenza vaccination uptake showed a slight increase, ranging from 59.05% in 2011–2013 to 67.49% in 2020–2022. Higher vaccination rates were observed among non-Hispanic Whites [63.16%; odds ratio (OR) 1.38, (95% CI 1.33–1.42)], individuals with education above high school [63.89%; OR 1.16, (95% CI 1.12–1.19)], and those with an income above \$50,000 [65.86%; OR 1.47, (95% CI 1.43–1.50)]. Compared to non-Hispanic Black people with an income below \$25,000 and education less than high school, the ORs were significantly higher among non-Hispanic whites [2.12, (95% CI 1.97–2.28)], non-Hispanic Black people [1.30, (95% CI 1.18–1.44)], and Hispanics [1.40, (95% CI 1.24–1.59)] earning above \$50,000 and education above high school. Those who received an influenza vaccination tended to be concentrated in the high-income group and high-education group.

Conclusion: There are substantial racial and socioeconomic disparities in influenza vaccination uptake among individuals aged 65 years or older. Health policy maybe urgently needed to reduce these avoidable inequalities.

KEYWORDS

influenza vaccine, racial groups, socioeconomic disparities, older adults, public health

1 Introduction

Influenza viruses circulate annually within the United States, and annual administration of the influenza vaccination is recommended for adults aged 65 years or older, who are at high risk of serious illness, hospitalization, and death due to influenza. This age group accounts for most influenza-related deaths and hospital admissions (1, 2). Moreover, data from the Hospitalized Adult Influenza Vaccine Effectiveness Network indicates a decline in vaccine effectiveness of approximately 10–11% per month specifically in individuals aged 65 years or older (3). Understanding influenza vaccination uptake in these vulnerable populations may inform future public health strategies.

Previous studies suggested that influenza vaccination uptake and influenza hospitalization rates differed by race/ethnicity (4). And individuals with higher socioeconomic status were more likely to receive an influenza vaccination (5). However, the evidence regarding sociodemographic disparities in influenza vaccination uptake, and the potential joint associations between socioeconomic inequalities and race/ethnicity in influencing these rates across the United States, is still not sufficiently comprehensive. The insights gained from these findings could help identify influenza vaccination disparities throughout the United States and offer guidance for policymakers in striving for a more inclusive and equitable allocation of resources.

Thus, this study aimed to compare the weighted and age-standardized prevalence of influenza vaccination uptake between United States adults aged 65 years or older from 2011 to 2022, and to assess the socioeconomic disparities and their potential joint association on overall influenza vaccination uptake using a nationally representative sample.

2 Methods

2.1 Data

We included individuals aged 65 years or older, utilizing data from the Behavioral Risk Factor Surveillance System (BRFSS) spanning the years 2011 to 2022 (6). The BRFSS, funded by the Centers for Disease Control and Prevention (CDC), is an annual survey designed to gather comprehensive information on sociodemographic factors, health behaviors, and comorbid conditions among non-institutionalized adults residing in the United States, Guam, and Puerto Rico. As the largest annual health survey across the 50 states, BRFSS enables estimates of Medicare's effects at age 65 years at national and state levels. Given that BRFSS data are publicly accessible, this study was exempt from review by the institutional review board committee.

2.2 Variables

Influenza vaccination uptake was self-reported, and individuals deemed to have received the influenza vaccination if they responded affirmatively to having been vaccinated within the 12 months preceding the survey completion. Age and sex were assessed via survey questions. Race/ethnicity was self-reported, with race categorized as non-Hispanic White, non-Hispanic Black, Hispanic, and other races. Education level

was assessed by asking participants, “What is the highest grade or year of school you have completed?” and categorized as less than high school, high school, and above high school. Income was assessed via the question, “Is your annual income from all sources: less than \$10,000, or \$10,000 to less than \$15,000, or \$15,000 to less than \$20,000, or \$20,000 to less than \$25,000, or \$25,000 to less than \$35,000, or \$35,000 to less than \$50,000, or \$50,000 to less than \$75,000, or \$75,000 or more.” Annual family income was then categorized as less than \$25,000, \$25,000 to \$50,000, and above \$50,000.

2.3 Statistical analysis

The weighted prevalence of influenza vaccination uptake among individuals in the United States aged 65 years or older from 2011 to 2022 was calculated based on the survey weights, as the BRFSS utilized design weighting (7). We used 2010 US Census population proportions to calculate the age-standardized prevalence of influenza vaccination uptake (8). Trends in prevalence over time were tested using a weighted logistic regression model.

For descriptive purposes, continuous data was grouped into categorical data, and categorical data are presented as numbers and percentages. Since the influenza vaccination uptake was a binary variable, thus adjusted odds ratios (ORs) with 95% confidence interval (CI) were calculated using binary logistic regression models to assess potential associations between influenza vaccination uptake and sociodemographic characteristics. Interactions between influenza vaccination uptake and socioeconomic factors were tested for predicting receipt of each vaccine and reported if statistically significant. Concentration indexes were calculated to measure socioeconomic inequality, with values ranging from -1 to $+1$. Positive (negative) values indicate that education or income is concentrated among rich (poor) individuals. A concentration index of zero indicates no inequality. All p -values were two-sided, with a significance level of 0.05. Analysis was performed using Stata version 15.0 (Stata Corp), and weighting procedures accounted for the complex survey design of the BRFSS.

3 Results

3.1 Crude prevalence of influenza vaccination uptake

The study included 1,391,440 older adults individuals aged 65 years and above, with a gender distribution of 593,748 males (42.67%) and 797,692 females (57.33%). Among these, 878,842 individuals (63.16%) had an education level above high school, and 528,726 individuals (38.00%) earned above \$50,000 annually. Ethnically, the sample consisted of 1,189,024 White individuals (85.45%), 86,600 Black people (6.22%), 54,890 Hispanics (3.94%), and 60,926 individuals of other races (4.38%). Nearly two-thirds (874,863, 62.87%) reported receiving an influenza vaccination (detailed in Table 1).

The weighted prevalence of influenza vaccination exhibited a slight increase over the study period, ranging from 59.05% in 2011–2013 to 67.49% in 2020–2022. This increase was consistent across age, sex, education, income and race subgroups (detailed in Supplementary Table 1). Individuals aged 80 years or older [OR 1.63, (95%CI, 1.59–1.66)] were more likely to receive an influenza

TABLE 1 Prevalence and distribution of influenza vaccination by patient characteristics among individuals aged 65 years or more based on BRFSS database from 2011 to 2022.

Characteristics	Subgroups	No. vaccinated/ total ^a	% Vaccinated (95% CI) ^b	OR (95%CI) ^c	Std. error	t value	P value
Overall	Crude	874,863 (1,391,440)	61.24 (61.05–61.42)				
	Age-standardization		61.65 (61.47–61.84)				
Age, y							
	65–69	265,076 (456,657)	56.33 (56.00–56.65)	1 [Reference]			
	70–74	233,655 (371,578)	61.71 (61.35–62.06)	1.27 (1.24–1.29)	0.013	23.07	<0.001
	75–79	171,246 (261,061)	64.32 (63.89–64.74)	1.47 (1.43–1.50)	0.017	32.47	<0.001
	≥80	204,886 (302,144)	65.77 (65.36–66.18)	1.62 (1.59–1.66)	0.019	41.19	<0.001
Gender							
	Male	373,971 (593,748)	61.10 (60.82–61.38)	1 [Reference]			
	Female	500,892 (797,692)	61.36 (61.11–61.61)	1.05 (1.03–1.07)	0.009	5.82	<0.001
Education							
	<High School	61,199 (109,281)	55.38 (54.74–56.02)	1 [Reference]			
	High School	240,905 (403,317)	58.94 (58.61–59.27)	1.00 (0.98–1.04)	0.015	0.32	0.75
	>High School	572,759 (878,842)	63.89 (63.66–64.12)	1.16 (1.12–1.19)	0.018	9.50	<0.001
Income							
	<\$25,000	241,070 (423,012)	55.60 (55.25–55.96)	1 [Reference]			
	≥\$25,000 and<\$50,000	275,271 (439,702)	61.05 (60.73–61.38)	1.18 (1.16–1.21)	0.012	15.51	<0.001
	≥\$50,000	358,522 (528,726)	65.86 (65.57–66.15)	1.47 (1.43–1.50)	0.017	33.81	<0.001
Race							
	Non-Hispanic White	763,638 (1,189,024)	63.16 (62.98–63.34)	1.38 (1.33–1.42)	0.022	19.75	<0.001
	Non-Hispanic Black	46,665 (86,600)	52.86 (52.12–53.60)	1 [Reference]			
	Hispanic	28,777 (54,890)	53.35 (52.40–54.29)	1.14 (1.08–1.19)	0.029	5.11	<0.001
	Other	35,783 (60,926)	59.22 (57.92–60.52)	1.26 (1.18–1.34)	0.040	7.16	<0.001

a. Unweighted.

b. Weighted percentage and 95%CI.

c. Model adjusted for age, sex, income, education and race/ethnicity.

vaccination, followed by those aged 75 to 79 years [OR 1.47, (95%CI, 1.43–1.50)] and those aged 70 to 74 years [OR 1.27, (95%CI, 1.24–1.29)] compared to those aged 65 to 69 years. Respondents with education above high school [63.89%; OR 1.16, (95% CI, 1.12–1.19)] were more likely to receive an influenza vaccination than those with less education (55.38%). Individuals earning above \$50,000 [65.86%; OR 1.47, (95% CI, 1.43–1.50)] and those earning between \$25,000 and \$50,000 [61.05%; OR 1.18, (95% CI, 1.16–1.21)] had higher rates of influenza vaccination uptake than those earning less than \$25,000 (55.60%). Non-Hispanic White individuals [63.16%; OR 1.38, (95% CI, 1.33–1.42)] and Hispanic individuals [53.35%; OR 1.14, (95% CI, 1.08–1.19)] were more likely to have been vaccinated than Black individuals (52.86%).

3.2 Age-standardized rates of influenza vaccination uptake varied in socioeconomic factors by races

Using the 2010 U.S. Census as the reference population, we calculated age-standardized rates of influenza vaccination

uptake (Table 2). There were noticeable increases in age-standardized rates of influenza vaccination uptake for non-Hispanic White and Black individuals with income above \$50,000 than those with income less than \$25,000, varied in education levels non-Hispanic White (increased by 1.27% for less than a high school, 5.37% for a high school, and 12.38% for above high school); non-Hispanic Black (increased by –7.42% for less than a high school, 3.90% for a high school, and 8.34% for above high school). The increase was more pronounced from 2020 to 2022 (detailed in Supplementary Table 2).

3.3 Joint associations of socioeconomic factors and races with influenza vaccination uptake

After adjusting for age and sex, the adjusted ORs were calculated to compare the likelihood of influenza vaccination uptake among racial and socioeconomic groups (detailed in Table 3). Compared to non-Hispanic Black individuals with an income less than \$25,000 and education less than high school, the

TABLE 2 Age-standardized rates of influenza vaccination uptake varied in socioeconomic factors by races.

Survey years	Races subgroups		Income level		
			Less than \$25,000	\$25,000 to less than \$50,000	\$50,000 or more
		Education level	Proportion (%) 95%CI	Proportion (%) 95%CI	Proportion (%) 95%CI
Overall	Non-Hispanic White				
		<High School	56.15 (55.24–57.05)	57.73 (56.33–59.11)	57.42 (54.98–59.82)
		High School	57.30 (56.77–57.84)	61.52 (61.00–62.04)	62.67 (61.89–63.45)
		>High School	57.39 (56.81–57.96)	63.82 (63.41–64.22)	69.77 (69.45–70.07)
	Non-Hispanic Black				
		<High School	52.36 (50.50–54.22)	54.22 (50.15–58.25)	44.94 (37.31–52.82)
		High School	50.89 (49.23–52.54)	53.52 (51.14–55.88)	54.79 (49.81–59.67)
		>High School	50.12 (48.07–52.16)	54.04 (52.11–55.96)	58.46 (56.02–60.85)
	Hispanic				
		<High School	52.87 (51.17–54.57)	53.21 (48.15–58.20)	58.30 (47.72–68.16)
		High School	51.84 (49.50–51.17)	55.11 (51.40–58.75)	58.05 (52.37–63.52)
		>High School	50.29 (47.70–52.87)	56.63 (53.59–59.63)	60.46 (57.77–63.08)
	Other				
		<High School	52.89 (49.05–56.69)	54.79 (48.45–60.97)	54.64 (42.37–66.27)
		High School	55.78 (52.13–59.38)	59.55 (54.42–64.48)	63.22 (56.26–69.67)
		>High School	55.96 (52.80–59.07)	59.54 (56.11–62.89)	64.76 (62.17–67.26)

TABLE 3 Joint associations between socioeconomic factors and races in predicting the influenza vaccination uptake.

Income level							
Races	Education	Less than \$25,000		\$25,000 to less than \$50,000		\$50,000 or more	
		OR (95%CI)	<i>p</i> value	OR (95%CI)	<i>p</i> value	OR (95%CI)	<i>p</i> value
Non-Hispanic White							
	<High school	1.15 (1.06–1.24)	0.001	1.25 (1.14–1.37)	<0.001	1.24 (1.09–1.40)	0.001
	High school	1.20 (1.12–1.30)	<0.001	1.44 (1.33–1.55)	<0.001	1.51 (1.40–1.64)	<0.001
	>High school	1.22 (1.13–1.31)	<0.001	1.60 (1.48–1.72)	<0.001	2.12 (1.97–2.28)	<0.001
Non-Hispanic Black							
	<High school	Refer.		1.06 (0.88–1.28)	0.527	0.77 (0.55–1.07)	0.118
	High school	0.94 (0.85–1.03)	0.183	1.05 (0.94–1.18)	0.378	1.07 (0.88–1.29)	0.49
	>High school	0.92 (0.83–1.03)	0.131	1.09 (0.98–1.20)	0.11	1.30 (1.18–1.44)	<0.001
Hispanic							
	<High school	1.06 (0.96–1.17)	0.214	1.15 (0.94–1.40)	0.167	1.58 (1.10–2.27)	0.014
	High school	1.01 (0.90–1.14)	0.832	1.17 (1.00–1.37)	0.057	1.26 (0.99–1.60)	0.058
	>High school	0.94 (0.83–1.06)	0.316	1.22 (1.05–1.40)	0.007	1.40 (1.24–1.59)	<0.001
Other							
	<High school	1.05 (0.88–1.25)	0.579	1.12 (0.83–1.51)	0.453	1.29 (0.66–2.51)	0.452
	High school	1.25 (1.06–1.46)	0.006	1.35(1.09–1.67)	0.007	1.57 (1.13–2.17)	0.006
	>High school	1.21 (1.05–1.39)	0.010	1.46 (1.25–1.70)	<0.001	1.78 (1.57–2.01)	<0.001

ORs were significantly higher among all non-Hispanic White groups (ORs ranging from 1.15 to 1.12), non-Hispanic Black individuals with income above \$50,000 and education above high

school (1.30, 95% CI, 1.18–1.44), and some Hispanic groups with higher income and higher education (Statistical test parameters were detailed in [Supplementary Table 3](#)).

TABLE 4 Concentration index among different income and education levels by races.

Characteristics		Subgroups	No.	Index value	Std. error	P value
Overall			1,391,440	0.0650	0.0010	<0.001
	Income	<\$25,000	423,012	0.0037	0.0018	0.04
		≥\$25,000 and<\$50,000	439,702	0.0388	0.0018	<0.001
		≥\$50,000	528,726	0.0981	0.0017	<0.001
	Education	<High school	109,281	0.0067	0.0035	0.06
		High school	403,317	0.0225	0.0018	<0.001
		>High school	878,842	0.0812	0.0013	<0.001
Non-Hispanic White						
	Income	<\$25,000	324,607	−0.0038	0.0020	0.07
		≥\$25,000 and<\$50,000	384,506	0.0399	0.0019	<0.001
		≥\$50,000	479,911	0.1002	0.0018	<0.001
	Education	<High school	70,130	−0.0125	0.0044	0.0045
		High school	345,615	0.0219	0.0020	<0.001
		>High school	773,279	0.0830	0.0014	<0.001
Non-Hispanic Black						
	Income	<\$25,000	41,813	0.0491	0.0056	<0.001
		≥\$25,000 and<\$50,000	24,849	0.0746	0.0073	<0.001
		≥\$50,000	19,938	0.1218	0.0082	<0.001
	Education	<High school	15,170	0.0432	0.0093	<0.001
		High school	27,264	0.0586	0.0070	<0.001
		>High school	44,166	0.0996	0.0055	<0.001
Hispanic						
	Income	<\$25,000	33,524	0.0642	0.0063	<0.001
		≥\$25,000 and<\$50,000	12,221	0.0536	0.0104	<0.001
		≥\$50,000	9,145	0.0936	0.0122	<0.001
	Education	<High school	17,643	0.0834	0.0086	<0.001
		High school	14,540	0.0394	0.0095	<0.001
		>High school	22,707	0.0949	0.0076	<0.001
Other						
	Income	<\$25,000	23,068	−0.0273	0.0076	0.0003
		≥\$25,000 and<\$50,000	18,126	0.0034	0.0087	0.69
		≥\$50,000	19,732	0.0672	0.0085	<0.001
	Education	<High school	6,338	−0.0477	0.0145	0.001
		High school	15,898	−0.0135	0.0092	0.14
		>High school	38,690	0.0441	0.0060	<0.001

3.4 The concentration indexes

Overall, those who received an influenza vaccination tended to be concentrated in the high-income group (index value 0.0981 for earning above \$50,000, p value <0.001) and high-education group (index value 0.0812 for above high school, p value <0.001). This trend was consistent among non-Hispanic White, non-Hispanic Black, and Hispanic individuals (detailed in Table 4). The concentration index for income and education showed a notable increase from 2011 to 2022 (income coefficient

0.0077; 95% CI, 0.0047 to 0.0107, and education coefficient 0.0048; 95% CI, 0.0028 to 0.0068) (detailed in Table 5).

4 Discussion

In this nationally representative sample, influenza vaccination uptake rates among individuals aged 65 years or older showed a clear increasing trend from 2011 to 2022. Lower education levels, lower income levels, and non-Hispanic Black individuals were associated with

TABLE 5 Trends of concentration indexes over time were tested using logistic regression model.

Characteristics		Subgroups	Coefficient	95%CI		P value	R ²	F statistic
				Lower	Upper			
Income	Overall		0.0077	0.0047	0.0107	<0.001	0.7678	33.07
	Age	65–69 years	0.0050	0.0025	0.0075	0.001	0.6675	20.07
		70–74 years	0.0081	0.0050	0.0112	<0.001	0.7716	33.79
		75–79 years	0.0085	0.0045	0.0124	0.001	0.6939	22.66
		80 years or more	0.0063	0.0030	0.0095	0.001	0.6540	18.9
	Sex	Male	0.0084	0.0051	0.0117	<0.001	0.7651	32.57
		Female	0.0073	0.0041	0.0105	<0.001	0.7189	25.57
	Races	Non-Hispanic White	0.0082	0.0058	0.0107	<0.001	0.8467	55.24
		Non-Hispanic Black	0.0055	0.0006	0.0105	0.031	0.3854	6.27
		Hispanic	0.0035	−0.0026	0.0096	0.227	0.1419	1.65
		Other	0.0083	0.0043	0.0122	0.001	0.6845	21.69
Education	Overall		0.0048	0.0028	0.0068	<0.001	0.7387	28.28
	Age	65–69 years	0.0051	0.0033	0.0070	<0.001	0.7916	37.98
		70–74 years	0.0035	0.0019	0.0051	0.001	0.6922	22.49
		75–79 years	0.0038	0.0015	0.0061	0.004	0.5816	13.9
		80 years or more	0.0039	0.0010	0.0069	0.014	0.4713	8.91
	Sex	Male	0.0057	0.0033	0.0081	<0.001	0.7379	28.15
		Female	0.0038	0.0019	0.0057	0.001	0.6689	20.2
	Races	Non-Hispanic White	0.0054	0.0039	0.0068	<0.001	0.8721	68.16
		Non-Hispanic Black	0.0049	0.0009	0.0088	0.021	0.4269	7.45
		Hispanic	0.0021	−0.0036	0.0077	0.437	0.0616	0.66
		Other	0.0063	0.0025	0.0101	0.004	0.5819	13.91

lower influenza vaccination uptake, indicating evident racial and socioeconomic disparities. Non-Hispanic White individuals with any level of socioeconomic status were more likely to receive an influenza vaccination compared to non-Hispanic Black individuals with lower socioeconomic status. Overall, individuals with higher socioeconomic status have greater advantages in influenza vaccination uptake.

Although annual influenza vaccination is recommended for adults aged 65 years or older, the influenza vaccination uptake remains low in previous studies (9, 10). In our study, similarly, only 62.60% individuals reported receiving an influenza vaccination using BRFSS data from 2011 to 2022. Following the release of the first COVID-19 vaccines, individuals who received an influenza vaccination were more likely to report getting a COVID-19 vaccine (11). In our study, the weighted influenza vaccination rate in 2020–2022 was the highest at 67.48%, possibly due to the increasing trend of COVID-19 vaccination.

Low influenza vaccination coverage in U.S. adults suggests that a multitude of factors may be responsible for under-vaccination or non-vaccination including vaccine hesitancy (12). Social media as a source of health information, those users of Twitter and Facebook as sources of health information were more likely to be vaccinated in comparison to users who do not use Twitter or Facebook as a source of health information (13). More than a third of adults were hesitant to receive an influenza vaccination for concerns about vaccination side effects, serious side effects or healthcare provider was not the most trusted source of information about influenza vaccinations (12). Thus, the government departments should strengthen promotional efforts

for influenza vaccination on social media platforms. The government departments should intensify their promotional efforts actively on social media platforms to disseminate knowledge related to influenza vaccination.

Racial and ethnic inequities in access and use of the influenza vaccine are pervasive and persistent (14, 15). Previous study indicated that white adults 65 years and older were significantly more likely to receive influenza vaccine than those blacks (16), since that those whites persons were more likely to believe the vaccine is very effective than blacks (66% vs. 50%). Our findings show a 38% higher rate of influenza vaccination among non-Hispanic White individuals and a 14% higher rate among Hispanic individuals compared to Black individuals. Further analysis of joint associations revealed that non-Hispanic White individuals earning above \$50,000 with education above high school had a 112% higher rate of receiving an influenza vaccination relative to Black individuals earning less than \$25,000 with less than a high school education, a finding rarely described before. Besides, socioeconomic inequalities in access to influenza vaccination uptake are evident (17, 18). Our study indicates that adults who received an influenza vaccination tend to be concentrated in high-income and high-education groups, who have higher health awareness and health literacy, another finding rarely described before.

The principal strength of this study is the use of the BRFSS database, which included 1,391,440 older adults individuals aged 65 years and older spanning the years 2011 to 2022, compared to smaller samples in previous studies based on the BRFSS database (10,

17). Limitations include the reliance on self-reported vaccination history, which may introduce recall bias. This was especially relevant to the pneumococcal vaccine where the respondent was asked to recall whether they ever had received the immunization. While the BRFSS weighting procedures account for the undersampling of populations with reduced telephone coverage and racial minorities, these do not correct for the underrepresentation of people with severe mental, cognitive, and communication limitations. Moreover, BRFSS data do not ask questions surrounding attitudes and beliefs toward vaccines, we were not able to evaluate reasons for opting in or opting out of influenza vaccination. This is a cross-sectional study, and causal relationship cannot be determined even when relevant confounders are adequately controlled. Finally, our results might be subject to cohort and period effects, and further studies are needed to examine the role of vaccine hesitancy or other additional obstacles to vaccination among old adults. Strategies to improve influenza vaccination uptake and completion include disseminating health information through social media, leveraging university or community vaccination campaigns, identifying the need for vaccination, and eliminating barriers.

In conclusion, using the BRFSS 2011–2022 database, older adults with higher socioeconomic status have greater advantages in influenza vaccination uptake. Strategies to increase influenza vaccination uptake in the United States should address barriers faced by people with racial and socioeconomic inequalities. Addressing existing disparities requires attention to the role of social determinants of health in determining access to vaccination, particularly among older people, racial and ethnic minority populations.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

HT: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. JC: Conceptualization,

Writing – review & editing. XZ: Formal analysis, Software, Writing – review & editing. TW: Methodology, Writing – review & editing. NJ: Project administration, Validation, Writing – review & editing. YJ: Conceptualization, Project administration, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This study was supported by 1-3-5 project for disciplines of excellence–Clinical Research Incubation Project, West China Hospital, Sichuan University, China (2020HXXFH020), Clinical New Technology Project, West China Hospital, Sichuan University, China (20HXJS0 10). Those funders played no role in the conceptualization, data collection or draft preparation of this article.

Acknowledgments

We acknowledge all of the participants and staff involved in BRFSS for their valuable contributions and we greatly appreciate the support from other members of the study team who provided their generous contribution of time and efforts help during the research.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1474677/full#supplementary-material>

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OPEN ACCESS

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RECEIVED 09 September 2024

ACCEPTED 24 December 2024

PUBLISHED 17 February 2025

CITATION

Osaghae EO, Sirek G, Roberson T,
Chandler M, Childs A, Crespo-Bosque M,
Curry G, Dhand A, Dollear M, Eggelston A,
Ezeh N, Fleurissaint D, Garrett D, Granville G,
Jean-Jacques M, Losina E, Milaeger H,
Muhammad L, Nelson MA, Nosamiefan C,
Ojikutu B, Pillai N, Son MB, Toussaint MJ,
Valle A, Williams JN, York M,
Mancera-Cuevas K, Feldman CH and
Ramsey-Goldman R (2025)
Community-engaged curriculum
development using racial justice and
biomedical lenses to address COVID-19
vaccine hesitancy in black individuals with
rheumatologic conditions.
Front. Public Health 12:1493331.
doi: 10.3389/fpubh.2024.1493331

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Dollear, Eggelston, Ezeh, Fleurissaint, Garrett,
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Muhammad, Nelson, Nosamiefan, Ojikutu,
Pillai, Son, Toussaint, Valle, Williams, York,
Mancera-Cuevas, Feldman and
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Community-engaged curriculum development using racial justice and biomedical lenses to address COVID-19 vaccine hesitancy in black individuals with rheumatologic conditions

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Despite the efficacy of the COVID-19 vaccine in reducing mortality and illness severity, racial inequities in vaccination uptake persist. Among individuals with rheumatologic conditions who are often immunocompromised, the impact of disparities in preventive care threatens to widen existing inequities in adverse outcomes related to COVID-19 infection. There exists an urgent need to develop interventions that reduce COVID-19 vaccine hesitancy and promote vaccine uptake. We leveraged long-standing community-academic partnerships in two cities to develop a curriculum that will be part of an intervention to decrease COVID-19

vaccine hesitancy within Black communities. We describe the collaborative efforts that resulted in the creation of two interactive virtual curricula with similar core content but different theoretical lenses. One lens uses a racial justice approach to acknowledge the effects of historical and current structural racism on vaccine hesitancy, the other utilizes a traditional biomedical lens. In a future trial, we will compare the efficacy of these curricula to empower Black individuals identified as Popular Opinion Leaders (POLs), or trusted community members with large social networks, to disseminate health information to promote COVID-19 vaccine uptake. Strategies to reduce racial inequities in COVID-19 vaccine uptake must begin with accurately identifying and empathetically acknowledging the root causes of vaccine hesitancy, as well as addressing nuanced concerns that drive vaccine avoidance among Black individuals. Community engagement and collaboration are central in creating interventions to develop and test culturally relevant strategies, as observed with our curricula, that bridge scientific efforts with community concerns and practices.

KEYWORDS

community academic partnerships, COVID-19, African American/black, community health promotion, health equity, rheumatic and autoimmune disease, vaccine hesitancy

Introduction

With an estimated death toll of 14.8 million globally and approximately 1.1 million lives lost along with 6.4 million hospitalizations in the United States alone, the COVID-19 pandemic profoundly impacted the world on an unprecedented scale and specifically revealed many shortcomings present within the United States healthcare system (1, 2). Currently, historically marginalized populations remain disproportionately affected by the COVID-19 pandemic. Accounting for nearly 13% of the United States population, individuals of African ancestry, here after referred to as Black, are more likely to contract COVID-19 and experience adverse long-term outcomes (3–5). With higher hospitalization rates, these individuals are more likely to require intensive care unit admission, mechanical ventilation, and have an 11% higher mortality rate than their white counterparts (3, 6, 7). It is essential to note that there is significant heterogeneity within the Black population and many statistics related to COVID-19 do not specifically address ancestry (5). Yet, despite the efficacy of the COVID-19 vaccine and its subsequent boosters, we continue to see this population have lower COVID-19 vaccination rates and report more hesitancy to get vaccinated or receive a booster (8–10). As one of the top threats to global health as described by the World Health Organization, vaccination hesitancy refers to “a delay or refusal to accept vaccination despite its availability (11).” At the height of the pandemic, misinformation and the rise of anti-vaccination movements bolstered an increase in global vaccine hesitancy and avoidance (12). Though U.S.-based Black individuals were not exempt from this phenomenon, the roots of vaccination hesitancy in this group extend past misinformation and harken back to historical instances of unethical and unjust practices in the healthcare system that have ultimately bred mistrust and avoidance (12).

The pervasiveness of vaccination hesitancy within this population is concerning as certain rheumatic conditions like systemic lupus erythematosus (SLE) disproportionately affect Black individuals, and

require immunosuppressive therapies, which heighten risk of severe infection (13, 14). Studies have demonstrated reduced efficacy of the COVID-19 vaccine in immunosuppressed individuals, highlighting the importance both of booster vaccinations and of advocacy to vaccinate not only individuals with rheumatic conditions but also their close contacts (15). Thus, our future intervention trial focuses on addressing and ultimately, decreasing vaccine hesitancy among Black individuals with rheumatic conditions.

In this paper, we describe the process of developing two virtual curricula, informed by the racial justice and biomedical models, respectively, with collaboration between longstanding academic and community partners in two cities. These curricula contain similar core content with two different lenses and objectives (Figure 1; Table 1). We ultimately aim to use these curricula to train Popular Opinion Leaders (POLs), or trusted community leaders, to disseminate health information to their social network members. Our forthcoming trial utilizes the POL model, an evidence-based and community-based approach previously used to reduce HIV stigma and increase SLE awareness (16, 17). Grounded in the social network and diffusion of innovation theories, the POL model trains community leaders to engage their social network members in health-related discussions that ultimately lead to adoption of positive health norms and behaviors (17, 18). Thus, our primary goals are to influence the content of these discussions through developing curricular material that trains POLs while determining the efficacy of two distinct curricular perspectives - biomedical versus racial justice - in training these POLs to effectively disseminate information concerning the COVID-19 vaccine. This dissemination is intended to decrease COVID-19 vaccine hesitancy and increase vaccine uptake among their social network members. This paper's objective is to illustrate our community-engaged, iterative approach to design these two curricula and their relevant pre- and post-tests for use in this planned NIH-funded randomized clinical trial (Northwestern University Institutional Review Board (IRB, ID #STU00217038) and Mass General Brigham IRB (#2022P000633 and #2023P000686) (19).

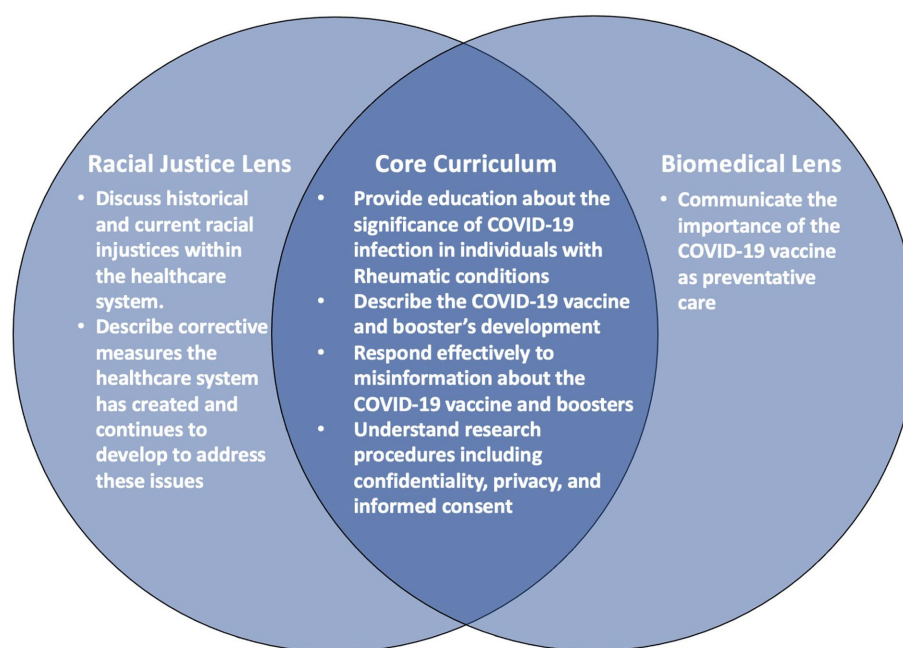


FIGURE 1
Objectives of two virtual curricula embedded with different theoretical frameworks.

Theoretical framework

Curricula strategy: biomedical model or racial justice model

To decrease COVID-19 vaccine hesitancy, current strategies commonly emphasize educating individuals about COVID-19 through development of innovative training materials. These teaching materials are often framed with a biomedical lens highlighting the vaccine as an individual-level tool to prevent serious infection. This model proposes that illness primarily arises as an outcome of abnormal biology or deviations from normal physiological function with psychological or sociological factors having less significant roles (20). With the biomedical approach, the COVID-19 vaccine is placed among other trusted preventative health practices with vaccine hesitancy addressed primarily by acknowledging and addressing scientific concerns. An example of a strategy utilizing the biomedical model involved the creation of a digital intervention through individualized motivational interviewing techniques that addressed COVID-19 vaccine misinformation and provided education about its development following a systematic literature review and qualitative interviews with public health experts (21).

Previously published work that involved semi-structured interviews with physicians and community leaders to determine barriers toward COVID-19 vaccination for Black individuals identified strategies that differed from the biomedical model to decrease COVID-19 vaccine hesitancy (22). These strategies emphasized the importance of acknowledging racial, ethnic and socioeconomic injustices, using compassionate and motivational messaging, and addressing misinformation, that is, taking a racial justice-oriented approach (22). Unlike the biomedical approach, the racial justice model recognizes and openly acknowledges the role of current and historical racial and social inequities in poor health

outcomes, focusing on population-level motivations and goals as opposed to individual-level objectives (23). This model contends that acknowledging and addressing the psychological and sociological health of Black communities is an essential factor to reduce health inequities. We see this strategy utilized by Peteet et al. (24) with the development of a webinar for Black churchgoers that discussed the psychology behind the fear of the COVID-19 vaccine by acknowledging medical mistrust. Another study reported the development of a vaccine education campaign focused on transparency and having culturally sensitive discussions regarding COVID-19 vaccine hesitancy with Black employees of nursing homes and their social networks (25). Though both interventions successfully decreased COVID-19 vaccine hesitancy in their respective populations, neither study compared racial justice-focused strategies to the norm, a biomedical-based educational approach to understand if there was a difference in efficacy between these two models. Therefore, to develop innovative strategies to reduce COVID-19 vaccine hesitancy among Black individuals, it is necessary to determine which educational model is more successful in changing health attitudes and behaviors.

Diffusion of innovation theory, the foundation of the POL model, focuses on the process of how and why innovative ideas and behaviors are adopted in a population (18). It proposes that searching for and creating new methods that better fit existing ideals and needs of hesitant individuals is necessary for behavioral change (18). This theory describes early adopters as individuals who embrace change and cautiously adopt new behaviors, and early and late majorities as individuals who are hesitant, and require more information and time for deliberation (18). Thus, when considering our approach to decrease COVID-19 vaccine hesitancy among Black individuals, we aimed to develop educational materials that were informative and both culturally relevant and sensitive such that Black individuals or POLs who are

“early adopters” of the COVID-19 vaccine can influence members of their communities and social networks who might then become part of the “early and late majorities” (18).

TABLE 1 Summary of each module.

Racial justice lens	Biomedical lens
Module I: Introduction & background	
POL model (what it is, how to influence community, how to communicate, how to measure success, etc.)	
Framed with emphasis on racial justice to reduce mistrust, add transparency to the vaccination process, change cultural norms and behaviors to reduce inequities in vaccine uptake at the population level	Framed with role of health information/education dissemination to change individual beliefs & behaviors around vaccine uptake
Module II: COVID-19 infection risk & vaccine mechanisms	
- Part A: Infection risk in rheumatic diseases, highlighting racial & socioeconomic inequities in COVID-19 infections and vaccine use; discussions of other infections (e.g., influenza) and vaccines - Part B: COVID vaccine mechanisms, safety, efficacy, and side effect data with trial data from racial/ethnic minority individuals	- Part A: Infection risk in rheumatic diseases; discussions of other infections (e.g., influenza) and vaccines - Part B: COVID vaccine mechanisms, safety, efficacy, and side effect data with trial data
Module III: Vaccine-related myths and evidence-based responses	
- Common myths include beliefs regarding the speed of COVID-19 vaccine development and the likelihood or possibility of developing severe side effects such as stroke, infertility, stroke, and sudden death after receiving the COVID-19 vaccine. - Other myths involve the ingredients within the COVID-19 vaccine being unsafe and concerns that the COVID-19 vaccine is a government ploy.	
Addresses concerns regarding racial diversity in COVID-19 vaccine clinical research	Addresses commonly held myths regarding the COVID-19 generally
Module IV: Structural racism, racial inequities in infection risk and preventative care uptake	Module IV: General preventative care
- Part A: Discrimination in healthcare - Part B: Historical injustices in medical research, and protection in place for patients	- Part A: Discuss Unhealthy health practices - Part B: Examples of preventative care
Module V: Research methods	
Human Subjects Training, Collecting Research Data, Data collection procedures, HIPAA, confidentiality	
Module VI: Review of material role-play with common questions	
- General conversation strategies (who, what, when, where) - Examples: storytelling, direct language, iterative conversations - Role play including consenting and dissemination of information	
Racial justice-framed conversation starters	Conversation starters incorporating preventative care strategies

Learning environment

Curricula audience

These curricula were created to be delivered to Black individuals who are older than 18 years, have a rheumatic and musculoskeletal condition, speak English, and have received at least one COVID-19 vaccine. These individuals will receive curricula training virtually over Zoom meetings.

Curricula development overview

To develop our curricula, we utilized longstanding collaborations between our research team and academic and community partners from Boston and Chicago. This group consisted of racially and ethnically diverse academic clinicians and researchers, rheumatic disease, infectious disease, and general medicine healthcare providers, neighborhood organization and community leaders, advocacy groups, social workers, and experts in public health. POLs from our previous studies were also significant members in this group. These individuals met monthly through Zoom meetings within and across both cities since summer 2022 and continue to meet.

Curricula objectives

To create our curricula, we leveraged findings from previous work where a series of semi-structured interviews with physician and community stakeholders focused on finding strategies to address COVID-19 vaccine hesitancy among Black individuals with rheumatic condition (22). Combining information from this work with the lived experiences and expertise of our community and academic partners, we planned to develop curricula that would accomplish the objectives as seen in Figure 1 (22).

Following the development of the learning objectives, we used multiple methods to review existing literature to understand inequities in vaccine uptake and adverse COVID-19 outcomes, as well as historical racial injustices. Meeting with our community and academic partners to discuss the concerns and questions they had heard about the COVID-19 vaccine from their patients and community members informed further literature review and our curricula drafts.

After creating the curricula’s initial drafts, developed using Microsoft PowerPoint, we sent the materials to our community and academic partners for review. Each partner also received a worksheet that allowed them to reflect and comment on their thoughts and concerns after reviewing the slides. This worksheet contained guided questions such as, “please list any slides you found confusing,” “suggest how the slides can be improved,” and “were the goals of this module clear?” After the partners completed their review, our research team met with them over Zoom meetings to discuss any suggestions and feedback. This process was repeated numerous times during the development of our curricula to ensure the curricula met our objectives. Throughout this iterative process to develop educational materials that accurately accomplished our learning objectives, the primary challenges we repeatedly encountered were addressing the curricula’s content, accessibility, and tone (Figure 2).

Curricula content

Developing both curricula content involved multiple methods to broaden our understanding of COVID-19 incidence and prevalence, vaccine development, vaccination recommendations, and common misconceptions regarding vaccination. Various sources were reviewed and utilized including data from the Centers for Disease Control and Prevention (CDC), articles from the lay press, and peer-reviewed published manuscripts in PubMed indexed journals. Creating the material for the curriculum with a racial justice lens required extensive research about data on bias and mistrust in medicine and historical and current treatment of Black individuals in the health care system and general society. Furthermore, upon receiving feedback from some of our partners regarding tailoring the curriculum content specifically to the sites where we will ultimately deliver the curriculum, we searched for distinct examples of how the healthcare systems in both cities addressed mistrust and medical bias. Additional content to inform the biomedical lens involved review of health screening and preventative guidelines for people with rheumatic conditions (15). Some of our public health experts provided several examples of teaching materials focused on preventative care which were incorporated into our curriculum.

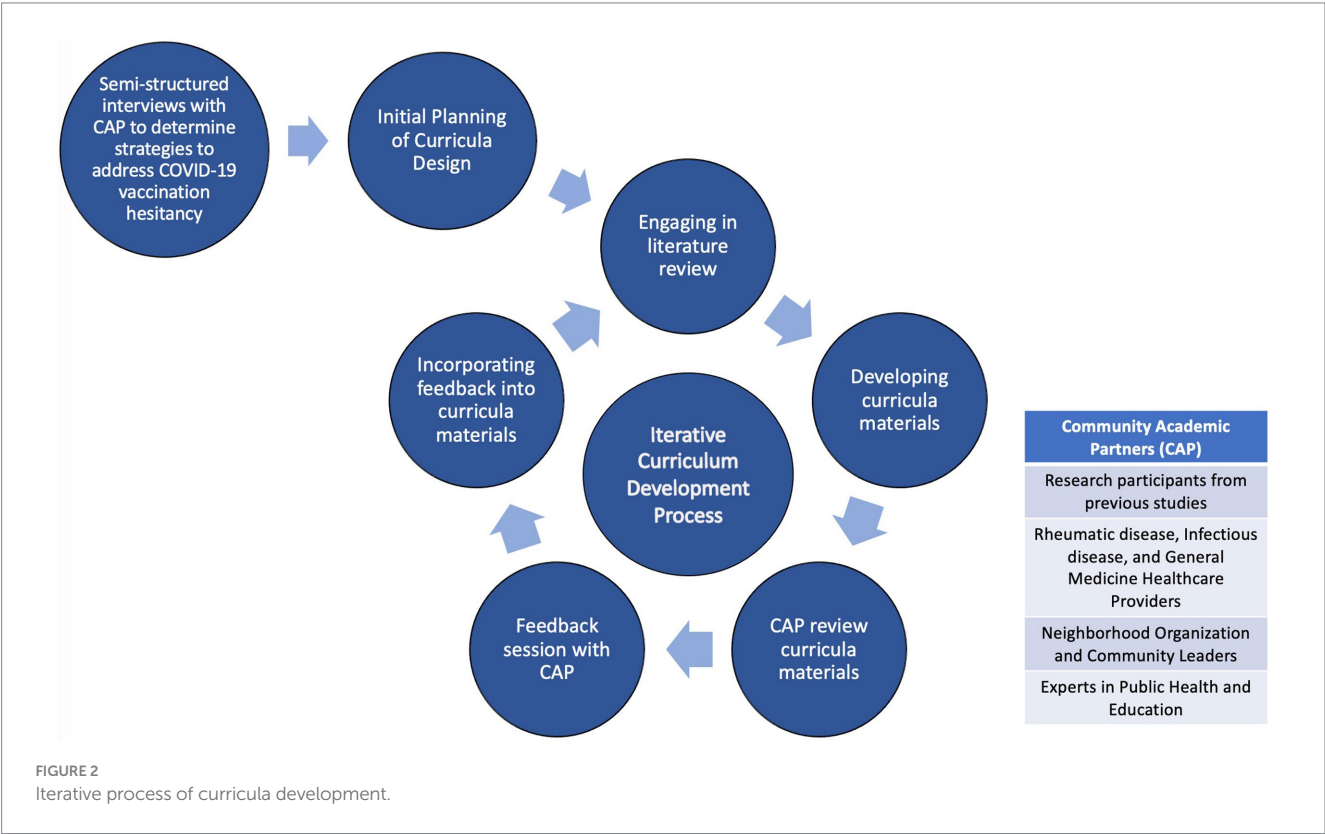
Given the collaborative nature of the curricular development, at times, our community and academic partners had differing perspectives on the curricula’s content. To address these conflicts, we integrated the varying ideas into our curricula drafts and, as part of the iterative process, invited our partners to evaluate which approach best aligned with our overall goals.

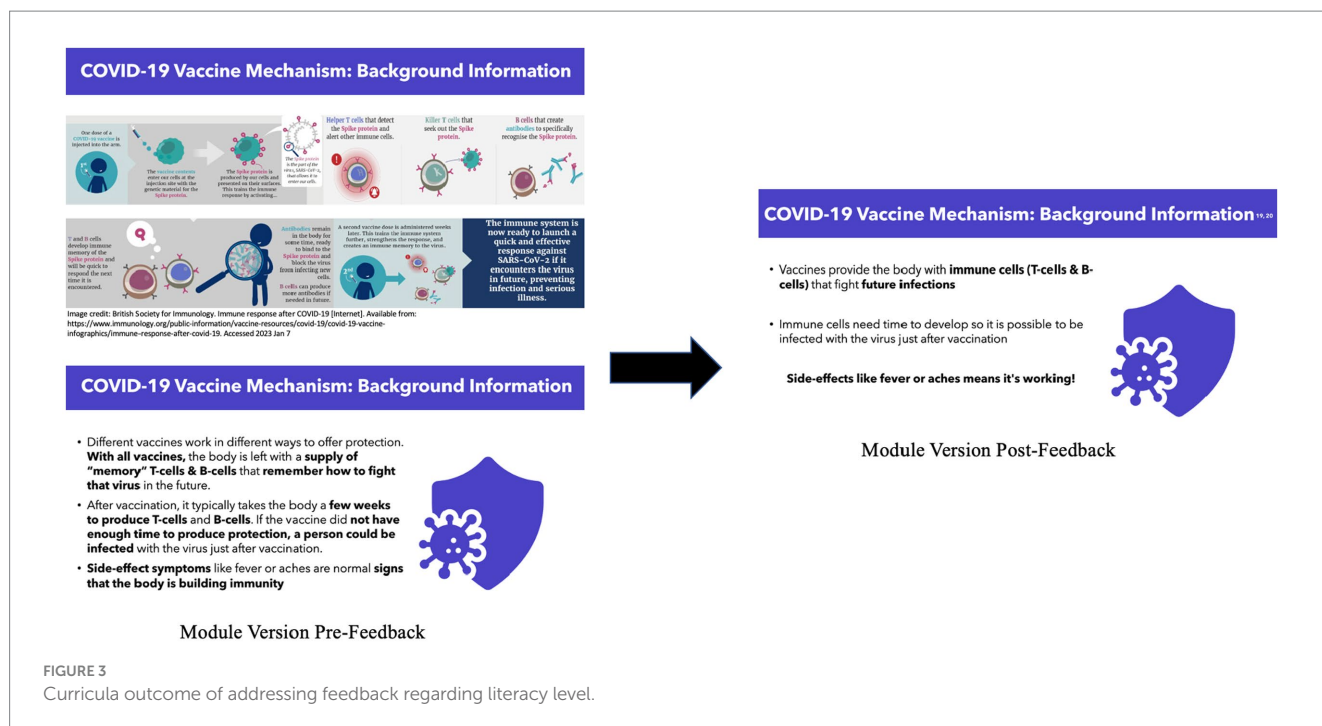
Curricula accessibility

During meetings with our community and academic partners, we identified certain language used in our curricula drafts that was too scientific or contained medical jargon, which would limit accessibility of our curricula to a broad audience (Figure 3). To enhance the materials’ comprehensibility and create an approachable learning environment, we revised the language used, replacing technical terminology with understandable terms (Figure 3). Several strategies were used to check on the literacy of the materials including having the curricula reviewed by individuals blinded to the curricula or intervention’s goals. A literacy check was conducted to ensure the language met the desired comprehension level of an 8th-grade student (26). Based on feedback and comments about challenges understanding biomedical terminology, we also created a glossary to define terms such as “beneficence” or “variant” to further achieve this goal.

Curricula tone

In our meetings, we frequently discussed the tone of the curricula, particularly the version with the racial justice lens. Initially, the feedback from our community and academic partners was that this curriculum lens could be perceived as disheartening and demoralizing notably when discussing racial bias or discrimination Black individuals encounter. In response, we made this curriculum’s language empowering and removed images that elicited feelings of disillusionment identified by community members as problematic (Figure 4). We changed the language used in the curriculum from having an individualized perspective,





removing any individualized culpability and instead, created a sense of collective responsibility. For example, rather than stating, “here’s what you need to do to become healthier,” we revised the curriculum to describe a collective “we” as in “here’s how we can be healthier.” In addition, we added information about current initiatives within the healthcare system that address issues such as medical mistrust and bias to further decrease feelings of frustration or defeat for curricula learners.

We addressed feedback about the lecture-based tone of both curricula by making the modules more interactive with content checks and multiple choice/true or false questions, and specifically created a module to practice anticipated conversations using role play.

Learning assessment

To assess POLs curricular knowledge retention following training, we followed the format of previous research where a curriculum was developed for POLs to promote familiarity of clinical trials and research methods to Black individuals with Lupus (27). Similar to that study, each module in our curricula contained pre- and post-test questionnaires to assess POLs’ knowledge acquisition. Each curriculum had similar questions testing core competencies, but also contained additional questions specific to that curriculum’s lens. These test questions had a format of multiple choice, short answer, and true or false per feedback from the previous POL study suggesting only utilizing a multiple-choice format was intimidating (27). These questions, along with the curricula slides, were sent to our community and academic partners to review. They were asked to assess the clarity and simplicity of the questions with space to offer suggestions for improvement, which were then incorporated into the pre- and post-tests (Supplementary Table 1).

Results: curricula design

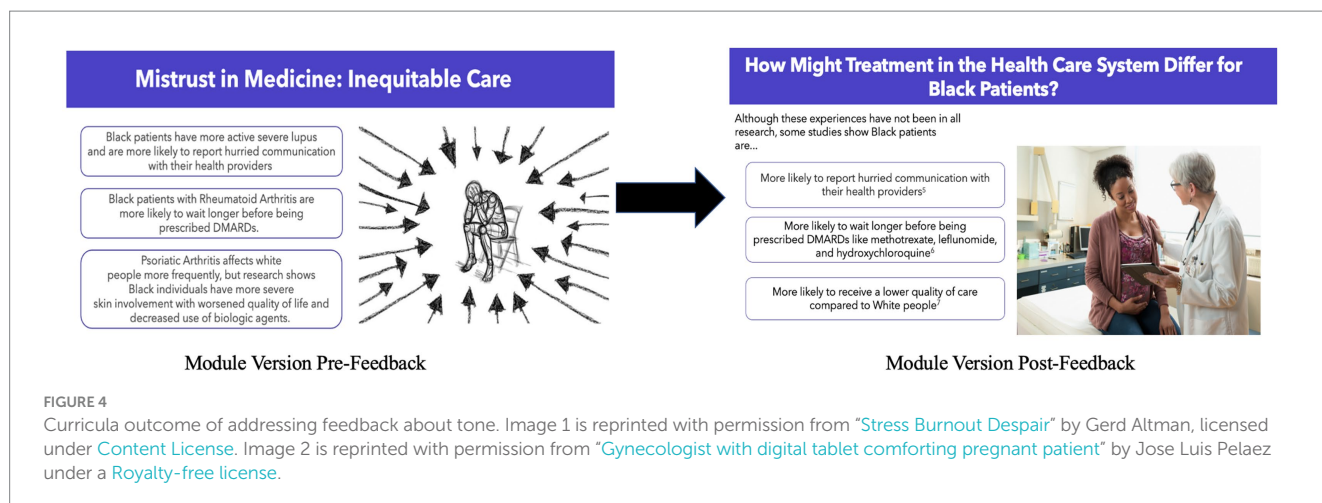
Following an iterative process with our community and academic partners over a period of a year, we developed two virtual curricula with shared core content, but two different theoretical lenses. Each curriculum contained five distinct modules as described below. The curricula both provide education about the development of the COVID-19 vaccine and address COVID-19 misinformation. The modules with a racial justice lens describe the origins of vaccine hesitancy among the Black population and the health care system’s role informing this belief, whereas the curriculum with a biomedical lens explores the importance of preventative care and highlights the COVID-19 vaccine as a tool in reducing an individual’s adverse health outcomes.

Modules description

Module I: We described the role of POLs as trusted individuals within their social networks. These modules discussed how these individuals will influence and promote healthy behaviors in their communities.

Module II: We discussed the mechanism and development of the COVID-19 vaccine, detailing its side effects and safety profile (Figure 3). These modules included information about COVID-19 risks, current epidemiology data, and education regarding various rheumatic disease presentations. The curriculum with the racial justice lens differed from the biomedical lens by specifically detailing COVID-19 risk in Black populations and provided trial data about Black individuals’ participation in the development of the COVID-19 vaccine.

Module III: We described common myths and provided evidence-based discussions to dispel misinformation about the



COVID-19 vaccine. Some myths discussed were concerns that the COVID-19 vaccine could cause COVID-19 infection and beliefs that there was an increased possibility or likelihood of getting severe side effects from the COVID-19 vaccine such as stroke, infertility, and sudden death. Other myths addressed included concerns about how quickly the COVID-19 vaccine was developed, beliefs about the presence of dangerous ingredients within the vaccine, and notions that the vaccine was a government ploy. The curriculum framed with the racial justice lens also addressed concerns regarding the diversity of individuals involved in developing and participating in the COVID-19 research clinical trials.

Module IV: The racial justice framed curriculum defined structural racism, discussed etiologies of current inequities in the COVID-19 infection risk and severity for the Black population, and addressed healthcare mistrust by acknowledging past injustices within the health care system and current methods for preventing recurrence (Figure 4). Short video recordings and visual art played prominent roles in this module to explain difficult and emotionally charged concepts. The module from the curriculum framed with the biomedical lens discussed general preventative care strategies including highlighting the importance of nutrition, physical activity, cancer screenings, and vaccinations for individuals with rheumatic conditions. The objective of this module was to describe the COVID-19 vaccine as a form of preventative care.

Module V: We emphasized the role POLs play as community researchers. We discussed data collection procedures, highlighting HIPAA and confidentiality.

Module VI: We provided a summary of the prior modules, revisiting any key information previously discussed. These modules included role play to reinforce previous teaching and allow POLs to practice having difficult conversations.

As of December 2024, we have recruited our POLs at both cities and randomized them to either receive the racial justice or biomedical framed curriculum for their training (19). We will begin teaching the POLs virtually mid- December and pre and post-tests will be administered for each module to ensure that the teaching is effective. POLs will then be asked to disseminate the information they learned through their social networks and COVID-19 vaccine uptake among network members will be assessed.

Discussion: implications for practice

Inequities in COVID-19 vaccination uptake have often been attributed to poorer access to the vaccine and misinformation regarding vaccine safety and testing (28). However, a critical factor is the strained relationship between the United States' healthcare system and Black communities due to longstanding discrimination and societal and healthcare injustices. Prior studies document that Black individuals are more likely to report hurried communication with their health providers and feel less cared for or listened to by their physicians (29, 30). These experiences coupled with historical and contemporary examples of racism and mistreatment have led to medical mistrust which ultimately play a key role in COVID-19 vaccine hesitancy (31). To address COVID-19 vaccine hesitancy and improve vaccine uptake among Black individuals, we have developed two virtual curricula that will equip community leaders across two cities who identify as Black to disseminate information about the COVID-19 vaccine and acknowledge concerns about the vaccine to hesitant Black individuals given prior and current racial injustices. The objectives of these curricula are to acknowledge the historical and current racial discrimination Black individuals encounter in the healthcare system, address the role these interactions have on COVID-19 vaccine hesitancy, and ultimately empower Black individuals to teach members of their social networks, through transparent and informative discussions, about the importance of getting vaccinated.

One of the innovative aspects of creating these curricula is the utilization of community and academic partnerships at every step of the developmental process to shape the curricula's content, accessibility, and tone. From previous work involving focus groups with community leaders and physician partners, we know that strategies to improve COVID-19 vaccine uptake in Black populations with rheumatic conditions must be motivational while acknowledging and addressing racial and social injustices (22). Prior studies have described the need for a social justice framework in public health education that adequately recognizes the effects of social inequities on health outcomes (23). Many researchers have developed anti-racist curricula to educate health professionals and equip them with tools to address health inequities (32–34). With our curricula, created by a diverse group of individuals motivated by the common mission to reduce inequities, we step outside of the health system into the community and focus attention on the

individuals affected by these inequities to create materials that are directly informed by their perspectives and experiences.

Another benefit of community engaged collaboration is the creative environment these interactions form that leads to the development and implementation of innovative ideas. Currently, the literature is lacking data on which curricular approach, the traditional biomedical or the racial justice model, is more successful for improving COVID-19 vaccine uptake among Black individuals. Creating two adjacent curricula with these two lenses addresses this gap by allowing for direct comparison to determine which perspective leads to knowledge acquisition and which leads to more effective knowledge dissemination to reduce inequities in COVID-19 vaccination. Independent of curricula perspective, developing these curricula addresses the urgent need for researchers in public health to find strategies that reduce COVID-19 vaccination inequities for Black individuals. However, creating a racial justice curriculum specifically acknowledges the population that lives with these inequities and establishes materials that directly caters to this group on a sociological, psychological, and cultural level. The COVID-19 pandemic only highlighted known racial and ethnic health inequities that are deeply rooted in our society. The iterative process used to develop these curricula acknowledges and addresses these inequities while providing useful information for future curricula development and interventions that address other health issues where we find similar inequities.

As with any curricula development, there were notable challenges in this process. One such challenge involved resolving conflicting ideas and suggestions between team members which is inevitable within collaborative efforts. Being cognizant of the etiologies of these suggestions along with the role life experiences played in each person's perspective led to learning opportunities that enriched this work and future perspectives. Though our curricula discuss concerns Black individuals have about the COVID-19 vaccine, we recognize the great heterogeneity within the United States Black population and note that our curricula do not represent the entirety of diverse perspectives and concerns within this group (5). However, due to structural racism, there are commonalities regarding concerns about the COVID-19 vaccine and the health care system generally that stem from similar experiences of racism that we hope to acknowledge and represent. Moreover, for our future intervention, we plan to recruit a diverse group of POLs to capture aspects of the diversity within the Black population.

Addressing COVID-19 vaccination uptake and decreasing vaccine hesitancy among Black individuals is essential. Strategies to improve health outcomes for Black individuals are most successful when trusted members from their communities are included in the development of these interventions. This collaboration, which can be replicated in other cities and countries, lays the groundwork for transparency and trust which increases the likelihood of creating impactful, effective, and culturally sensitive work.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Author contributions

EO: Writing – original draft, Writing – review & editing. GS: Writing – review & editing. TR: Writing – review & editing. MC: Writing – review & editing. AC: Writing – review & editing. MC-B: Writing – review & editing. GC: Writing – review & editing. AD: Writing – review & editing. MD: Writing – review & editing. AE: Writing – review & editing. NE: Writing – review & editing. DF: Writing – review & editing. DG: Writing – review & editing. GG: Writing – review & editing. MJ-J: Writing – review & editing. EL: Writing – review & editing. HM: Writing – review & editing. LM: Writing – review & editing. MN: Writing – review & editing. CN: Writing – review & editing. BO: Writing – review & editing. NP: Writing – review & editing. MT: Writing – review & editing. MS: Writing – review & editing. AV: Writing – review & editing. JW: Writing – review & editing. MY: Writing – review & editing. KM-C: Writing – review & editing. CF: Writing – review & editing. RR-G: Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. Research reported in this publication was supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institute of Health under award number R01 AR080089-01A1 to Northwestern (MPIs: Ramsey-Goldman; contact PI and Feldman).

Conflict of interest

Rosalind Ramsey-Goldman served as Chair of the Collaborative Initiatives Committee for the American College of Rheumatology. She consults for Merck, Biogen, Cabaletta, Exagen Diagnostics, Ampel Solutions, Clarivate, Upstart Research all less than \$10 K. She has consults for Duke University and the State University of New York, Syracuse. She is supported by the John P. Gallagher Research Professor of Rheumatology at Northwestern University, and she serves on the Medical and Scientific Advisory Council of the Lupus Foundation of America and on the Site Selection & Evaluation Committee for Lupus Therapeutics, an arm of the Lupus Research Alliance. She has received honoraria for lectures from Georgetown University, AstraZeneca, and the International Lupus meeting in Korea. Candace Feldman serves on the DEI Task Force for the Arthritis Foundation and the DEI Committee for the American College of Rheumatology. She consults for OM1, Inc., Bain Capital, LP, the Lupus Foundation of America, and the American College of Rheumatology, and previously consulted for Harvard Pilgrim and the University of Alabama. She serves on the Editorial Board of Arthritis Care & Research, as an Associate Editor for Lupus Science & Medicine and on the Medical and Scientific Advisory Council of the Lupus Foundation of America. Chisa Nosamiefan serves as a consultant with The Light Collective and is a member of the Brigham and Women's Hospital Patient Advisory Board.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1493331/full#supplementary-material>

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OPEN ACCESS

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RECEIVED 30 July 2024

ACCEPTED 10 March 2025

PUBLISHED 01 April 2025

CITATION

Low JM, Khoo EJ, Thong MK, Soo C, Tran AP, Lee LY and Cheah FC (2025) Comparative analysis of the role of healthcare beliefs on childhood vaccination uptake among parents in Malaysia and Singapore during the COVID-19 pandemic.

Front. Public Health 13:1470345.

doi: 10.3389/fpubh.2025.1470345

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Comparative analysis of the role of healthcare beliefs on childhood vaccination uptake among parents in Malaysia and Singapore during the COVID-19 pandemic

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Introduction: The rollout of successful vaccination programs during the COVID-19 pandemic has been impeded worldwide by high rates of vaccine hesitancy. We investigated vaccine hesitancy rates in Malaysia and Singapore, and explored whether these rates were associated with parents' health beliefs.

Methods: A total of 226 Malaysian parents (MPs) and 635 Singaporean parents (SPs) participated in an online voluntary survey between November 2021 and August 2022.

Results: MPs were younger and had more children compared to SPs. SPs were more likely to have received the COVID-19 vaccine than MPs, and less likely to delay vaccinations for their children. SPs displayed greater trust in information about vaccines, their children's doctors and healthcare authorities than MPs. Despite the similarities in ethnography and geographic proximity, the prevalence of perceived parental vaccine hesitancy was higher in Malaysia than in Singapore; this was associated with differences in healthcare beliefs.

Discussion: Beyond educational campaigns, strengthening community-based healthcare support, addressing misinformation, and fostering transparent communication from healthcare authorities may further enhance parental trust in vaccine.

KEYWORDS

COVID-19, health beliefs, paediatric vaccines, trust, vaccine hesitancy

1 Introduction

Vaccine hesitancy is a worldwide but complex phenomenon listed among the top ten threats to global health by the World Health Organization in 2019 (1). The COVID-19 pandemic has further compounded the various factors contributing to vaccine hesitancy, perhaps due to heightened public attention and scrutiny of news surrounding the accelerated development and approval of COVID-19 vaccines, as well as the potential spread of misinformation on social media. When the vaccines are offered to children, parents play an important role in making informed decisions for their child's well-being.

Prior to the COVID-19 pandemic, both Malaysia and Singapore reported high overall national immunization rates of up to 95% (2, 3). Previous studies have reported that up to 8.0% of Malaysian parents had concerns about vaccine safety and side effects, driven by cultural and religious factors as well as misinformation (2, 4, 5). Similarly, in Singapore, localized pockets of hesitancy have been observed primarily for paediatric influenza and pneumococcal vaccines (6). This largely stemmed from the common misconception among both parents and healthcare workers that these vaccines were primarily required only when traveling overseas.

In Malaysia, COVID-19 childhood vaccination was first offered to teenagers aged 12 years and older from September 15, 2021, and subsequently to children younger than 12 years from February 3, 2022 (7). The brands of vaccines used in Malaysia were from Pfizer (61.2%), Sinovac (29.8%), AstraZeneca (7.9%), and Cansino (0.3%) (8). In Singapore, its Ministry of Health approved the use of the paediatric dose of the Pfizer-BioNTech/Comirnaty vaccine for teenagers in June 2021, and for children aged 5–11 years in December 2021. However, the uptake of the paediatric COVID-19 vaccination was significantly lower compared to the rate of adult and adolescent vaccination (9).

In facing the continuing waves of COVID-19, it is important to address the various factors contributing to vaccine hesitancy amongst parents in societies with diverse cultural and socioeconomic contexts. Malaysia and Singapore are two adjacent countries with similar diverse populations but differing economic wealth. Analyzing the results of vaccine hesitancy rates in these countries can provide valuable insights into common areas of interest, the different risk factors, and the development of solutions identified when one country performs better than the other in terms of vaccine acceptance. These findings can inform health care policies and communitarian decisions that shape appropriate public health interventions in the future.

The aim of this study was to determine and compare the healthcare beliefs among parents of eligible children for COVID-19 vaccination in Malaysia and Singapore during the COVID-19 pandemic. We also aimed to compare the social and demographic features of parents who perceived themselves as more vaccine hesitant, to determine parental trust in their healthcare systems, and to identify the preferred type of vaccine that they would have had considered for their children.

2 Methods

The online cross-sectional study was conducted from November 2021 to August 2022 through a secure electronic platform. A prospective, anonymous, and voluntary electronic

survey modified from the previously developed “Measuring vaccine hesitancy: the development of a survey tool” was used (Supplementary Table 1), and it has been validated in a separate study (10). A translated version in Bahasa Melayu was utilized in Malaysia.

The study population consisted of parents of children who were hospitalized or attending outpatient clinics, as well as individuals who accessed the survey via links disseminated through official institutions' social media platforms or official email channels. The study excluded parents less than 21 years of age who may not yet be eligible for the COVID-19 vaccines. Respondents did not receive any compensation for participating in the study.

The survey obtained demographic data of respondents and their children, as well as information on vaccine hesitancy, parental trust in the healthcare system, and preferred COVID-19 vaccine. Results were analyzed using chi-square analysis and multiple logistic regression analysis with Statistical Programme for Social Sciences (SPSS), IBM version 27. Statistical significance was defined when $p < 0.05$ in two-tailed tests.

The calculation of the sample size was based on the formula by Kish (11) for population survey using the StatCalc in EpiInfo software. With an estimated combined adult population in Malaysia and Singapore of 29,520,000 in 2022, an acceptable margin of error of 5%, an expected vaccine hesitancy prevalence of 50% (to optimize the sample size in view of the lack of previous studies for the current topic in the region) and, a design effect of 2.0 for possible clustering in the sampling, the calculated minimum sample size needed to achieve 95% confidence level was 768. The final sample size achieved was 861 – oversampling was done in anticipation of the high probability of non-response and missing data among the subjects.

The study was registered with the ethics review boards of the following institutions: Malaysia's International Medical University (IMU) (reference no. 279/2021) and Universiti Kebangsaan Malaysia (UKM) (reference no. PPI/111/8/JEP-2021-824), as well as Singapore's National Healthcare Group Domain Specific Review Board (NHG DSRB) (reference no. 2021/00900). Completion of the survey indicated participants' consent to participate in the study.

3 Results

Supplementary Table 2 (unweighted) shows the demographic data of 861 parents who participated in the study, comprising 226 (26.2%) Malaysian parents (MPs) and 635 (73.8%) Singaporean parents (SPs). Due to the much higher non-response rate of the respondents in the Malaysian population than the Singapore population, post-stratification weight was determined based on the estimated adult population percentage ratio in both countries for the year 2022 (24,700,000 and 4,820,000, respectively). Based on the calculation explained by DeBell and Kronsnick (12). The post-stratification weight for respondents from Malaysia is 3.19 (0.8367/0.2625), whereas the post-stratification weight for respondents from Singapore is 0.22 (0.1633/0.7375). Due to this adjustment, all analyses would be shown with the unweighted and weighted results for comparison. For the weighted analyses in SPSS, the complex samples procedure was used whereby the sample weight was based on the post-stratification weight and the estimation of error was based on sampling with replacement design.

The findings show that MPs were generally younger, though the difference was not statistically significant (38.8 ± 8.8 vs. 39.1 ± 6.7 years, $p = 0.64$). Additionally, they had more children on average (2.4 ± 1.8 vs. 2.0 ± 0.8 , $p = 0.003$) compared to SPs (Supplementary Table 2). There were also statistical differences noted in their educational level ($p = 0.005$) (Table 1), with more SPs having tertiary education than MPs (50.9% vs. 38.9%) (Supplementary Table 2). In terms of employment, more SPs were involved in the healthcare-related industries and information technologies, and were homemakers, while more MPs worked in the education sector (Supplementary Table 2; Table 1). With regards to their religious affiliations, SPs were more likely to identify themselves as Catholic, Christian, or with no religious belief, whereas MPs were more likely from the Muslim faith (Supplementary Table 2; Table 1). Comparing their marital statuses, a higher proportion of SPs were married (Supplementary Table 2; Table 1). This study found no significant difference in the proportions of parents who were able to work from home during the pandemic lockdown (Table 1).

SPs were more likely to have received the COVID-19 vaccine themselves (99.1% vs. 96.5%, $p = 0.013$) and perceived themselves as less vaccine hesitant (5.8% vs. 16.4%, $p < 0.001$ for overall hesitancy categories) (Supplementary Table 2; Table 2). They were also less likely to delay vaccination for their children, although non-significant statistically (19.4% vs. 26.5%, $p = 0.507$ for overall delay categories), and perceived vaccine-preventable diseases as more severe (62.7% vs. 56.2%, $p = 0.008$ for overall perception categories) (Supplementary Table 2). More than one-third of MPs were “very concerned” that the vaccines may not actually prevent the disease (36.3% vs. 27.2%, $p = 0.010$ for overall “concern” categories) (Supplementary Table 2; Table 2). Of interest, perceived vaccine hesitancy was lower among SPs than MPs, although a significantly higher percentage of SPs knew of someone with a bad reaction to the vaccine (46.3% vs. 35.4%, $p = 0.005$) (Supplementary Table 2; Table 2).

The study also found that SPs were less likely to distrust the information that they received about vaccines (6.6% vs. 14.6%, $p < 0.001$ for overall “trust” categories) and were less likely to question the necessity of vaccinations for their child (5.5% vs. 12.8%, $p = 0.001$ for overall “agree” categories), compared to MPs (Supplementary Table 2; Table 2). However, most parents in both countries agreed that they were able to openly discuss their concerns about vaccinations with their child’s doctor. Approximately two-thirds of parents (65.5 and 65.2% in Malaysia and Singapore, respectively) agreed with the recommended childhood vaccination schedule by their government (Supplementary Table 2; Table 2).

As shown in Supplementary Table 3 (unweighted) and Table 3, 68.1% of MPs and 70.2% of SPs stated that they would give the COVID-19 vaccine to their child between 6–11 years of age ($p = 0.556$).

A higher proportion of parents expressed a willingness to vaccinate their teenager, with 79.2% of MPs and 82.8% of SPs indicating that they would do so ($p = 0.224$) (Supplementary Table 3). A significantly greater proportion of SPs than MPs expressed trust in information, advice, and recommendations regarding COVID-19 vaccination from their children’s doctors or healthcare authorities (80.8% vs. 69.9%, $p = 0.005$ for overall “source” categories) (Supplementary Table 3 and Table 3). Furthermore, respondents from both countries rated mRNA vaccines as the most effective in terms of preventing deaths and hospital admission compared to other types of

COVID-19 vaccines (45.6% for MPs vs. 60.6% for SPs, $p < 0.001$ for overall vaccine categories) (Supplementary Table 3; Table 3).

Table 4 (unweighted) shows a significantly higher proportion of perceived “very hesitant” parents in Malaysia compared to Singapore ($p < 0.001$). Furthermore, parents of Muslim faith exhibited a higher likelihood of perceived vaccine hesitancy compared to other religions (47.4% Muslims accounts for very hesitant group vs. 29.5% Muslims accounts for non-hesitant or somewhat hesitant group, $p = 0.026$ for overall religion categories). A notable association was also found between trust in the child’s doctor and vaccine hesitancy ($p < 0.001$), where parents who were fully trusting in their child’s doctor were less likely to be classified as “very hesitant.” Correspondingly, parents who disagreed with their government’s ($p = 0.01$) and healthcare system/department’s ($p < 0.001$) management of the pandemic were more likely to be “very hesitant” about vaccines (Table 4).

Based on the multiple logistic regression analysis (Table 5) (unweighted), vaccine hesitancy was associated with (i) the lower income group (i.e., compared to the \$4,000 group, the other income groups have adjusted prevalence odds ratio below than 1); (ii) distrust of child’s doctor (i.e., those who trust their child doctor have adjusted prevalence odds ratio below than 1); and, (iii) perception that the healthcare system has not managed the COVID-19 pandemic well (i.e., those who agree that the healthcare system was successful have adjusted prevalence odds ratio below 1).

4 Discussion

This study findings suggest that there are significant differences in the COVID-19 vaccine health care beliefs among parents in the two neighboring Southeast Asian countries. Our results are aligned with other estimates from different countries in Asia where the level of parental vaccine hesitancy varies, reportedly ranging between 10.8 and 42.8% (10, 13–15).

Factors identified in our study showed that parental vaccination status, trust in their healthcare provider and system were key factors associated with differences in vaccine beliefs. These findings confirm the result of other authors. A cross-sectional nationwide survey of Malaysian parents also showed that parents’ history of COVID-19 vaccination was the strongest predictor of their willingness to vaccinate their children (7). Likewise, in Singapore, trust in the child’s doctors was rated more important than information obtained from social media despite the high media usage in the country (10).

As such, we recommend that in managing future pandemics, it is imperative for all primary health care providers to receive up to date accurate information for dissemination to the public during the clinic visits. Doing so will foster an environment of greater understanding and cooperation. It is also important that healthcare providers remain up to date and provide evidence-based reasoning with regards to vaccination strategies in the face of potential new variants.

Unsurprisingly, a critical factor undermining vaccine use was trust in healthcare systems (16). Parents might be aware of shortcomings in the healthcare systems, both currently and historically. There can also be suspicion that when financial gains are involved, it is not unreasonable for suspecting dishonesty from those producing, distributing or promoting the vaccine. This belief could potentially be influenced by profits generated from COVID-19 vaccination by the pharmaceutical companies (17). Recommendations

TABLE 1 Multiple logistic regression analysis comparing socio-demographics of parents surveyed in Malaysia and Singapore.

Independent variables ^a	Unweighted ^b (<i>n</i> = 848)		Weighted ^c (estimated <i>n</i> = 841)	
	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (Wald's test)	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (t-test)
Parent's age in years	0.96	<u>0.013</u>	0.95	<u>0.004</u>
Education level		<u>0.005</u>		
• Primary school or lower	Reference group	-	Reference group	-
• Secondary school/Institute of Technical Education (ITE)	3.09	0.14	1.32	0.67
• Junior college/polytechnic	2.06	0.32	1.24	0.71
• University degree	1.92	0.37	1.35	0.60
• Master's degree or above	0.88	0.86	0.49	0.23
Area of work		<u>0.007</u>		-
• Healthcare	Reference group	-	Reference group	0.34
• Financial	0.94	0.8	0.67	0.72
• Service industry	0.87	0.74	0.85	<u>0.003</u>
• Manufacturing	5.63	<u>0.011</u>	6.71	0.10
• Education	0.74	0.33	0.56	0.065
• Energy and infrastructure	0.55	0.16	0.40	0.29
• Information and communication technologies or biotechnology	2.09	0.087	1.62	<u>0.013</u>
• Transport	2.57	0.19	4.30	0.88
• Freelance/self-employed	1.37	0.51	0.90	0.18
• Homemaker or unemployed	2.18	0.054	1.82	-
Religion		<u><0.001</u>		
• Buddhism	Reference group	-	Reference group	-
• Catholic Christianity	14.44	<u>0.013</u>	20.3	<u>0.001</u>
• Other Christianity	1.73	0.089	2.25	<u>0.024</u>
• Hinduism	0.92	0.85	1.30	0.59
• Muslim	0.12	<u><0.001</u>	0.16	<u><0.001</u>
• Taoism	5.39	0.11	9.68	<u>0.003</u>
• No religion	8.69	<u><0.001</u>	14.13	<u><0.001</u>
• Others	0.38	0.29	0.89	0.89
Worked from home during lockdown period		<u>0.011</u>		
• No	Reference group	-	Reference group	-
• Partially	0.52	<u>0.017</u>	0.79	0.39
• Yes	0.43	<u>0.004</u>	0.55	0.061
Marital status				
• Married	Reference group	-	Reference group	-
• Others	0.18	<u><0.001</u>	0.17	<u><0.001</u>
Model assumptions tested				
• Ratio of cases to variables	Fulfilled		Fulfilled	
• Adequacy of expected frequencies and power	Fulfilled		Fulfilled	

(Continued)

TABLE 1 (Continued)

	Unweighted ^b (<i>n</i> = 848)		Weighted ^c (estimated <i>n</i> = 841)	
Independent variables ^a	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (Wald's test)	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (t-test)
• Absence of multicollinearity	Fulfilled		Fulfilled	
Model diagnostics				
• Hosmer-Lemeshow goodness-of-fit (<i>p</i> value)	0.115 (Acceptable model fit)		Cannot be tested in SPSS	
• Nagelkerke's pseudo <i>r</i> ²	0.42		0.40	
• Area under the receiver operating characteristic curve (AUC ROC) (<i>p</i> value)	0.85 (<u><0.001</u>) (moderately accurate model)		0.85 (<u><0.001</u>) (moderately accurate model)	

Underlined *p* value: statistically significant result at *p* < 0.05.

^aFinal independent variables from the stepwise unweighted multiple logistic regression done based on the initial variables in [Supplementary Table 2](#), whereby regrouping of categories in the variable was done if there was violation of the χ^2 test assumption of minimum expected frequencies. If the issue of the violation persisted even if the regrouping was done or if it was not possible, then the variable was removed from the initial variables list.

^bThe unweighted multiple logistic regression was done by backward stepwise (Wald test criteria) method.

^cThe weighted multiple logistic regression was done by forced entry method based on the significant variables in the unweighted model.

for boosters, vaccinations in the paediatric population who have been relatively spared from the COVID-19 pandemic may have only exacerbated negative vaccine belief sentiments amongst some individuals. Furthermore, rapid changes to policy statements, masking and isolation requirements, make vaccine hesitant parents more sceptical of the need for vaccine and its reliability.

The results of this survey indicate that perceived parental vaccine hesitancy was more prevalent in Malaysia than Singapore. The surveyed MPs trust of their doctors and healthcare system did not rate as high as the SPs, with a higher proportion of the MPs themselves remained unvaccinated against COVID-19. This finding is consistent with previous research that suggests vaccine hesitancy is more common in developing countries where one of the reasons for this may be related to the level of health literacy (18). Dubov et al. identified four groups of vaccine-hesitant individuals, including the misinformed, uninformed, undecided and unconcerned (19). Identification would allow for tailored individualized interventions to each (19). For example, personal analogies may be more effective for the “misinformed” individual, while motivational interviewing may be better suited for the “undecided” cluster. The study also found that Muslim parents were more likely to be “very hesitant” towards COVID-19 vaccines than parents of other religions. This result may be attributed to the predominant Muslim faith among MPs although this finding is also consistent with another similar online cross-sectional study conducted in ten countries in Asia, Africa, and South America earlier in the pandemic (20). However, parents' age, gender, educational level, and marital status were not significantly associated with vaccine hesitancy in this study. This contrasts with other research that reported these demographic factors to be associated with vaccine hesitancy (21, 22). A possible explanation for these results may be a preponderance of respondents from urban communities in this study.

Our findings reveal that parental vaccine hesitancy is driven by a complex interplay of parental concerns and beliefs. Apart from trust in health information and the healthcare system, the way parents perceive the severity of vaccine-preventable diseases can drive their decision making. Our results show that SPs, who are more likely to

perceive these complications as severe, have lower levels of hesitancy. This may be attributed to a higher parental health literacy level in a generally more educated population. This perception may be reinforced by social norms and the influence of healthcare professionals, who strive to effectively convey the importance of vaccination.

It was also reflected in our survey that a large proportion of parents surveyed in both countries agreed with the recommended childhood vaccination schedule by their government whilst holding back on vaccinating their child against COVID-19. We speculate that some parents may view vaccinating against COVID-19 as separate and unrelated, possibly due to the novelty of the mRNA technology and the rapidity of the development. This concurs with other published literature which have also shown that vaccine beliefs are not a stable trait (23). Some may also wrongly classify the vaccine as “experimental” and may feel that they do not want to subject their child to an ongoing experiment even though monitoring of adverse events after FDA approval is a standard procedure for all pharmaceuticals (24). On the other spectrum of things and contrary to these perceptions, parents in this study rated mRNA vaccines as the “most effective” in terms of preventing deaths and hospital admission compared to other types of COVID-19 vaccines. The reason for this is not clear but it may have something to do with the efficacy data of mRNA vaccines from clinical trials and real-world studies. In contrast, 1 in 6 surveyed parent perceived inactivated and non-replicating viral vector vaccines are most effective in preventing death and hospital admission with almost 40% of the parents believed they have the least side effects. Such vaccines are used in some other developing countries for children, and perhaps by having more options available, this may increase the vaccine uptake.

To address this issue of vaccine-hesitancy, effective communication strategies that address key concerns from stakeholders are crucial. A systematic review of interventions has revealed that the most successful campaigns are those that are dialogue-based and multi-pronged (25). Healthcare policy makers should also leverage on routine childhood immunization visits at community health centres

TABLE 2 Multiple logistic regression analysis comparing parental views on childhood immunizations in Malaysia and Singapore.

Independent variables ^a	Unweighted ^b (<i>n</i> = 861)		Weighted ^c (estimated <i>n</i> =861)	
	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (Wald's test)	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (t-test)
Identified as vaccine hesitant for childhood vaccines (%)		<u>0.001</u>		
• Not hesitant	Reference group	-	Reference group	-
• Somewhat hesitant	1.12	0.59	0.99	0.98
• Very hesitant	0.40	<u>0.001</u>	0.36	<u>0.001</u>
Level of concern that vaccine might not be able to prevent disease		0.062		
• Not concerned	Reference group	-	Reference group	-
• Somewhat concerned	0.70	0.11	0.75	0.23
• Very concerned	0.55	<u>0.018</u>	0.58	<u>0.046</u>
Known someone with a bad reaction to a vaccine				
• Yes	1.99	<u><0.001</u>	1.87	<u>0.001</u>
• No	Reference group	-	Reference group	-
The only reason why I consented for my child to receive vaccinations is because it is a mandated requirement for day-care/school		<u>0.004</u>		
• Disagree	Reference group	-	Reference group	-
• Ambivalent	0.54	<u>0.004</u>	0.50	<u>0.004</u>
• Agree	0.54	<u>0.005</u>	0.51	<u>0.004</u>
I trust the information I received about vaccins.		<u><0.001</u>		
• Disagree	Reference group	-	Reference group	-
• Somewhat agree/disagree	3.08	<u><0.001</u>	3.38	<u><0.001</u>
• Agree	2.75	<u>0.001</u>	2.94	<u>0.001</u>
It is my role as a parent to question the need for vaccines administered to my child		<u><0.001</u>		
• Disagree	Reference group	-	Reference group	-
• Ambivalent	3.77	<u><0.001</u>	3.70	<u><0.001</u>
• Agree	3.75	<u><0.001</u>	3.54	<u><0.001</u>
I am able to openly discuss my concerns about vaccinations with my child's doctor				
• Yes	0.55	0.071	0.72	0.37
• No	Reference group	-	Reference group	-
Model assumptions tested				
• Ratio of cases to variables	Fulfilled		Fulfilled	
• Adequacy of expected frequencies and power	Fulfilled		Fulfilled	
• Absence of multicollinearity	Fulfilled		Fulfilled	
Model diagnostics				
• Hosmer-Lemeshow goodness-of-fit <i>p</i> value	0.611 (acceptable model fit)		Cannot be tested in SPSS	
• Nagelkerke's pseudo <i>r</i> ²	0.13		0.11	
• Area under the receiver operating characteristic curve (AUC ROC) (<i>p</i> value)	0.70 (< <u>0.001</u>) (Moderately accurate model)		0.70 (< <u>0.001</u>) (moderately accurate model)	

Underlined *p* value: statistically significant result at *p* < 0.05.

^aFinal independent variables from the stepwise unweighted multiple logistic regression done based on the initial variables in [Supplementary Table 3](#), whereby regrouping of categories in the variable was done if there was violation of the χ^2 test assumption of minimum expected frequencies. If the issue of the violation persisted even if the regrouping was done or if it was not possible, then the variable was removed from the initial variables list.

^bThe unweighted multiple logistic regression was done by backward stepwise (Wald test criteria) method.

^cThe weighted multiple logistic regression was done by forced entry method based on the significant variables in the unweighted model.

TABLE 3 Multiple logistic regression analysis of factors associated with vaccine hesitancy among parents in Malaysia and Singapore.

Independent variables ^a	Unweighted ^b (n = 850)		Weighted ^c (estimated n = 856)	
	Adjusted prevalence odds ratio (being in the very Hesitant of vaccination group)	p value of adjusted prevalence odds ratio (Wald's test)	Adjusted prevalence odds ratio (being in the very Hesitant of vaccination group)	p value of adjusted prevalence odds ratio (t-test)
Family monthly income (SGD)		<u>≤ 0.001</u>		
• Below \$4,000	Reference group	-	Reference group	-
• \$4,000–\$9,999	0.41	<u>0.004</u>	0.27	<u>0.011</u>
• \$10,000–\$14,999	0.14	<u>≤ 0.001</u>	0.37	0.23
• \$15,000–\$19,999	0.45	0.12	0.22	<u>0.008</u>
• \$20,000 or above	0.21	<u>0.012</u>	0.15	<u>0.003</u>
Marital status				
• Married	Reference group	-	Reference group	-
• Others (single, divorce, separated)	0.25	0.079	0.49	0.35
Do you trust your child's doctor?				
• Yes (somewhat trust, Fully trust)	0.12	<u>0.002</u>	0.09	<u>0.006</u>
• No (distrust)	Reference group	-	Reference group	-
The healthcare system has managed the COVID-19 pandemic well				
• Yes (agree, somewhat agree, fully agree)	0.41	<u>0.018</u>	0.54	0.22
• No (do not agree, somewhat disagree)	Reference group	-	Reference group	-
Model assumptions tested				
• Ratio of cases to variables	Fulfilled		Fulfilled	
• Adequacy of expected frequencies and power	Fulfilled		Fulfilled	
• Absence of multicollinearity	Fulfilled		Fulfilled	
Model diagnostics				
• Hosmer-Lemeshow goodness-of-fit p value	0.770 (acceptable model fit)		Cannot be tested in SPSS	
• Nagelkerke's pseudo r ²	0.16		0.18	
• Area under the receiver operating characteristic curve (AUC ROC) (p value)	0.75 (< <u>0.001</u>) (moderately accurate model)		0.69 (< <u>0.001</u>) (less accurate model)	

Underlined p value: statistically significant result at $p < 0.05$.

^aFinal independent variables from the stepwise unweighted multiple logistic regression done based on the initial variables in [Supplementary Table 4](#), whereby regrouping of categories in the variable was done if there was violation of the χ^2 test assumption of minimum expected frequencies. If the issue of the violation persisted even if the regrouping was done or if it was not possible, then the variable was removed from the initial variables list.

^bThe unweighted multiple logistic regression was done by backward stepwise (Wald test criteria) method.

^cThe weighted multiple logistic regression was done by forced entry method based on the significant variables in the unweighted model.

or private health facilities to engage and get the buy-in from this group of parents. Finally, infotainment products in various languages may be used as an outreach strategy to supplement these efforts and specific media campaigns can be optimized to the type of vaccine attitude amongst different individuals who might be unsure or willing (26).

Strengths of this study include a detailed comparative analysis exploring the role of healthcare beliefs on childhood vaccination uptake between two countries with similarities in ethnography and geographic proximity between these two countries. This study may provide insights in the event of future pandemics to help fill the gaps between public engagement and health care beliefs of parents when it

comes to administering novel vaccines to their children in the light of a pandemic.

We acknowledge some of the limitations of this survey. Firstly, this study was static and may not capture the rapidly evolving reality in the science, understanding, disease statistics and vaccination coverage during this COVID-19 pandemic. Secondly, the rather small sample size of parents who participated, may not be entirely representative of the views of the population especially in the geographically vaster Malaysia. A larger study involving other Asian countries with diverse socioeconomic backgrounds may allow for more in depth examination of the factors that influence vaccine hesitancy, which is a global health problem. In

TABLE 4 Descriptive analyses of factors associated with perceived vaccine hesitancy among parents in Malaysia and Singapore.

	Unweighted			Weighted		
Variables	Not hesitant or somewhat hesitant parents, <i>n</i> = 787 unless otherwise stated (%)	Very hesitant parents, <i>n</i> = 74 unless otherwise stated (%)	<i>p</i> -value (χ^2 test)	Not hesitant or somewhat hesitant parents, estimated <i>n</i> = 734 unless otherwise stated (%)	Very hesitant parents, estimated <i>n</i> = 126 unless otherwise stated (%)	<i>p</i> -value [weighted χ^2 test (Rao-Scott adjusted)]
Country						
• Malaysia	189 (24.0)	37 (50.0)	<u>≤ 0.001</u>	603 (82.1)**	118 (93.5)**	<u>≤0.001</u>
• Singapore	598 (76.0)	37 (50.0)		131 (17.9)**	8 (6.5)**	
Gender						
• Female	506 (64.3)	46 (62.2)	0.72	390 (53.2)**	72 (57.5)**	0.61
• Male	281 (35.7)	28 (37.8)		344 (46.8)**	54 (42.5)**	
Place of birth of parent						
• Singapore	435 (55.3)	23 (31.1)	<0.001 [§]	99 (13.4)**	5 (4.0)**	0.18
• Malaysia	234 (29.7)	41 (55.4)		577 (78.6)**	113 (89.5)**	
• India, Sri Lanka, Pakistan	40 (5.1)	5 (6.8)		27 (3.6)**	4 (3.2)**	
• China, Taiwan, Hong Kong, Japan	21 (2.7)	3 (4.1)		5 (0.6)**	1 (0.5)**	
• Other South-East Asia countries	36 (4.6)	2 (2.7)		11 (1.5)**	3 (2.7)**	
• Australia, New Zealand, USA, European countries, South American countries	21 (2.7)	0 (0.0)		17 (2.2)**	0 (0.0)**	
Age of parent						
	<i>n</i> =783	<i>n</i> =72	0.65	<i>n</i> =722	<i>n</i> =120	0.61
• ≤30 years	64 (8.2)	7 (6.0)		82 (11.4)**	10 (8.7)**	
• >30 years	719 (91.8)	65 (90.3)		639 (88.6)**	109 (91.3)**	
Education level						
• Primary education or lower	13 (1.7)	2 (2.7)	0.068	18 (2.4)**	3 (2.7)**	0.49
• Secondary school or ITE	63 (8.0)	12 (16.2)		61 (8.4)**	20 (16.2)**	
• Junior college or polytechnic	126 (16.0)	11 (14.9)		135 (18.3)**	23 (18.4)**	
• University degree	374 (47.5)	37 (50.0)		299 (40.7)**	53 (41.8)**	
• Masters and above	211 (26.8)	12 (16.2)		222 (30.2)**	26 (20.9)**	

(Continued)

TABLE 4 (Continued)

Variables	Unweighted			Weighted		
	Not hesitant or somewhat hesitant parents, <i>n</i> = 787 unless otherwise stated (%)	Very hesitant parents, <i>n</i> = 74 unless otherwise stated (%)	<i>p</i> -value (χ^2 test)	Not hesitant or somewhat hesitant parents, estimated <i>n</i> = 734 unless otherwise stated (%)	Very hesitant parents, estimated <i>n</i> = 126 unless otherwise stated (%)	<i>p</i> -value [weighted χ^2 test (Rao-Scott adjusted)]
Religion						
• Buddhism	145 (18.4)	13 (16.7)	<u>0.026^s</u>	112 (15.3) ^{##}	12 (9.3) ^{##}	<u>0.032</u>
• Catholic Christianity	41 (5.2)	3 (3.8)		12 (1.6) ^{##}	1 (0.5) ^{##}	
• Other Christianity	165 (21.0)	8(10.3)		108 (14.6) ^{##}	5 (3.7) ^{##}	
• Hinduism	48 (6.1)	5 (6.4)		40 (5.5) ^{##}	7 (5.6) ^{##}	
• Islam	232 (29.5)	37 (47.4)		404 (55.1) ^{##}	100 (79.4) ^{##}	
• Taoism	27 (3.4)	0 (0.0)		9 (1.2) ^{##}	0 (0.0) ^{##}	
• No religion	123 (15.6)	8(10.3)		39 (5.3) ^{##}	2 (1.4) ^{##}	
• Others	6 (0.1)	0 (0.0)		10 (1.4) ^{##}	0 (0.0) ^{##}	
Family monthly income (SGD)	<i>n</i> = 784	<i>n</i> = 74	<u>≤ 0.001</u>	<i>n</i> = 725	<i>n</i> = 126	<u>0.003</u>
• Below \$4,000	203 (25.9)	42 (56.7)		493 (68.0) ^{##}	113 (89.7) ^{##}	
• \$4,000–\$9,999	269 (34.3)	20 (27.0)		133 (18.4) ^{##}	7 (5.8) ^{##}	
• \$10,000–\$14,999	163 (20.8)	4 (5.4)		48 (6.6) ^{##}	4 (3.1) ^{##}	
• \$15,000–\$19,999	67 (8.5)	5 (6.8)		27 (3.7) ^{##}	1 (0.9) ^{##}	
• \$20,000 or above	82 (10.5)	3 (4.1)		24 (3.3) ^{##}	1 (0.5) ^{##}	
Type of housing	<i>n</i> = 598	<i>n</i> = 37	<u>0.024^s</u>	<i>n</i> = 132	<i>n</i> = 8	<u>≤0.001</u>
• Government HDB rental housing	25 (4.2)	3 (8.1)		6 (4.2) ^{##}	1 (8.1) ^{##}	
• HDB 1–3 room flat	45 (7.5)	4 (10.8)		10 (7.5) ^{##}	1 (10.8) ^{##}	
• HDB 4–5 room flat/executive condominium	346 (57.9)	20 (54.1)		76 (57.9) ^{##}	4 (54.1) ^{##}	
• Maisonette	10 (1.7)	0 (0.0)		2 (1.7) ^{##}	0 (0.0) ^{##}	
• Private condominium/landed property	171 (28.6)	8 (21.6)		38 (28.6) ^{##}	2 (21.6) ^{##}	
• Others	1 (0.2)	2 (5.4)		1 (0.2) ^{##}	1 (5.4) ^{##}	

(Continued)

TABLE 4 (Continued)

	Unweighted			Weighted		
Variables	Not hesitant or somewhat hesitant parents, <i>n</i> = 787 unless otherwise stated (%)	Very hesitant parents, <i>n</i> = 74 unless otherwise stated (%)	<i>p</i> -value (χ^2 test)	Not hesitant or somewhat hesitant parents, estimated <i>n</i> = 734 unless otherwise stated (%)	Very hesitant parents, estimated <i>n</i> = 126 unless otherwise stated (%)	<i>p</i> -value [weighted χ^2 test (Rao-Scott adjusted)]
Marital status	<i>n</i> = 785	<i>n</i> = 74	0.67 [§]	<i>n</i> = 728	<i>n</i> = 126	0.63
• Single	16 (2.0)	2 (2.7)		36 (5.0) ^{**}	6 (5.1) ^{**}	
• Married	746 (95.0)	72 (97.3)		663 (91.1) ^{**}	120 (94.9) ^{**}	
• Divorced	17 (2.2)	0 (0.0)		16 (2.1) ^{**}	0 (0.0) ^{**}	
• Separated	6 (0.8)	0 (0.0)		13 (1.8) ^{**}	0 (0.0) ^{**}	
Have you received your COVID-19 vaccination?						
• Yes	780 (99.1)	67 (90.5)	<u>≤ 0.001</u> [§]	724 (98.6) ^{**}	110 (87.0) ^{**}	<u>≤0.001</u>
• No	7 (0.9)	7 (9.5)		10 (1.4) ^{**}	16 (13.0) ^{**}	
Trust in Child’s doctor	<i>n</i> = 785	<i>n</i> = 74	<u>≤ 0.001</u>			<u>≤0.001</u>
• Distrust	4 (0.5)	9 (12.2)		7 (0.9) ^{**}	23 (18.0) ^{**}	
• Somewhat Trust	301 (38.3)	37 (50.0)		259 (35.6) ^{**}	62 (48.8) ^{**}	
• Fully Trust	480 (61.1)	28 (37.8)		462 (63.5) ^{**}	42 (33.1) ^{**}	
My government had managed the pandemic well						
• Do not agree	42 (5.3)	11 (14.9)	<u>0.016</u> [§]	72 (9.7) ^{**}	29 (23.1) ^{**}	0.18
• Somewhat disagree	69 (8.8)	9 (12.1)		92 (12.6) ^{**}	14 (11.0) ^{**}	
• Agree	41 (5.2)	5 (6.8)		45 (6.1) ^{**}	7 (5.6) ^{**}	
• Somewhat agree	369 (46.9)	26 (35.1)		307 (41.8) ^{**}	44 (35.1) ^{**}	
• Fully agree	266 (33.8)	23 (31.1)		219 (29.8) ^{**}	32 (25.2) ^{**}	
My country healthcare system/health department has managed the pandemic well						
• Do not agree	19 (2.4)	13 (17.6)	<u>≤ 0.001</u> [§]	43 (5.8) ^{**}	36 (28.2) ^{**}	<u>≤0.001</u>
• Somewhat disagree	36 (4.5)	5 (6.8)		47 (6.3) ^{**}	4 (3.2) ^{**}	
• Agree	66 (8.4)	7 (9.4)		80 (10.9) ^{**}	10 (8.3) ^{**}	
• Somewhat agree	239 (30.4)	17 (23.0)		266 (36.3) ^{**}	33 (26.5) ^{**}	
• Fully agree	427 (54.3)	32 (43.2)		299 (40.7) ^{**}	43 (33.8) ^{**}	

Underlined *p* value: statistically significant result at *p* < 0.05 (2-tailed); *Independent t-test; ** Weighted general linear model; ^Independent t-test with a Satterthwaite approximation for degree of freedom due to unequal variance; * Estimated mean ± Standard deviation; ** Estimated frequency (%); §Fisher's exact test done due to violation of χ^2 test assumption of minimum expected frequencies.

TABLE 5 Multiple logistic regression analysis of willingness to vaccinate their children against COVID-19, trust in the healthcare system and preferences for vaccine type.

Independent variables ^a	Unweighted ^b (<i>n</i> = 861)		Weighted ^c (estimated <i>n</i> = 861)	
	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (Wald's test)	Adjusted prevalence odds ratio (being in the Singapore parents group)	<i>p</i> value of adjusted prevalence odds ratio (t-test)
Would you give the COVID-19 vaccine to your child between 6–11 years old?				
• Yes	0.61	<u>0.022</u>	0.77	0.24
• No	Reference group	-	Reference group	-
My government has managed the COVID-19 pandemic well				
• Yes	1.88	<u>0.032</u>	2.28	<u>0.012</u>
• No	Reference group	-	Reference group	-
The healthcare system has managed the COVID-19 pandemic well				
• Yes	2.34	<u>0.016</u>	2.41	<u>0.032</u>
• No	Reference group	-	Reference group	-
Which source of information about safety and effectiveness of COVID-19 vaccines do you trust most?				
• Government & health department	Reference group	-	Reference group	-
• Television and radio	0.42	<u>0.002</u>	0.34	<u>0.001</u>
• Social Media (including Facebook) or YouTube and Blog	1.39	0.36	1.65	0.22
• Messaging platforms (including WhatsApp, WeChat, Telegram platforms)	0.76	0.45	0.81	0.58
Which of the following vaccines do you think has the least side effects?				
• Inactivated vaccines	Reference group	-	Reference group	-
• Non-replicating viral vectors vaccines	0.39	<u>0.030</u>	0.31	<u>0.007</u>
• mRNA vaccines	1.12	0.61	1.03	0.90
• Protein subunit vaccines or DNA vaccine type	2.54	0.11	3.90	<u>0.013</u>
• Which of the vaccines do you think is the most effective (i.e., best prevent you from dying or requiring hospital admission)?				
• Inactivated vaccines	Reference group	-	Reference group	-
• Non-replicating viral vectors vaccines	0.33	<u>0.019</u>	0.39	<u>0.045</u>
• mRNA vaccines	2.99	<u><0.001</u>	3.45	<u><0.001</u>
• Protein subunit vaccines or DNA vaccine type	2.64	0.162	3.17	0.103
Model assumptions tested				
• Ratio of cases to variables	Fulfilled		Fulfilled	
• Adequacy of expected frequencies and power	Fulfilled		Fulfilled	
• Absence of multicollinearity	Fulfilled		Fulfilled	
Model diagnostics				
• Hosmer-Lemeshow goodness-of-fit (<i>p</i> value)	0.233 (acceptable model fit)		Cannot be tested in SPSS	
• Nagelkerke's pseudo <i>r</i> ²	0.22		0.17	
• Area under the receiver operating characteristic curve (AUC ROC) (<i>p</i> value)	0.74 (<0.001) (moderately accurate model)		0.74 (<0.001) (moderately accurate model)	

Inactivated vaccines (e.g., Sinovac, Sinopharm, Bharat), mRNA vaccines (e.g., Pfizer/BioNTech, Moderna, Curevac), Protein subunit (e.g., Novavax), DNA (e.g., ZyCoV-D); Underlined *p* value: statistically significant result at *p* < 0.05.

^aFinal independent variables from the stepwise unweighted multiple logistic regression done based on the initial variables in [Supplementary Table 4](#), whereby regrouping of categories in the variable was done if there was violation of the χ^2 test assumption of minimum expected frequencies. If the issue of the violation persisted even if the regrouping was done or if it was not possible, then the variable was removed from the initial variables list.

^bThe unweighted multiple logistic regression was done by backward stepwise (Wald test criteria) method.

^cThe weighted multiple logistic regression was done by forced entry method based on the significant variables in the unweighted model.

addition, a deeper exploration of how public health initiatives shape parental attitudes towards vaccination would enhance this report. However, the aim of our study was to examine parental healthcare beliefs regarding COVID-19 vaccination. As such, our data did not include measures capturing the influence of different public health approaches. Lastly, compared to Malaysia, Singapore is characterized by a much smaller geographic area, higher per capita income, and centralized healthcare system. Thus, the vaccine supply chain may be more streamlined in Singapore, ensuring rapid and widespread access. Such robust infrastructure may have contributed to the higher levels of trust observed amongst Singaporean parents. In contrast, while Malaysia has made significant strides in its national immunization program, the country's larger and more geographically diverse landscape may pose unique logistical challenges.

In conclusion, our study highlighted the importance of healthcare providers in promoting vaccine acceptance and addressing vaccine hesitancy, and the importance of effective communication and public health messaging in this respect. Despite the proximity of these two countries that share many ethnographic similarities, perceived parental vaccine hesitancy is more common in Malaysia than Singapore because of different healthcare beliefs. Increasing educational efforts and public health awareness campaigns may be an approach to increase parental trust to improve the uptake of COVID-19 vaccinations in the paediatric population. Future research should explore and identify effective strategies for promoting vaccine acceptance.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by International Medical University (IMU), MalaysiaUniversiti Kebangsaan Malaysia (UKM), MalaysiaNational Healthcare Group Domain Specific Review Board, Singapore. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JL: Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing. EK: Data curation, Formal analysis, Methodology, Project administration, Resources, Validation, Writing – review & editing. MT: Data curation, Formal analysis, Methodology, Project administration, Resources, Validation, Writing – review & editing. CS: Writing – review & editing. AT: Data curation, Formal analysis, Methodology, Project administration, Resources, Validation, Writing – review & editing. LL: Conceptualization, Data curation, Formal analysis, Funding

acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. FC: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. The Malaysian component of this survey was partially funded with an unrestricted educational grant provided to the College of Paediatrics, Academy of Medicine of Malaysia, which was disbursed to Cheah FC in UKM as project lead (FF-2021-481). Jia Ming Low received funding from the National University Health System (NUHS), Singapore, Clinician Scientist Program 2.0 (grant reference no.: NCSP2.0/2023/PVO/LJM) and the National Medical Research Council (Singapore) Research Training Fellowship (MH 095:003/008-337) to support this work.

Acknowledgments

The authors of this paper would like to thank (1) all the study participants who donated their time generously to complete the survey, (2) the doctors and nurses involved for their assistance in approaching the potential survey respondents for this study, (3) Dr. Jia Min Leong for her technical help, and (4) Ms. Sheena Nishanti Ramasamy for her assistance in formatting and submitting the manuscript. We accord our many thanks to our biostatistician, Mr. Boekhtiar Borhanuddin, Director & Chief Researcher at Boekh Statistical Solution, for his expert contribution to ensure the accuracy of the statistical computations in this paper. Finally, this paper is also dedicated to all the frontline healthcare providers who faced the pandemic in all its uncertainties and fought valiantly to protect their patients.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1470345/full#supplementary-material>

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