frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 12 August 2025
DOI 10.3389/fsufs.2025.1592661

OPEN ACCESS

EDITED BY
Anindya Chanda,
Mycologics LLC, United States

REVIEWED BY
Ramendra Pal,
Birla Institute of Technology and Science, India
Sarah Nanyiti,
National Crops Resources Research Institute (NaCRRI), Uganda

*CORRESPONDENCE
Jenifer Apil
✉ jenieapil@gmail.com

RECEIVED 12 March 2025
ACCEPTED 15 July 2025
PUBLISHED 12 August 2025

CITATION
Apil J, Mulugo L, Atekyereza P and Obaa B (2025) Cassava cyanide knowledge, risk perception, and adoption of preventive measures in Northwestern Uganda: a moderated mediation perspective. *Front. Sustain. Food Syst.* 9:1592661. doi: 10.3389/fsufs.2025.1592661

Cassava cyanide knowledge, risk perception, and adoption of preventive measures in Northwestern Uganda: a moderated mediation perspective

Jenifer Apil[1]*, Lucy Mulugo[1], Peter Atekyereza[2] and Bernard Obaa[1]

[1]Department of Extension and Innovation Studies, Makerere University, Kampala, Uganda, [2]Department of Sociology and Anthropology, School of Social Sciences, Makerere University, Kampala, Uganda

Background: With widely adequate efforts to promote food (cassava) safety, adoption still remains low. This study explored the knowledge of cassava cyanide poisoning, perceived threat, and adoption of preventive measures in Northwestern Uganda.

Methods: Data were collected using focus group discussions (10), in-depth individual interviews (10), and household interviews (420). Participants responded to a culturally specific questionnaire that comprised demographic inquiries and adapted questions from the qualitative findings on knowledge, perceived threat, and adoption of preventive measures.

Results: Perceived threat mediated the path between knowledge and the adoption of preventive measures, and the indirect effect was moderated by education and not gender. In other words, having knowledge of cassava cyanide poisoning was interconnected to the adoption of preventive measures through the risk perception of educated respondents.

Conclusion: From the Health Belief Model perspective, the study recommends that cassava cyanide poisoning responsiveness campaigns should hinge on raising awareness of the risk associated with cyanide poisoning to motivate households to adopt recommended preventive measures.

KEYWORDS

cassava cyanide knowledge, risk perception, preventive measures, Northwestern Uganda, adoption

1 Introduction

Cyanide is a natural toxic chemical compound that comprises acetone cyanohydrin, hydrogen cyanide (HCN), and cyanogenic glucosides (Long et al., 2020; Indrastuti et al., 2018). The toxic compounds cause adverse health impairments not limited to Konzo diseases, stunted growth in children, and cyanide poisoning (Baguma et al., 2021). The former is prevalent in several plants, including wild yams and cassava. Cassava (*Manihot esculenta Crantz*) is a drought-tolerant shrub recognized for its adaptability to various soil types and climatic conditions (Galford et al., 2020). The crop naturally produces cyanogenic glycosides, primarily linamarin (95%) and lotaustralin (5%), which serve as a defense mechanism against herbivores and pathogens (Mensah, 2022; Balagopalan et al., 1988; Panghal et al., 2021; Masamba et al., 2022). These secondary metabolites, while harmless when intact, pose a significant risk upon the plant's damage (Ballhorn et al., 2009). When cassava roots are harvested or their tissues are disrupted, a process known as cyanogenesis occurs (Poulton, 1990). During cyanogenesis, the enzyme linamarinase converts linamarin into hydrogen cyanide, a highly potent toxin (Anjum et al., 2022).

Cassava cultivars contain varying hydrogen cyanide levels. Bitter varieties can have dangerously high levels (up to 2,000 ppm of dry matter), while sweet varieties contain much lower levels [up to 100 ppm (Tumwesigye, 2014)]. The recommended safe limit is below 10 ppm (FAO/WHO, 1991). Doses exceeding 112–140 ppm can be fatal within an hour, 140 ppm within half an hour, and 188 ppm within 10 min (Simeonova and Fishbein, 2004). Even small amounts of cyanide, with prolonged exposure, can lead to poisoning, causing symptoms such as dizziness, vomiting, headaches, loss of consciousness, seizures, and even death (Kashala-Abotnes et al., 2018). Globally, cassava toxicity poses health threats to over 1 billion people (FAOSTAT, 2023). Several sub-Saharan African countries, including Uganda, Nigeria, Tanzania, Mozambique, and the Democratic Republic of Congo, have reported cases of cyanide toxicity (Mushumbusi et al., 2020; Baguma et al., 2021). In Uganda, cyanide poisoning outbreaks have occurred, including a fatal incident in Kasese district, western region of Uganda, in 2017 and another in the Terego district in February 2023 (Alitubeera, 2019; Atim et al., 2023). Experiences of morbidity and subsequently mortality were reported in Terego (Atim et al., 2023).

Studies indicate that cassava processing methods, such as fermentation, drying, soaking, grating, crushing, boiling, and the formulation of composite flours, can significantly reduce the amount of cyanide content (Forkum et al., 2025; Egboduku et al., 2024). For instance, 24-h soaking has also been found to be an effective way of reducing cyanide by 25–50%, yet subsequent drying and milling of the dried matter into flour further eliminates cyanide by 81% (Erliana and Yudi, 2013). Erchafo (2024) also indicated that fermentation of grated cassava roots for a period of 72 h has been proven as an effective method of reducing cyanide levels up to 10 ppm, meeting the Codex standard. Thaweewong and Anuntagool (2023) reported that a 24-h incubation and drying for several hours can reduce cyanide content by ∼30.5–53.7% and 53.6–78.5%, respectively, while Kasankala et al. (2019) reported that grating techniques were also more efficient than chipping in reducing cassava cyanide, especially from bitter varieties.

However, inadequate processing of cassava roots, especially while using traditional methods, can lead to minimal cyanide detoxification, hence leading to cyanide poisoning (Chiwona-Karltun et al., 2022; Bokundabi et al., 2023). To improve the quality and safety of cassava products, various research and extension efforts at global, national, and local echelons have converged to improve the breeding of high-yielding, early maturing, and low cyanide cassava varieties (Ssemakula et al., 2000). In Uganda, varieties, including NASE19, NASE14, NAROCASS1, and NAROCASS3, have been bred and disseminated to cassava farmers (Faizo et al., 2020; Oloya et al., 2023). Furthermore, appropriate cassava processing technologies, such as cassava chippers, mechanized mills, and PICS bags (Almansouri et al., 2021; TAAT Clearinghouse, 2022), have been promoted within communities largely dependent on processed cassava products. These technologies are proven to be effective and efficient, thus reducing postharvest handling losses and enhancing the safety of the products (Akumu et al., 2020; Fadeyibi and Faith Ajao, 2020). However, these initiatives have had limited success, as many traditional processors continue to use traditional varieties and processing methods (Chiwona-Karltun et al., 2022; Abaca et al., 2021). This continued reliance on traditional practices puts populations at risk of recurrent cyanide poisoning.

Such public health interventions are often influenced by knowledge of a particular disease (Abu et al., 2021; Chen et al., 2020; Hussein and Husseiny, 2021). While the role of knowledge in promoting preventative measures has been extensively studied in contexts such as COVID-19 (Zhong et al., 2021; Rayani et al., 2022; Rayani et al., 2022), Ebola (Musaazi et al., 2022; Winters et al., 2020; Thompson, 2020; Garfin et al., 2022), and Dengue fever (Ahmed and Amin, 2024; Rahman et al., 2022; Ahmad Zamzuri et al., 2022), there is no evidence of research regarding cassava cyanogen poisoning in Uganda. Existing studies on cassava-related risks are limited in scope, focusing on perceived health risks of cassava *leaves* in Nigeria (Okareh et al., 2021) or cyanide presence in raw cassava in Tanzania (Mushumbusi et al., 2020).

While knowledge is important, it is not the sole driver of positive outcomes. Other factors, such as perceived threat, play a crucial mediating role between knowledge and adoption of preventative measures (Mortada and Elhessewi, 2022; Iorfa et al., 2020). The question remains: how does perceived threat influence the relationship between knowledge and the adoption of preventative measures against cassava cyanide poisoning, specifically in Uganda? Moreover, recent research highlights the importance of considering cultural values when studying knowledge, risk perception, and disease prevention (Li et al., 2022; Wu et al., 2023). However, many studies rely heavily on quantitative methods, which may not fully capture the cultural nuances influencing these factors (Irnaningsih et al., 2021; Hossain et al., 2020; Behera et al., 2022; Haddad et al., 2021; Hosen et al., 2021). This study addresses this methodological gap by using a mixed-methods design, incorporating culturally sensitive insights within a Health Belief Model (HBM). The study investigates how knowledge and perceived threat influence the adoption of preventative measures against cassava cyanide poisoning in Uganda, specifically examining the mediating role of perceived threat. The findings are critical in providing crucial insights to inform public health strategies, educational initiatives, and efforts to ensure the safety and nutritional value of cassava both in Uganda and globally. The study further makes a theoretical contribution by adding construct knowledge to the HBM.

2 Theoretical framework and hypotheses

The Health Belief Model was used to understand knowledge, risk perception, and preventive behaviors related to cassava cyanide poisoning among the Lugbara people of northwestern Uganda.

The HBM is a well-established psychological model that explains health behaviors using six constructs: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Hochbaum et al., 1952). The HBM is a particularly useful framework for understanding individual behaviors, especially in the face of life-threatening situations, compared to other theories, namely Social Cognitive Theory (SCT) (Bandura, 1989), the Theory of Planned Behavior (TPB) (Ajzen, 1991), and Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1977). While these theories offer valuable insights into behavioral intentions, they are less effective when considering health threats. The HBM provides a more comprehensive framework for understanding and predicting behavior in such contexts.

This present study used two key constructs of perceived susceptibility and perceived severity (perceived threat) to explain intentions to adhere to cassava cyanide poisoning preventive measures among Lugbara communities. These constructs were chosen for their strong predictive power in health behavior research (Rosenstock, 1974). Additionally, this study incorporates knowledge as a crucial factor influencing adherence to preventive measures (Iorfa et al., 2020).

2.1 Knowledge and adoption of preventive measures

Knowledge, defined as awareness of a health threat, its causes, symptoms, experiences, and treatment, is strongly correlated with the adoption of preventive measures (Trevethan, 2017). Studies across various locations and health contexts have demonstrated that higher knowledge levels are associated with adherence to preventive behaviors. Hussein and Husseiny (2021) found that individuals with higher knowledge levels tend to perceive a greater threat and consequently adhere to preventive behaviors. This finding has been consistently echoed in studies conducted across diverse geographical locations and health contexts, including Bangladesh (Hosen et al., 2021), China (Chen et al., 2020), and Pakistan (ul Haq et al., 2020). Limited disease knowledge has also been shown to negatively impact adoption of precautionary measures (Abate and Mekonnen, 2020; Arslanca et al., 2021; Handebo et al., 2021). Beyond COVID-19 context, studies on diseases, such as dengue fever (Judijanti et al., 2024), type 2 diabetes mellitus (Kalsum et al., 2023), and cancer (Jovanov et al., 2024) have reported similar findings.

Studies consistently show that socio-demographic factors, such as gender, occupation, location, and income, influence knowledge levels and adherence to preventive measures. For example, higher education levels (often indicating increased knowledge) are linked to positive attitudes and adoption of preventive behaviors (Alves et al., 2021). Research on dengue fever has specifically identified being male and having lower education and income levels as barriers to knowledge acquisition and preventive practices (Valencia-Jiménez et al., 2024). Other research reinforces this connection, demonstrating that gender, education, and prior disease experience influence both knowledge and preventive actions (Siddique et al., 2024; Hamed, 2024; Khaled et al., 2020; Alawia et al., 2020).

While a substantial body of research suggests a strong link between knowledge and preventive behaviors, it is crucial to recognize that this relationship is not always linear or straightforward. For instance, Behera et al. (2022) reported unexpected findings where knowledge of preventive measures did not necessarily translate into corresponding actions. Similarly, Lo Moro et al. (2023) found a negative association between vaccine hesitancy and knowledge, risk perception, and preventive measures. Furthermore, Putri et al. (2024) observed that knowledge about dengue fever did not significantly correlate with the incidence of the disease.

2.2 Perceived threat and adoption of preventive measures

The HBM identifies perceived severity and perceived susceptibility as key components of perceived threat (Hochbaum et al., 1952). Perceived severity refers to an individual's belief about the seriousness and potential negative consequences of a disease (Rosenstock, 1974). Many studies show a link between perceived severity and taking precautions. For example, individuals who perceived COVID-19 as severe were more likely to adhere to preventive measures (Mortada and Elhessewi, 2022). Similar findings have been reported in various contexts, including COVID-19 vaccine acceptance in Nepal, Turkey, the USA, Pakistan, China, and Saudi Arabia (Subedi et al., 2021; Sonmezer et al., 2022; Wise et al., 2020; Qiao et al., 2022; Saleem et al., 2020; Beg et al., 2022; Deng et al., 2020; Li et al., 2020).

The link between perceived severity and preventive measures is not unique to COVID-19; for example, studies on cancer (Azriful et al., 2021), anal cancer (Jovanov et al., 2024), Human Papillomavirus Vaccines (Markowitz and Schiller, 2021), purchase intention of organic food (Wang et al., 2022), HIV cure (Noorman et al., 2024), food and drink factories (Asefa et al., 2020), and among healthcare professionals in Pakistan (Saqlain et al., 2020). However, some research contradicts these findings, indicating that perceived severity is not always a reliable predictor of protective behavior, especially concerning COVID-19 (Thompson et al., 2024). Additionally, the relationship between perceived severity and preventive actions can be influenced by socio-demographic factors. For example, He et al. (2021) found that older participants were found to perceive COVID-19 as more severe than the younger ones. However, Glei and Weinstein (2024) indicated conflicting results, suggesting that perceived severity is not significantly associated with the mortality of the elderly at 50 years of age.

Perceived susceptibility, the individual's belief about their risk of contracting a specific health threat, plays a crucial role in decisions about preventive behaviors (Rosenstock, 1974). When individuals believe they are vulnerable to a disease, they are more likely to take preventive measures (Hochbaum et al., 1952). Vast studies within the COVID-19 context in Ethiopia (Birhanu et al., 2021), China (Bin et al., 2024), urban areas of Afghanistan (Siddiqi, 024), the United States (DeDonno et al., 2022; Raza et al., 2022), Hong Kong (Li et al., 2021), and Brazil (Giordani et al., 2022) have acknowledged the inseparable relationship between perceived susceptibility and adoption of preventive measures.

This relationship extends beyond COVID-19. For example, studies have shown that a mother's perception of her daughter's susceptibility to cervical cancer influences HPV vaccine uptake (Agustini et al., 2024). Higher perceived susceptibility to colorectal and prostate cancer increases willingness to undergo screening (Gilfoyle et al., 2021), and similar findings exist for anal cancer and HIV (Jovanov et al., 2024; Noorman et al., 2024). Furthermore, perceived susceptibility to climate change has been linked to pro-environmental behaviors (Son and Jun, 2024). However, not all research supports this connection. Some studies found that perceived vulnerability did not strongly predict preventive measures (Clark et al., 2020; Shahnazi et al., 2020). Other research suggests that personality traits, such as narcissism, can influence perceived susceptibility (Venema and Pfattheicher, 2021). Socio-demographic factors, such as gender, occupation, location, and income, influence the relationship between perceived susceptibility and adopting preventive measures (Commodari et al., 2020; Scarinci et al., 2021; Giordani et al., 2022). Studies also indicate that employed individuals and those in households with healthcare professionals show higher perceived susceptibility to COVID-19, and that individuals with lower health literacy tend to perceive lower susceptibility toward the same health threat (Giordani et al., 2022). Conversely, Rattay et al. (2021), reported that education levels had no association to perceived susceptibility of disease.

2.3 Moderated mediating role of risk perceptions

Research on knowledge, risk perception, and precautionary behaviors yields mixed findings. Some studies show a link between knowledge and precautionary behaviors (Irnaningsih et al., 2021; Rincón Uribe et al., 2021; Stangier et al., 2022), while others find no such relationship (Hossain et al., 2020). It is clear that knowledge alone does not always translate into action (Thoma et al., 2021). Factors such as information about the disease, attitudes, and perceived threat can mediate the relationship between knowledge and adopting preventive measures (Raza et al., 2020; Molla Legesse and Wondimu, 2023; Mortada and Elhessewi, 2022; Iorfa et al., 2020). This highlights the non-linear path between knowledge and preventive behaviors. Understanding these complex relationships is essential, especially when there are gaps in specific contexts, such as cassava cyanide poisoning. Similarly, within different contexts, for example, a study on occupational hazards also reported risk perception acting as a mediator between knowledge and precautionary behavior (Yovi et al., 2023). During the COVID-19 pandemic, higher levels of knowledge about the virus were associated with increased precautionary behavior, mediated by risk perception (Shinan-Altman and Levkovich, 2020).

While increasing knowledge can improve precautionary behavior, its effectiveness varies across populations (Permatasari et al., 2024). Studies show a complex interplay between knowledge, risk perception, and precautionary behavior. For example, research indicates differences in how education and gender relate to COVID-19 preventive measures: educated women were more likely to comply with hand washing, while educated men were more likely to practice social distancing (Rattay et al., 2021). Similarly, vast studies (Noghabi et al., 2021; Karimy et al., 2021; Shahnazi et al., 2020; Arslanca et al., 2021) have documented that female gender is an important predictor of preventive measures because women have a greater motivation than men. Hee et al. (2020) also acknowledged that gender, income, and education levels moderated factors that influenced the adoption of mobile money payments. Similarly, Ren et al. (2024) indicated that factors such as education levels, occupation, and gender influenced the acceptance of Tuberculosis Preventive Treatment. Moreover, Hussein and Ibrahim (2024) reported that gender and education significantly affected knowledge about climate change. Moreover, Alnaeem et al. (2023) found that gender, age, and education level significantly impact vaccine knowledge and acceptability in the eastern region of Saudi Arabia. Similarly, Alomran et al. (2024) observed a correlation between higher education levels and positive vaccine perceptions, suggesting that individuals with higher education tend to have better knowledge and more favorable attitudes toward vaccination. Given the complex interplay between knowledge, perceived severity, and adoption of preventive behaviors, this study hypothesized that:

H1: Knowledge will predict adoption of preventive measures in the way that higher levels of knowledge will positively and significantly influence adoption of preventive measures.
H2: Perceived threat will predict adoption of preventive measures in the way that high perceived threat will trigger adoption of preventive measures.
H3: Perceived threat will mediate the path between knowledge and adoption of preventive measures, and this effect will be more significant in women than men and within educated populations than the uneducated ones. The hypothesized conceptual model of the anticipated moderated mediation is presented in Figure 1.

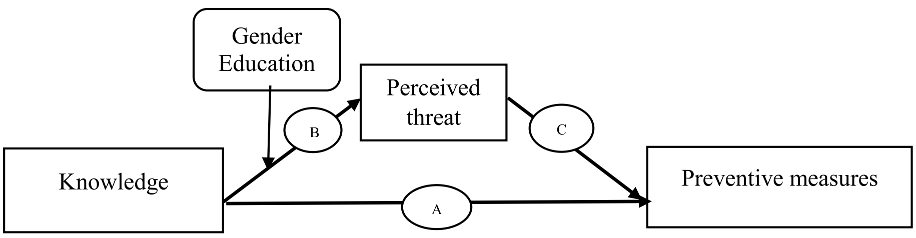

FIGURE 1
Hypothesized moderated mediation model on cassava cyanide poisoning knowledge, perceived threat, and preventive measures.

3 Materials and methods

3.1 Study area

The study was conducted in northwestern Uganda in the district of Terego, given heavy reliance on subsistence agriculture, with 98.8% of households actively engaged in cassava production and processing of cassava (UBOS, 2022). Among the Lugbara communities, cassava processing is mandatory, as the processed cassava bread, commonly known as *Enyasa*, is their staple food (Amone, 2014; Nanyonjo et al., 2018). The Lugbara have been processing cassava for a long time using their traditional processing practices such as fermentation, drying, and storage (Bilate Daemo et al., 2023). Terego district was purposively selected because of different cassava processing interventions promoted by Welt Hunger Hilfe and the Government of the Republic of Uganda for more than a decade. This study focused on four villages, namely Amia, Owadri, Zua, and Akua, located in the subcounties of Odupi and Avii-Vu of Terego District. Amia and Owadri located in Odupi subcounty were selected for having hosted cassava processing interventions from the ABI Zonal Agricultural Research and Development Institute (ABI ZARDI)—a government institution purposed to breed and disseminate cassava varieties within communities in Northwestern Uganda.

The communities have also benefited from the different cassava processing technologies such as the cassava chippers, mills, and drying yards disseminated by Welt Hunger Hilfe—a German private aid agency. The assumption was that adoption of these technologies would improve on the quality and safety of processed cassava products. Zua and Akua, located in Aiivu subcounty, were also selected based on their proximity to the district headquarters, Arua city, and ABI Zonal Agricultural Research and Development Institute (ABI ZARDI). This selection was based on the assumption that proximity to the city, district headquarters, and ABI ZARDI enhances opportunities for access and uptake of improved cassava processing technologies. Most importantly, the locations were also chosen based on reported cases of cassava cyanide poisoning, despite efforts to improve food safety (Atim et al., 2023).

3.2 Research design/approaches

An exploratory sequential mixed-method approach was employed. The study started with the collection of qualitative data, which facilitated the development of a survey tool (Creswell and Creswell, 2017; Creswell et al., 2011). This approach is particularly well-suited to gaining in-depth insights into the contextual factors surrounding knowledge, perceived threats, and preventive behaviors related to cassava cyanide poisoning. Qualitative data were collected between February and April 2024. Subsequently, a household survey was conducted between October and December 2024.

3.3 Sampling procedure and sample size

For the qualitative portion of this study, 10 Focus Group Discussions (FGDs), each consisting of 8–10 participants, were purposively selected with the help of the Village Local Council chairpersons. Purposive sampling was employed to select participants based on their knowledge of cassava cyanide poisoning, including youths and elderly, as defined by the Uganda National Housing Survey (UNHS) 2016/2017. A heterogeneous population allowed the capturing of different experiences and deliberations.

Based on the interactions with the participants throughout the FGDs, 10 key informants (three males and seven females from the selected villages) were identified (based on their experience with cassava cyanide poisoning). These interviews provided an opportunity for in-depth conversations and documentation of experiences.

For the quantitative data collection, 422 households were selected using a single-stage cluster sampling method. The sample size was determined using Kish's (1965) single population proportion formula. A sample proportion formula was adopted to generate the sample size from each cluster (village) as $p = x/n$. (p) is the number of successes found in the sample (x) divided by the sample size (n). Within each cluster (village), a simple random sampling technique was used to select the participating households, ensuring each household had an equal chance of selection.

3.4 Data collection methods and instrumentation

A total of 10 FDGs were conducted using a checklist of questions. The discussion aimed at generating qualitative data on traditional cassava processing methods within the Lugbara community. Questions such as "What could be the possible causes of cassava cyanide poisoning?", "What symptoms is a patient likely to have when they get poisoned with cyanide" and How have you managed to treat such occurrences within your households/communities?" were explored to understand the knowledge participants had on cassava cyanide poisoning. Participants were also probed on the severity of cyanide poisoning and whether they felt they were vulnerable to cyanide poisoning with inquiries such as "How predisposed are you/household members to cyanide poisoning (probe)?" and how would you rate the severity of cassava cyanide poisoning compared to other health complications (probe reasons for their answers). Participant's answers were documented based on their agreement about the articulated understandings, and clarifications. FGDs were conducted till data saturation.

As earlier indicated, the FGDs created ground for the In-depth Interviews (IDIs). Using an interview guide, questions such as "I would like you to explain the incident when your household members got cassava cyanide poisoning", "When did this occur?", "Since that experience, how have your household members tried to mitigate cassava cyanogen poisoning?" were asked. Probing was emphasized during this phase to capture data on participant experiences. Both FGDs and IDIs were conducted in Lugbara (the local language), recorded for purposes of capturing the narratives and later translated into English. Crucially, informed consent was obtained from every participant before data collection.

Data from the qualitative phase was then used to build a structured questionnaire. Subsequently, a household survey employed a semi-structured questionnaire designed using insights from the qualitative phase, ensuring cultural sensitivity and relevance. This strategic combination of qualitative and quantitative data collection methods allowed for a comprehensive understanding of the problem.

3.5 Measures

The first part of the questionnaire had participant demographic characteristics, such as gender, age, income, level of education, household (HH) size, HH structure, and location, among others. This type of data was important to establish the level of knowledge, risk perception, and adoption of preventive measures against cassava cyanogen poisoning among different categories of respondents. The tool also had a series of measures on cassava cyanogen knowledge, risk perceptions, and recommended preventive measures.

3.5.1 Cassava cyanide poisoning knowledge

Independent variable knowledge about cassava cyanide poisoning was assessed using a "yes, no" question format adapted from the qualitative data. Respondent's knowledge was then arrived at by computing yes responses across: (1) awareness, (2) causes of cassava cyanide poisoning, (3) experience with cassava cyanide poisoning, (4) symptoms of cassava cyanide poisoning, and (5) treatments of cassava cyanide poisoning.

3.5.2 Cassava cyanide poisoning risk perception

The mediating variable, perceived threat, was measured as severity and susceptibility to cassava cyanide poisoning. Risk perception was measured using a 10-item Likert scale adapted from qualitative data. For items related to perceived severity (e.g., "I am concerned about the potential health effects of cyanogen poisoning") and perceived susceptibility (e.g., "I am likely to experience cyanogen poisoning from consuming improperly processed cassava"), respondents appraised the items on a 5-point Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree). Aspects with mean response =>3.5 were closer to slightly agree on the Likert scale, and were therefore taken to imply that respondents agreed with the occurrence of the aspect. The reliability coefficient (Cronbach's alpha) of 0.71 was obtained at the pre-test, while the present data generated 0.75.

3.5.3 Cassava cyanide poisoning preventive measures

Outcome variable, adoption of preventive measures, was measured using an 8-item Likert scale. The 7-item scale had related statements dealing with action taken to prevent cassava cyanogen poisoning during processing and consumption. These included "I ferment cassava for recommended period of time", "I use improved cassava with low cyanide toxics", I dry my cassava chips properly to reduce moisture content", "I ensure cassava is cooked thoroughly", and "I consume only traditional varieties" (reverse scored). The respondents rated these items on a 5-point Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree). Items 6 and 7 were reverse-scored. The mean response =>3.5 implied respondents acted well to prevent cassava cyanide poisoning. The reliability coefficient (Cronbach's alpha) of 0.71 was obtained at pre-test, while the present data generated 0.75.

3.6 Data analysis

3.6.1 Qualitative data

This study employed a six-step thematic analysis, following Braunand Clarke's framework (Braun and Clarke, 2006), to analyze qualitative data from FGDs and in-depth interviews. First, audio recordings in the Lugbara language were transcribed and translated into English. The data were then imported into Atlas.ti 12 software for organization and initial coding. Next, following an iterative process, codes were grouped into categories and sub-themes, which were then developed into broader themes. These themes were reviewed, refined, and organized within Atlas.ti. The final stage involved further refinement of the themes, ensuring clear definitions and supporting narratives. The resulting thematic framework formed the basis for developing the survey instrument.

3.6.2 Quantitative data

Quantitative data were analyzed using SPSS version 22.0 software. Descriptive statistics, using frequencies, percentages, means, and standard deviations, were conducted for socio-demographic variables. This was proposed to ascertain the status of the variables of interest. Pearson correlations were calculated to establish the relationship between cassava cyanide knowledge, risk perception, and adoption of preventive measures. A regression was then run to ascertain the contribution of knowledge and perceived threat on the adoption of preventive measures.

Moderated mediation analysis was run with model 58 of Hayes' PROCESS macro for SPSS (Hayes, 2018). The model 58 of the Hayes PROCESS macro uses ordinary least squares (OSL) analysis for calculating the mediation and moderated mediation effects, and bootstrapping for calculating the confidence intervals (CIs) (Miers et al., 2017). This choice of statistical analysis was influenced by the thought that a moderated mediation would test the influence of two variables (gender and level of education) on the mediated relationship between cassava poisoning knowledge and preventive behavior. The adoption of preventive measures was entered as the outcome variable, cassava cyanide poisoning knowledge as the independent variable, and risk perception as the mediator. Gender and level of education were also incorporated as moderators of the independent variable, knowledge, and the mediating variable, risk perception, to predict the outcome variable, adoption of preventive measures.

4 Results

4.1 Social demographic characteristics for respondents

Out of 422 participants, two questionnaires were excluded because of incomplete answers to the questions. The mean age of the respondents was 36.16, SD = 13.5 in the range of 20–83 years; 52.4% were men and 37.4% of the general subjects had attended at least some primary education. The age, education, and experience level was satisfactory to delve into cassava poisoning knowledge, perceived threat, and benefits and barriers of adopting preventive measures (Okui et al., 2021). A majority (78.8%) were subsistence farmers, with an average of six members in their households. Cassava was the most consumed compared to other crops (Table 1).

All participants (100%) consumed cassava in *Enyasa* form, with 44% forming composite flour for Enyasa bread. Sorghum (72%) was the most commonly used ingredient to formulate composite flour. Households relied on cassava flour (for *Enyasa*) from local markets and home-processed (85%). This implies that cassava, among other crops, is an important crop within households, and the majority rely on two sources, i.e., home-processed and purchases from local markets. Data suggest that local markets are major (81%) sources of flour during the lean season, a factor that often predisposes households to poorly processed cassava flour (Bokundabi et al., 2023).

TABLE 1 Demographic characteristics of the respondents ($n = 420$).

Variables	Category	Mean ± SD	%
Age		38.16 ± 13.5	
Household size		6.08 ± 4.05	
Gender	Male		52.4
Marital status	Female		47.6
	Married monogamous		66.0
	Married polygamous		22.4
	Divorced		4.0
Educational qualification	Widow/Widower		7.6
	No formal education		12.1
	Some primary education		37.4
	Completed primary level		14.3
	Some secondary education		21.9
	Completed secondary education		3.6
Employment status consumption of cassava	Post-secondary education		10.5
	Subsistence farming		78.8
	Business		27.9
	Formal employment		7.6
	Breakfast		27
	Lunch		60
Forms of consumption	Dinner		80
	Enyasa		100
	Steamed		21
Formulation of composite flour	Deep fried		6.7
	Yes		44
	No		56
Commonly used ingredients	Sorghum		72
	Millet		17
	Maize		13
Sources of Enyasa	Processed from home		8.6
	Bought from markets		10
Variables	Processed and bought from markets		85
	Family/friends		14

Source: Primary data from the field (2024).

4.2 Cassava cyanide knowledge

Generally, respondents had sufficient knowledge (0.47 ± 0.11) on cassava cyanide poisoning (Table 2). They affirmed adequate knowledge with a mean score of (0.76 ± 0.03) on causes, (0.45 ± 34) on treatment, (0.43 ± 0.37) on symptoms, and (0.31 ± 0.35) on experience. Respondents reported their consciousness about the causes of cassava cyanide poisoning (0.99 ± 0.11), consuming cassava with high cyanide causes poisoning (0.95 ± 0.22), it can get cassava cyanide poisoning when not processed cassava well (0.92 ± 0.26), and continuous eating of small portion of cyanide can cause cassava cyanide poisoning (0.81 ± 0.38). As far as treatment is concerned, participants agreed to treating cassava cyanide poisoning with *Ayiku* (mean = 0.61, SD = 0.49) and Tamarind juice (0.63 ± 0.41), but disregarded medical attention (0.15 ± 0.36), lemon juice (0.19 ± 0.38), and milk (0.11 ± 0.31). This implies that even when participants know causes and treatment, they prefer using traditional methods to manage cyanide than formal sources such as medical facilities (Table 2, Knowledge of cassava cyanide poisoning).

Regarding experience, participants admitted that while they have witnessed someone in neighborhood who has been poisoned (0.74 ± 0.29), they have not experienced it themselves (0.08 ± 0.29) or seen a distant relative being poisoned (0.08 ± 0.27) or witnessed their household member having being poisoned with cyanogen (0.14 ± 0.34). In connection to symptoms, participants admitted that the condition displayed nausea and vomiting (0.63 ± 0.48), as well as headache (0.59 ± 0.49), but disregarded muscle pain (0.13 ± 0.34) and diarrhea (0.37 ± 0.48). This implies that generally, participants had more knowledge about causes and treatment of cassava cyanide poisoning than symptoms and experiences.

Generally, respondents had sufficient knowledge of cassava cyanide poisoning, specifically on the causes and treatment. However, this finding reveals a concerning gap: while individuals may be familiar with the causes, their understanding of the

TABLE 2 Cassava cyanide knowledge.

Knowledge	Mean	SD
Causes		
I am acquainted with the fact that Cassava cyanide poisoning is a public health problem	0.72	0.43
I am conscious about the cause of cyanide positioning	0.99	0.11
I am aware that consuming cassava with high cyanide causes poisoning	0.95	0.22
I am aware that when I do not process my cassava well, I can get cassava cyanide poisoning	0.92	0.26
I am aware that continuous eating of a small portion of cyanide can cause cassava cyanide poisoning	0.81	0.38
I'm aware that eating immature bitter variety cassava can cause cyanide poisoning	0.19	0.39
Score	0.76	0.3
Experience		
I have experienced cassava cyanide poisoning	0.52	0.57
I myself experienced it	0.08	0.27
I have witnessed someone in neighborhood who has been poisoned	0.74	0.29
I have seen a distant relative being poisoned	0.08	0.27
I have witnessed my own household member having been poisoned with cyanogen	0.14	0.34
Score	0.31	0.35
Symptoms		
I am aware of cassava cyanide poisoning symptoms	0.99	0.09
Symptoms display Continuous fever	0.12	0.33
Symptoms display Muscle pain	0.13	0.34
Symptoms display Nausea/vomiting	0.63	0.48
Symptoms display Headache	0.59	0.49
Symptoms display Diarrhea	0.37	0.48
Symptoms displayed loss of consciousness and seizures	0.16	0.36
Score	0.43	0.37
Treatment		
I am aware of the treatment for cassava cyanide poisoning	0.99	0.11
medical attention	0.15	0.36
Treatment with *Ayiku* juice	0.61	0.49
Treatment with Lemon juice	0.19	0.38
Treatment with Raw milk	0.11	0.31
Treatment with Tamarind juice	0.63	0.41
Score	0.45	0.34
Overall Score	0.47	0.11

Source: Primary data from the field (2024).

symptoms lags. This knowledge gap, which is likely stemming from a reliance on informal sources that prioritize causes and treatments over symptoms, poses significant risks. First, it can delay recognition of cyanide poisoning symptoms, hindering timely treatment and potentially worsening outcomes. Second, it can compromise awareness of the potential threats and limit the adoption of preventive measures. This aligns with studies that suggest that reliance on informal sources often leads to misconceptions that influence health behaviors (Ren et al., 2024; Alomran et al., 2024).

4.3 Information sources

The majority of the participants sourced information on cassava cyanide poisoning from their parents (70.5%) and personal experiences (63.1%), as shown in Figure 2. These findings were similarly emphasized by a female participant in an FGD who noted that:

We were also taught by our mother, aunties and grandmothers. I remember my grandmother used to tell us that the strength of a woman is the ability to process and prepare Enyasa for her household without causing them sickness. (24/06/2024-Amia village).

This implies that most individuals rely on traditional hereditary knowledge on cassava cyanide poisoning, which is often interwoven within cultural norms, beliefs, and values, ultimately influencing their perceptions.

4.4 Relationship between cassava cyanide poisoning knowledge, risk perception, and adoption of preventive measures

We examined whether and to what extent cassava cyanide knowledge, risk perception, and adoption of preventive measures were related. The findings are summarized in Table 3.

The results indicate that knowledge, perceived threat, and adoption of cassava cyanide poisoning preventive measures were positively correlated with education ($r = 0.22^{**}$, $p < 0.01$; $r = 0.11^{**}$, $p < 0.01$; $r = 0.28^{*}$, $p < 0.05$), respectively. Furthermore, adoption of preventive measures was significantly correlated with knowledge ($r = 0.25$, $p < 0.01$), and it was mainly knowledge on causes ($r = 0.13^{**}$, $p < 0.01$) and treatment ($r = 0.24^{**}$, $p < 0.01$) that were involved in this relationship; thus, hypothesis (H1) was accepted. On the other side, the relationship between adoption of preventive measures and perceived threat was positive and significant ($r = 0.52$, $p < 0.01$). Both perceived severity ($r = 0.41$, $p < 0.01$) and perceived susceptibility ($r = 0.50$, $p < 0.01$) indicated positive and significant correlation with adoption of preventive measures, reinforcing our hypothesis.

A simple regression analysis was then run to ascertain the contribution of knowledge and perceived threat to the adoption of preventive measures (Table 4). Knowledge had a significant influence ($\beta = 0.24$, $p = 0.000 < 0.05$) on the adoption of preventive measures, though it explained by only 5.8% of the variation. Perceived severity ($\beta = 0.413$, $p = 0.000 < 0.05$) also had a positive and significant influence on adoption of preventive measures, and explained 17.1% of the variation and perceived susceptibility ($\beta = 0.502$, $p = 0.000 < 0.05$) had a positive

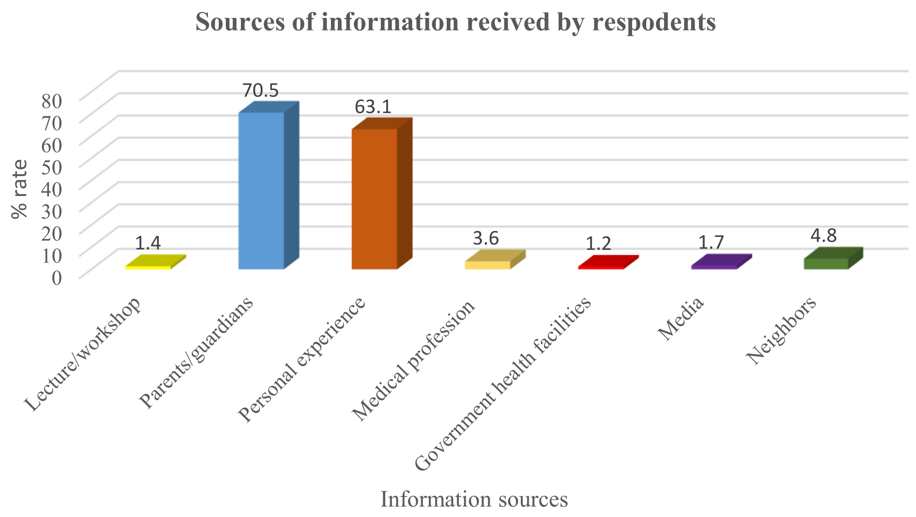

FIGURE 2
Sources of information on cassava cyanide knowledge.

TABLE 3 Correlation matrix for cassava cyanide poisoning knowledge, risk perception, and adoption of preventive measures.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Adoption	1											
2. Knowledge	0.18**	1										
3. Risk perception	0.52**	0.12*	1									
4. Causes	0.13**	0.26**	0.02	1								
5. Experience	0.09	0.13**	0.15**	0.08	1							
6. Symptoms	0.06	0.77**	−0.06	−0.08	−0.28**	1						
7. Treatment	0.24**	0.77**	0.17**	−0.07	−0.15**	0.55**	1					
8. Severity	0.41**	0.09	0.87*	0.03	0.14**	−0.08	0.15**	1	.			
9. Susceptibility	0.50**	0.05	0.79**	0.02	0.15**	−0.07	0.05	0.41**	1			
10. Gender	0.07	0.02	0.06	0.02	0.03	−0.02	−0.03	0.02	0.08	1		
11. Age	−0.09	−0.04	−0.07	0.06	0.14**	−0.07	−0.11*	−0.05	−0.07	0.03	1	
12. Education	0.28*	0.22*	0.11**	0.01	−0.12*	0.03	0.06	−0.02	0.04	−0.19*	−0.26**	1

Significant level: $^{**}p < 0.01$, $^{*}p < 0.05$.

and significant influence on adoption of preventive measures and explained 25.2% of the variation.

This implies that susceptibility had a bigger influence ($R^2 = 0.252$) on the adoption of preventive measures than severity ($R^2 = 0.171$). Overall, the fear that cassava cyanide poisoning would affect participant's health and lives contributed more to the likelihood of respondents adopting preventive measures.

TABLE 4 Simple linear regression parameters of selected variables.

Predictors	R^2	Adj R^2	F	β	P-value
Knowledge	0.058	0.056	13.52	0.024	0.000*
Perceived Severity	0.171	0.169	85.91	0.413	0.000*
Perceived Susceptibility	0.252	0.250	140.03	0.502	0.000*

*Values significant at 0.05 level.

4.5 Mediating effect of risk perception on the relationship between knowledge and adoption of preventive measures

Using the SPSS Process Macro, bootstrapping was carried out to investigate the mediating role of risk perception on the relationship between knowledge and adoption of preventive measures. Risk perception was entered as the mediator variable (M), and adoption of preventive measures as the dependent variable (Y).

The results in Table 5 suggest that the indirect effect of knowledge on adoption of preventive measures in the presence of a mediator was significant (b = 0.29, $p < 0.001$). Therefore, risk perception mediated the relationship between knowledge and adoption of preventive measures.

4.6 Moderated mediation analysis for the path between cassava cyanide knowledge and adoption of preventive measures

The study further hypothesized that the effect of the mediator would be moderated by gender and education. Knowledge as an independent variable (X) and gender and education as covariates.

The results in Table 6 revealed a significant indirect effect of impact of knowledge on adoption of preventive measures in the presence of mediator ($b = 0.29$, $p < 0.001$). Gender did not significantly moderate the relationship between an individual's perception of risk and their engagement in precautionary behaviors ($b = 0.06$, $p > 0.001$). However, education significantly moderated the relationship between an individual's perception of risk and their engagement in precautionary behaviors ($b = 0.03$, $p < 0.001$) (Table 7). This implies that the relationship between knowledge and perceived threat and hence adoption preventive measures varies across different education levels but not gender. In other words for knowledge to enhance adoption, a person must have perceived a disease as a threat and must have attended school. The moderated mediated model presented in Figure 3.

TABLE 5 Mediation analysis estimates of direct, indirect effects of risk perception on adoption of preventive measures.

Variable/effect	B	se	t	95% CI-lower–upper		P
Knowledge → adoption	1.54	0.15	10.55	1.25	1.83	<0.00
Knowledge → Risk perception	0.59	0.21	3.59	0.18	0.99	<0.00
Knowledge→ Risk perception→ Adoption	0.38	0.03	12.23	0.32	0.43	<0.00
Effects						
Direct	0.59	0.21	2.81	0.18	0.99	<0.00
Indirect*	0.29	0.13		0.13	0.62	<0.00

*Indicates a statistical significance of the mediated pathway.

TABLE 6 Moderated Mediation effects of risk perception on adoption of preventive measures with gender as a covariate.

Variable/effect	B	se	t	95% CI-lower–upper		P
Knowledge → adoption	1.45	0.15	9.30	1.16	1.77	<0.00
Knowledge → Risk perception	0.58	0.21	2.76	0.17	1.0	<0.00
Knowledge→ Risk perception→ Adoption	0.58	0.03	12.16	0.31	0.44	<0.00
Gender	0.06	0.04	1.31	−0.03	0.14	0.19
Effects						
Direct	0.56	0.21	2.82	0.18	1.0	<0.00
Indirect*	0.29	0.15		0.12	0.61	<0.00

*Indicates a statistical significance of the mediated pathway.

TABLE 7 Moderated mediation analysis estimates of direct, indirect effects of risk perception on adoption of preventive measures with education as a covariate.

Variable/effect	B	se	t	95% CI-lower–upper		P
Knowledge → adoption	1.46	0.15	9.64	1.16	1.76	<0.00
Knowledge → Risk perception	0.58	0.21	2.76	0.17	0.98	<0.00
Knowledge→ Risk perception→ Adoption	0.38	0.03	12.24	0.32	0.44	<0.00
Education	0.03	0.01	2.05	0.00	0.05	<0.00
Effects						
Direct	0.58	0.21	2.76	0.17	0.98	<0.00
Indirect*	0.29	0.15		0.12	0.62	<0.00

*Indicates a statistical significance of the mediated pathway.

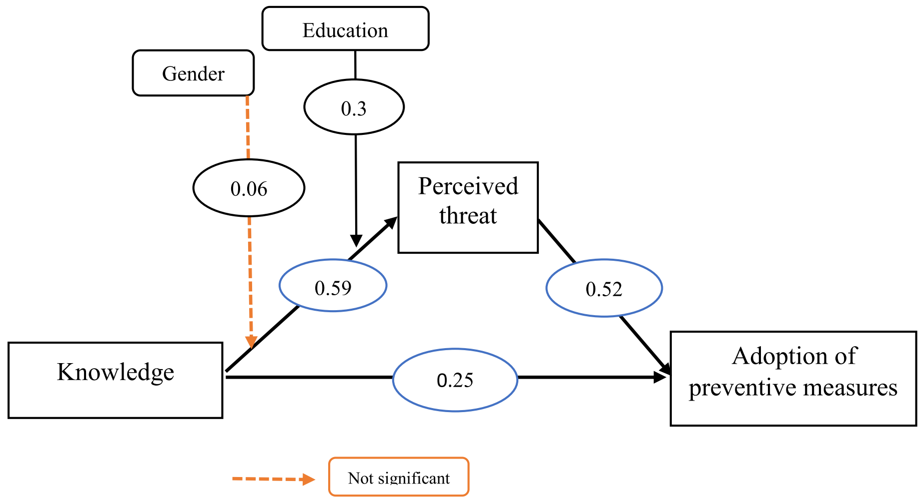

FIGURE 3
Moderated mediation model showing standardized coefficients.

This implies that the relationship between knowledge and perceived threat, and hence preventive measures, varies across different education levels. In other words, for knowledge to enhance adoption, a person must have perceived a disease as a threat and must have attended school.

5 Discussion

The present study explored cassava cyanide poisoning knowledge, perceived threat, and adoption of preventive measures in Northwestern Uganda, while scrutinizing the moderated mediation paths within selected variables. Findings indicate that cassava cyanide poisoning knowledge, perceived threat, and adoption of cassava cyanide poisoning preventive measures were positively correlated with education. This result aligns with Alves et al. (2021), who indicated that higher education levels are indicative of increased knowledge, positive attitudes, and motivation for the adoption of preventive behaviors. Similarly, Valencia-Jiménez et al. (2024) also emphasized the significant relationship between knowledge about dengue fever and respondents' education levels. This implies that as respondents acquire more education, their level of knowledge, risk perception, and chances of adopting cassava cyanide prevention practices increase. Hence, education is an important factor in the prevention of cassava cyanide.

Furthermore, adoption of preventive measures was significantly correlated with knowledge, thus supporting our hypothesis (H1). This result is consistently echoed in studies conducted across diverse geographical locations and health contexts (Hosen et al., 2021; Chen et al., 2020; ul Haq et al., 2020; Hussein and Husseiny, 2021). It is reasonable to find that when people are knowledgeable about a public health threat, they will tend to embrace the preventive measures that may disassociate them from the threat. Nonetheless, some studies (Putri et al., 2024; Behera et al., 2022; Lo Moro et al., 2023) suggest that having knowledge alone may not be tantamount to the adoption of preventive measures unless it is facilitated by other dynamics (Raza et al., 2020). This may explain why some households do not adhere to recommended preventive measures even when findings suggest adequate knowledge of cassava cyanide poisoning. Such unveiling discrepancies could be linked to inherent self-efficacy in their traditional remedies, as explained by a male participant during the FGDs:

> *"………We have the medicine for such issues. Otherwise we would be dead by now hahahahaha" (23rd/06/2024-Owadri village).*

The findings also indicate that the relationship between adoption of preventive measures and perceived threat was positive and significant. Both perceived severity and perceived susceptibility indicated positive and significant correlation with the adoption of preventive measures. These results reinforced our hypothesis, aligning with previous studies (Agustini et al., 2024; Birhanu et al., 2021; Moon, 2022). It is rational to suggest that when individuals know of the threat posed by a disease, they tend to embrace precautionary measures that may deter them from danger. However, some studies (Thompson et al., 2024) have suggested contradictory findings from the latter reporting that perceived threat may not necessarily allude to the adoption of preventive measures. Such exhibiting discrepancies could be attributed to other challenges that are associated with the adoption of cassava cyanide poisoning preventive measures.

The study further suggests a significant indirect effect of knowledge on the adoption of preventive measures. The direct effect of knowledge on the adoption of preventive measures in the presence of a mediator was also found significant (Table 4), aligning with previous studies (Molla Legesse and Wondimu, 2023; Mortada and Elhessewi, 2022; Iorfa et al., 2020) who acknowledged that risk perception often plays a crucial role in mediating the relationships between knowledge and precautionary behavior. Similar findings were reported by Yovi et al. (2023), who reported that risk perception mediated the path between knowledge and precautionary behavior. Moreover, a study by Shinan-Altman and Levkovich (2020) on COVID-19 pandemic indicated that knowledge about the virus was associated with increased precautionary behavior, mediated by risk perception. This implies that an individual's knowledge and preventive behaviors are not linear. In other words, it is logical that when an individual has knowledge about a disease and does not perceive it as a threat, there is a likelihood of not adopting the recommended preventive measures. This finding is further backed up by HBM, which asserts that risk perception acts as a conduit to predicting precautionary behavior (Becker, 1974).

Furthermore, the direct effect of knowledge on the adoption of preventive measures in the presence of a mediator was also found significant, although the variation of the effects across gender was not significant. This finding aligns with Sultan and Wong (2019) in a study titled "How service quality affects university brand performance, university brand image and behavioral intention" who indicated that although student's satisfaction and trust mediated the path between perceived service quality and brand performance, there was no moderation reported across gender. This is reasonable given that when an individual has knowledge of a disease, it will ignite fear (perceived threat), which kindles the zeal for embracing precautionary measures, irrespective of whether them being female or male. In contrast, studies by Rattay et al. (2021) and Ren et al. (2024) highlighted the important role played by gender in moderating the mediator (perceived threat), indicating that women are more likely to perceive the threat of a disease than men.

These discrepancies in results could be a result of contextual differences. On the other side, the direct effect of knowledge on the adoption of preventive measures in the presence of a mediator was also found to be significant. The variation of the effects was indicated across levels of education. The present study also indicated that to enhance adoption, a person must have perceived a disease as a threat and must have some level of education. This is factual because education ignites knowledge and positive attitudes, which motivates individuals to take up safety precautions. This result validates recent findings by Ren et al. (2024) and Alomran et al. (2024), who also agreed with the latter. However, this finding may not be uniform in all contexts, as Rattay et al. (2021) reported that education levels had no association with perceived susceptibility of disease. This gap can be explained by a contextual difference.

6 Implication of the findings

This study's findings highlight the need for a greater understanding of factors promoting the adoption of cassava cyanide poisoning preventive measures. The complex nature of cassava poisoning occurrences indicates that an individual's actions during processing and consumption can significantly impact their trajectory. However, individuals may not adopt preventive measures without accurate knowledge about the causes, symptoms, experiences, and treatment. Given the study's findings linking knowledge to the adoption of preventive measures, amidst existing myths and self-efficacy, public awareness campaigns are recommended to address misinformation. These campaigns should promote accurate knowledge and correct misconceptions, especially where conspiracy philosophies triumph. As the HBM suggests, realistic risk assessment and effective preventive measures should be communicated widely to motivate adoption beyond the dissemination of improved technologies said to minimize cyanide poisoning reoccurrences. Furthermore, technology developers, promoters, and researchers should explore effective risk communication strategies that focus on preventive measures rather than prejudice against the traditional practices of processing cassava.

7 Conclusion

Our study findings revealed that cassava cyanide poisoning knowledge predicted the adoption of preventive measures, and perceived threat significantly predicted the adoption of preventive measures. In the area of mediation, perceived threat aided the path between cassava cyanide knowledge and adoption of preventive measures. In other words, knowledge influenced the adoption of preventive measures through the perception of risk. The test for moderation indicated that education was an important variable. Specifically, findings indicate that education moderated the indirect path from cassava cyanide poisoning knowledge to the adoption of preventive measures.

8 Limitations of the study

This study focused on a specific context of the Lugbara people of West Nile. It relatively used a small sample size in relation to the wider population within communities highly dependent on cassava and facing similar challenges associated with cyanide poisoning. Forthcoming research is desired to determine whether these study findings are more generalizable within the broader communities within the country. This study's findings can be used as a baseline to inform other studies.

Data availability statement

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

Ethics statement

This study was approved by the Uganda National Health Laboratory Services research ethics committee (UNHLSREC).The approval number was UNHL-2025-1478. At the initial phase of this study, written informed consent was sought from all the participants of the study (During through Focus Group Discussions and in-depth interviews). The signing of the consent forms was made after the study participants had understood the purpose of this study and affirmed that there was no potential danger during interactions. This study adheres to the declaration of Helsinki.

Author contributions

JA: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. LM: Conceptualization, Methodology, Supervision, Writing – review & editing. PA: Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing. BO: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing.

Funding

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

Acknowledgments

We acknowledge and appreciate the time and knowledge shared with us by the participants. More thanks go to the Terego district team, particularly Mr. Osege, Mr. Jurua Popo, David, and Esther, for their field assistance.

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

The author(s) declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

References

Abaca, A., Odama, E., Komakech, A., Asiku, B., Andema, A. A., Sadik, K., et al. (2021). Evaluation of newly released cassava varieties for yield performance, reactions to cassava diseases and farmers' Preference in adjumani district of Uganda. *J. Agric. Sci.* 13, 84–96. doi: 10.5539/jas.v13n4p84

Abate, H., and Mekonnen, C. K. (2020). Knowledge, attitude, and precautionary measures towards COVID-19 among medical visitors at the university of gondar comprehensive specialized hospital Northwest Ethiopia. *Infect. Drug Resist.* 13, 4355–4366. doi: 10.2147/IDR.S282792

Abu, E. K., Oloruntoba, R., Osuagwu, U. L., Bhattarai, D., Miner, C. A., Goson, C., et al. (2021). Risk perception of COVID-19 among sub-Sahara Africans: a web-based comparative survey of local and diaspora residents. *BMC Public Health* 21, 1–13. doi: 10.1186/s12889-021-11600-3

Agustini, N. K. T., Sagitarini, N., Dayu, I. A. N. P., and Artsanthia, J. (2024). Mother's perception of implementing cervical cancer prevention behaviour through HPV (human papilloma virus) vaccination. *Adi Husada Nurs. J.* 10, 59–66. doi: 10.37036/ahnj.v10i1.527

Ahmad Zamzuri, M. A. I., Abd Majid, F. N., Dapari, R., Hassan, M. R., and Isa, A. M. M. (2022). Perceived risk for dengue infection mediates the relationship between attitude and practice for dengue prevention: a study in Seremban, Malaysia. *Int. J. Environ. Res. Public Health* 19:13252. doi: 10.3390/ijerph192013252

Ahmed, M. T., and Amin, M. A. (2024). Perilous resurgence of dengue fever in Bangladesh: Gender-based perspectives on risk perception and adaptation strategies. *Univ. J. Public Health 11*, 751–760. doi: 10.13189/ujph.2023.110525

Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T

Akumu, G., Atukwase, A., Tibagonzeka, J. E., Apil, J., Wambete, J. M., Atekyereza, R., et al. (2020). On-farm evaluation of effectiveness of improved postharvest handling of maize in reducing grain losses, mold infection and aflatoxin contamination in rural Uganda. *Afr. J. Food Agricult. Nutr. Dev.* 20, 16522–16539. doi: 10.18697/ajfand.93.19790

Alawia, R., Riad, A., and Kateeb, E. (2020). Knowledge and attitudes among dental students about COVID-19 and its precautionary measures: a cross-sectional study. *Med. Buccale Chir. Buccale* 26, 219–225. doi: 10.1051/mbcb/2020056

Alitubeera, H. (2019). Outbreak of cyanide poisoning caused by consumption of cassava flour—Kasese District, Uganda, September 2017. *MMWR* Morb. Mortal. Wkly. Rep. 68, 308–311. doi: 10.15585/mmwr.mm6813a3

Almansouri, M., Verkerk, R., Fogliano, V., and Luning, P. A. (2021). Exploration of heritage food concept. *Trends Food Sci. Technol.* 111, 790–797. doi: 10.1016/j.tifs.2021.01.013

Alnaeem, L., Alanizi, S., AlQarni, G., Alwadani, J., Bomouzah, F., and Ali, Z. (2023). Acceptance, knowledge, and attitude of parents toward the human papillomavirus vaccine in the eastern region of Saudi Arabia: a cross-sectional study. *Cureus* 15:e51293. doi: 10.7759/cureus.51293

Alomran, Z., AlAli, F., Bokhamseen, M., and Alhodibi, M. (2024). Barriers to Tdap vaccination among women attending Primary Health Care Centers in Al-Ahsa, Saudi Arabia (2023). *Int. J. Med. Dev. Ctries* 8, 2000–2000. doi: 10.24911/IJMDC.51-1720771644

Alves, R. F., Samorinha, C., and Precioso, J. (2021). Knowledge, attitudes and preventive behaviors toward COVID-19: a study among higher education students in Portugal. *J. Health Res.* 35, 318–328. doi: 10.1108/JHR-07-2020-0254

Amone, C. (2014). We are strong because of our millet bread: staple foods and the growth of ethnic identities in Uganda. *TRAMES-J. Humanit. Soc. Sci.* 18. doi: 10.3176/tr.2014.2.04

Anjum, N., Sheikh, M. A., Saini, C. S., Hameed, F., Sharma, H. K., and Bhat, A. (2022). "Cyanogenic glycosides," in *Handbook of Plant and Animal Toxins in Food* (Boca Raton: CRC Press), 191–202.

Arslanca, T., Fidan, C., Daggez, M., and Dursun, (2021). Knowledge, preventive behaviors and risk perception of the COVID-19 pandemic: A cross-sectional study in Turkish health care workers. *PloS ONE* 16:e0250017. doi: 10.1371/journal.pone.0250017

Asefa, A., Qanche, Q., Hailemariam, S., Dhuguma, T., and Nigussie, T. (2020). Risk perception towards COVID-19 and its associated factors among waiters in selected towns of Southwest Ethiopia. *Risk Manag. Healthc. Policy* 13, 2601–2610. doi: 10.2147/RMHP.S276257

Atim, B., Kabami, Z., and Gidudu, S. (2023). Cyanide poisoning investigation, Terego District, Uganda, February 2023. *Uganda Natl. Inst. Public Health Q. Epidemiol. Bull.* 8, e5030–e5041.

Azriful, Bujawati, E., Nildawati, Ramdan, R., Mallapiang, F., and Suyuti, S. (2021). Health Belief Model on women's cancer recovery (a phenomenological study on cancer survivors). *Gaceta Sanit.* 35, S9–S11. doi: 10.1016/j.gaceta.2020.12.003

Baguma, M., Nzabara, F., Balemba, G. M., Malembaka, E. B., Migabo, C., Mudumbi, G., et al. (2021). Konzo risk factors, determinants and etiopathogenesis: what is new? A systematic review. *Neurotoxicology* 85, 54–67. doi: 10.1016/j.neuro.2021.05.001

Balagopalan, C., Padmaja, G., Nanda, S. K., and Moorthy, S. (1988). *Cassava in Food, Feed and Industry*. Boca Raton, FL: CRC Press.

Ballhorn, D. J., Kautz, S., Heil, M., and Hegeman, A. D. (2009). Cyanogenesis of wild lima bean (*Phaseolus lunatus* L.) is an efficient direct defence in nature. *PloS ONE* 4:e5450. doi: 10.1371/journal.pone.0005450

Bandura, A. (1989). Human agency in social cognitive theory. *Am. Psychol.* 44:1175. doi: 10.1037/0003-066X.44.9.1175

Becker, M. H. (1974). The health belief model and personal health behavior. *Health Educ. Monogr.* 2, 324–473. doi: 10.1177/109019817400200407

Beg, B. M., Hussain, T., Ahmad, M., Areej, S., Majeed, A., Rasheed, M. A., et al. (2022). Perceived risk and perceptions of COVID-19 vaccine: a survey among general public in Pakistan. *PloS ONE* 17:e0266028. doi: 10.1371/journal.pone.0266028

Behera, B. K., Behera, J., and Mallick, H. (2022). Exploring knowledge, attitude and practices towards COVID-19: a case study in Odisha, India. *J. Contemp. Stud. Epidemiol. Public Health* 3. doi: 10.29333/jconseph/11974

Bilate Daemo, B., Belew Yohannes, D., Mulualem Beyene, T., and Gebreselassie Abtew, W. (2023). Assessment of cassava utilization patterns, postharvest handling practices, and productivity influencing factors in South and Southwest Ethiopia. *J. Food Qual.* 2023, 9914370.

Bin, Z., Luting, W., Lingen, W., Ryan, C. H. R. I. S., Siyi, L., Qihao, X., et al. (2024). The effect of perceived susceptibility of COVID-19 on health risk perception, risk aversion and travel intentions: The moderating effects of trust in government. *J. Resour. Ecol.* 15, 733–744. doi: 10.5814/j.issn.1674-764x.2024.03.019

Birhanu, Z., Ambelu, A., Fufa, D., Mecha, M., Zeynudin, A., Abafita, J., et al. (2021). Risk perceptions and attitudinal responses to COVID-19 pandemic: an online survey in Ethiopia. *BMC Public Health* 21:981. doi: 10.1186/s12889-021-10939-x

Bokundabi, G., Haskins, L., Horwood, C., Kuwa, C., Mutombo, B., John, V. M., et al. (2023). When knowledge is not enough: barriers to recommended cassava processing in resource-constrained Kwango, Democratic Republic of Congo. *J. Public Health Afr.* 14:2052. doi: 10.4081/jphia.2023.2052

Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. doi: 10.1191/1478088706qp063oa

Chen, Y., Zhou, R., Chen, B., Chen, H., Li, Y., Chen, Z., et al. (2020). Knowledge, perceived beliefs, and preventive behaviors related to COVID-19 among Chinese older adults: cross-sectional web-based survey. *J. Med. Internet Res.* 22:e23729. doi: 10.2196/23729

Chiwona-Karltun, L., Brimer, L., and Jackson, J. (2022). "Improving safety of cassava products," in *Root, Tuber and Banana Food System Innovations: Value Creation for Inclusive Outcomes* (Cham: Springer International Publishing), 241–258.

Clark, C., Davila, A., Regis, M., and Kraus, S. (2020). Predictors of COVID-19 voluntary compliance behaviors: an international investigation. *Global Transit.* 2, 76–82. doi: 10.1016/j.glt.2020.06.003

Commodari, E., La Rosa, V. L., and Coniglio, M. A. (2020). Health risk perceptions in the era of the new coronavirus: are the Italian people ready for a novel virus? A cross-sectional study on perceived personal and comparative susceptibility for infectious diseases. *Public Health* 187, 8–14. doi: 10.1016/j.puhe.2020.07.036

Creswell, J. W., and Creswell, J. D. (2017). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W., Klassen, A. C., Plano Clark, V. L., and Smith, K. C. (2011). *Best Practices for Mixed Methods Research in the Health Sciences* (Bethesda, MD: National Institutes of Health), 541-545.

DeDonno, M. A., Longo, J., Levy, X., and Morris, J. D. (2022). Perceived susceptibility and severity of COVID-19 on prevention practices, early in the pandemic in the state of Florida. *J. Community Health* 47, 627–634. doi: 10.1007/s10900-022-01090-8

Deng, S., Wang, W., Xie, Chao, Y., and Zhu, J. (2020). Perceived severity of COVID-19 and post-pandemic consumption willingness: the roles of boredom and sensation-seeking. *Front. Psychol.* 11:567784. doi: 10.3389/fpsyg.2020.567784

Egboduku, W. O., Ogwu, M. C., Egboduku, T., Enujeke, E. C., Edokpiawe, S., Golohor, O. M., et al. (2024). "Sustainable cassava processing techniques to eliminate cyanogenic glycosides," in *Sustainable Cassava* (San Diego, CA: Academic Press), 379–394.

Erchafo, A. (2024). Review of the performance of developed cassava primary processing technologies. *J. Eng. Basic Sci.* 3, 41–56. doi: 10.54709/joebs.1613418

Erliana, G., and Yudi, W. (2013). Cyanide reduction in cassava root products through processing and selection of cultivars in relation to food safety. *Buletin Palawija* 225852.

Fadeyibi, A., and Faith Ajao, O. (2020). Design and performance evaluation of a multi-tuber peeling machine. *AgriEngineering* 2, 55–71. doi: 10.3390/agriengineering2010004

Faizo, K., Wasswa, Mukasa, S. B., Okiror, A., Nghituwamhata, S. N., Rono, E. C., et al. (2020). Kasule, F farmer preference of cassava cultivars in eastern uganda: a choice beyond disease resistance. *Agricult. Sci.* 2, p169–p169. doi: 10.30560/as.v2n2p169

FAO/WHO (1991). *Joint FAO/WHO Food Standards Programme. Codex Alimentarius Commission XII, Supplement 4* (Rome, Italy: FAO).

FAOSTAT (2023). Crops and Livestock Products. Rome, Italy: Food and Agriculture Organization of the United Nations

Fishbein, M., and Ajzen, I. (1977). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley.

Forkum, A. T., Wung, A. E., Kelese, M. T., Ndum, C. M., Lontum, A., Kamga, E. B., et al. (2025). Safety of cassava and cassava-based products: a systematic review. *Front. Sustain. Food Syst.* 9:1497609. doi: 10.3389/fsufs.2025.1497609

Galford, G. L., Peña, O., Sullivan, A. K., Nash, J., Gurwick, N., Pirolli, G., et al. (2020). Agricultural development addresses food loss and waste while reducing greenhouse gas emissions. *Sci. Total Environ.* 699:134318. doi: 10.1016/j.scitotenv.2019.134318

Garfin, D. R., Holman, E. A., Fischhoff, B., Wong-Parodi, G., and Silver, R. C. (2022). Media exposure, risk perceptions, and fear: Americans' behavioral responses to the Ebola public health crisis. *Int. J. Disaster Risk Reduct.* 77:103059. doi: 10.1016/j.ijdrr.2022.103059

Gilfoyle, M., Chaurasia, A., Garcia, J., and Oremus, M. (2021). Perceived susceptibility to developing cancer and screening for colorectal and prostate cancer: a longitudinal analysis of Alberta's Tomorrow Project. *J. Med. Screen.* 28, 148–157. doi: 10.1177/0969141320941900

Giordani, R. C. F., Giolo, S. R., Zanoni Da Silva, M., and Muhl, C. (2022). Risk perception of COVID-19: susceptibility and severity perceived by the Brazilian population. *J. Health Psychol.* 27, 1365–1378. doi: 10.1177/13591053211044536

Glei, D. A., and Weinstein, M. (2024). Daily exposure to stressors, daily perceived severity of stress, and mortality risk among US adults. *PloS ONE* 19:e0303266. doi: 10.1371/journal.pone.0303266

Haddad, C., Bou Malhab, S., Malaeb, D., Sacre, H., Saadeh, D., Mourtada, V., et al. (2021). Stigma toward people with COVID-19 among the Lebanese population: a cross-sectional study of correlates and mediating effects. *BMC Psychol.* 9, 1–15. doi: 10.1186/s40359-021-00646-y

Hamed, M. (2024). Knowledge, attitude, and practices toward dengue fever among the public: a cross-sectional study in the Western region of Saudi Arabia. *Front. Public Health* 12:1327427. doi: 10.3389/fpubh.2024.1327427

Handebo, S., Adugna, A., Kassie, A., and Shitu, K. (2021). Determinants of COVID-19-related knowledge and preventive behaviours among students in reopened secondary schools: cross-sectional study. *BMJ Open* 11:e050189. doi: 10.1136/bmjopen-2021-050189

Hayes, A. F. (2018). Partial, conditional, and moderated moderated mediation: quantification, inference, and interpretation. *Commun. Monogr.* 85, 4–40. doi: 10.1080/03637751.2017.1352100

He, S., Chen, S., Kong, L., and Liu, W. (2021). Analysis of risk perceptions and related factors concerning COVID-19 epidemic in Chongqing, China. *J. Community Health* 46, 278–285. doi: 10.1007/s10900-020-00870-4

Hee, O. C., Ying, K. N., Kowang, T. O., and Ping, L. L. (2020). what influences urbanites' mobile payment adoption? The moderating roles of demographic divides. *Soc. Sci. Human.* 28, 3253–3276. doi: 10.47836/pjssh.28.4.42

Hochbaum, G., Rosenstock, I., and Kegels, S. (1952). Health belief model. *United States Public Health Serv.* 1, 78–80. doi: 10.1037/10519-035

Hosen, I., Pakpour, A. H., Sakib, N., Hussain, N., Al Mamun, F., Mamun, M. A., et al. (2021). Knowledge and preventive behaviors regarding COVID-19 in Bangladesh: a nationwide distribution. *PloS ONE* 16:e0251151. doi: 10.1371/journal.pone.0251151

Hossain, M. A., Jahid, M. I. K., Hossain, K. M. A., Walton, L. M., Uddin, Z., Haque, M. O., et al. (2020). Knowledge, attitudes, and fear of COVID-19 during the Rapid Rise Period in Bangladesh. *PloS ONE*, 15:e0239646. doi: 10.1371/journal.pone.0239646

Hussein, H., and Husseiny, Y. (2021). Egypt COVID-19: Assessment of knowledge, attitudes, and practices among the general population, a cross-sectional study. *Egypt. Family Med. J.* 5, 33–48. doi: 10.21608/efmj.2022.51354.1054

Hussein, S. M., and Ibrahim, B. A. (2024). Knowledge and attitude of general population towards climate change and its impact on health in Ismailia Governorate, Egypt. *J. Egypt. Public Health Assoc.* 99:15. doi: 10.1186/s42506-024-00162-y

Indrastuti, Y. E., Estiasih, T., Christanti, R. A., Pulungan, M. H., and Zubaedah, E. (2018). Microbial and some chemical constituent changes of high cyanide cassava during simultant spontaneous submerged and solid state fermentation of "gadungan pohung". *Int. Food Res. J.* 25, 487–498.

Iorfa, S. K., Ottu, I. F., Oguntayo, R., Ayandele, O., Kolawole, S. O., Gandi, J. C., et al. (2020). COVID-19 knowledge, risk perception, and precautionary behavior among Nigerians: a moderated mediation approach. *Front. Psychol.* 11:566773. doi: 10.3389/fpsyg.2020.566773

Irnaningsih, I., Asriati, A., and Tosepu, R. (2021). COVID-19 preventive behavior of the community in Southeast Sulawesi Province, Indonesia. *Public Health Indones.* 7, 87–92. doi: 10.36685/phi.v7i2.416

Jovanov, A., Parks, A., Jovanov, C., and Mdluli, X. (2024). A qualitative analysis of knowledge levels, perceived susceptibility, and perceived severity surrounding anal cancer and human papillomavirus. *J. Prim. Careand Commun. Health* 15:21501319241243198. doi: 10.1177/21501319241243198

Judijanti, L., Ahmad, H., Sahani, W., and Angkejaya, O. W. (2024). Role of family and community health center employees in controlling dengue fever in

Puskesmas Antang Makassar. *Jurnal Penelitian Pendidikan IPA*, 10, 2838–2845. doi: 10.29303/jppipa.v10i5.6204

Kalsum, U., Safitri, Y., Susanti, F., Jamiatun, J., and Nugraha, A. T. (2023). Hubungan Pengetahuan terhadap Perilaku Pencegahan Diabetes Melitus Tipe 2 pada Masyarakat di RT 09 RW 01 Kelurahan Bambu Apus Cipayung Jakarta Timur Tahun (2022). *Jurnal Bidang Ilmu Kesehatan* 13, 236–243. doi: 10.52643/jbik.v13i3.3442

Karimy, M., Bastami, F., Sharifat, R., Heydarabadi, A. B., Hatamzadeh, N., Pakpour, A. H., et al. (2021). Factors related to preventive COVID-19 behaviors using health belief model among general population: a cross-sectional study in Iran. *BMC Public Health* 21, 1–8. doi: 10.1186/s12889-021-11983-3

Kasankala, L. M., Kitunda, M. E., Towo, E. E., Ngwasy, G. M., Kaitira, L., Cyprian, C., et al. (2019). Antinutritional factors reduction from cassava (Manihot esculenta crantz) roots by grating or chipping processing technique in Mtwara Tanzania. *Eur. J. Nutr. Food Saf.* 9, 1–10. doi: 10.9734/ejnfs/2019/v9i230055

Kashala-Abotnes, E., Sombo, M. T., Okitundu, D. L., Kunyu, M., Bumoko Makila-Mabe, G., Tylleskär, T., et al. (2018). Dietary cyanogen exposure and early child neurodevelopment: an observational study from the Democratic Republic of Congo. *PLoS ONE* 13:e0193261. doi: 10.1371/journal.pone.0193261

Khaled, A., Siddiqua, A., and Makki, S. (2020). The knowledge and attitude of the community from the Aseer Region, Saudi Arabia, toward COVID-19 and their precautionary measures against the disease. *Risk Manag. Healthcare Policy* 13, 1825–1834. doi: 10.2147/RMHP.S271899

Kish, L. (1965). "Selection techniques," in *Genetics and the Epidemiology of Chronic Diseases*, *PHS Publication No. 1163* (Washington, DC: U.S. Department of Health, Education, and Welfare, Public Health Service), 165.

Li, J. B., Yang, A., Dou, K., and Cheung, R. Y. (2020). Self-control moderates the association between perceived severity of coronavirus disease 2019 (COVID-19) and mental health problems among the Chinese public. *Int. J. Environ. Res. Public Health* 17:4820. doi: 10.3390/ijerph17134820

Li, M., Zhang, L., Zhang, Z., and Hai, X. (2022). Work-family conflict and unethical pro-family behavior: the mediating effect of threat appraisal and the moderating effect of family collectivism orientation. *Front. Psychol.* 13:951904. doi: 10.3389/fpsyg.2022.951904

Li, Y., Luk, T. T., Wu, Y., Cheung, D. Y. T., Li, W. H. C., Tong, H. S. C., et al. (2021). High perceived susceptibility to and severity of COVID-19 in smokers are associated with quitting-related behaviors. *Int. J. Environ. Res. Public Health* 18:10894. doi: 10.3390/ijerph182010894

Lo Moro, G., Scaioli, G., Vola, L., Guastavigna, L., Frattin, R., Vito, D. e., et al. (2023). Exploring knowledge and awareness of HCV infection and screening test: a cross-sectional survey among an Italian sample. *J. Community Health* 48, 769–783. doi: 10.1007/s10900-023-01218-4

Long, L., Han, Y., Yuan, X., Cao, S., Liu, W., Chen, Q., et al. (2020). A novel ratiometric near-infrared fluorescent probe for monitoring cyanide in food samples. *Food Chem.* 331:127359. doi: 10.1016/j.foodchem.2020.127359

Markowitz, L. E., and Schiller, J. T. (2021). Human papillomavirus vaccines. *J. Infect. Dis.* 224(Suppl_4), S367–S378. doi: 10.1093/infdis/jiaa621

Masamba, K., Changadeya, W., Ntawuruhunga, Pankomera, Mbewe, W., Chipungu, F., et al. (2022). Exploring farmers' knowledge and approaches for reducing post-harvest physiological deterioration of cassava roots in Malawi. *Sustainability* 14:2719. doi: 10.3390/su14052719

Mensah, M. A. (2022). "Cyanogenic glycosides as food toxins," in *Analysis of Naturally Occurring Food Toxins of Plant Origin* (Boca Raton: CRC Press), 25–52.

Miers, A. C., Ziermans, T., and Van Rijn, S. (2017). Connecting the dots between schizotypal symptoms and social anxiety in youth with an extra X chromosome: a mediating role for catastrophizing. *Brain Sci.* 7:113. doi: 10.3390/brainsci7090113

Molla Legesse, S., and Wondimu, H. (2023). Development and validation of the amharic version of self-efficacy and outcome expectancy measures on intention to take preventive actions on non communicable disease. *Behav. Neurol.* 2023:6669157. doi: 10.1155/2023/6669157

Moon, H. (2022). Knowledge, health beliefs, and preventive behaviors regarding COVID-19 among the general public. *J. Korean Assoc. Crisis Emerg. Manag.* 18, 15–27. doi: 10.14251/crisisonomy.2022.18.2.15

Mortada, E. M., and Elhessewi, G. M. S. (2022). Assessment of perceived risk and precautionary behavior toward COVID-19 pandemic using the health belief model, Saudi Arabia. *J. Egypt. Public Health Assoc.* 97:16. doi: 10.1186/s42506-022-00111-7

Musaazi, J., Namageyo-Funa, A., Carter, V. M., Carter, R. J., Lamorde, M., Apondi, R., et al. (2022). Evaluation of community perceptions and prevention practices related to ebola virus as part of outbreak preparedness in Uganda, 2020. *Global Health Sci. Pract.* 10:e2100661. doi: 10.9745/GHSP-D-21-00661

Mushumbusi, C. B., Max, R. A., Bakari, G. G., Mushi, J. R., and Balthazary, S. T. (2020). Cyanide in cassava varieties and people's perception on cyanide poisoning in selected regions of Tanzania. *J. Agric. Sci.* 8, 136–146. doi: 10.5296/jas.v8i1.15511

Nanyonjo, A. R., Angudubo, S., Candiru, W., Hamba, S., Esuma, W., and Kawuki, R. S. (2018). *State of Knowledge for Boiled Cassava in Uganda.* Food Science, Gender and Market.

Noghabi, A. D., Mohammadzadeh, F., Yoshany, N., and Javanbakht, S. (2021). The prevalence of preventive behaviors and associated factors during the early phase of the COVID-19 pandemic among Iranian People: application of a Health Belief Model. *J. Prevent. Med. Hygiene* 62:E60.

Noorman, M. A., de Wit, J. B., Marcos, T. A., Stutterheim, S. E., Jonas, K. J., and den Daas, C. (2024). Engagement of HIV-negative MSM and partners of people with HIV in HIV cure (research): exploring the influence of perceived severity, susceptibility, benefits, and concerns. *AIDS Care* 36, 211–222. doi: 10.1080/09540121.2024.2307381

Okareh, O., Ajayeoba, T. A., Ugbekile, O. F., and Hammed, T. B. (2021). The use of cassava leaves as food and medicinal herbs in rural communities and the perceived health risks. *Bionature* 41, 19–38.

Okui, K., Sawada, Y., and Yoshida, T. (2021). "Wisdom of the elders" or "loss of experience" as a mechanism to explain the decline in traditional ecological knowledge: a case study on Awaji Island, Japan. *Hum. Ecol.* 49, 353–362. doi: 10.1007/s10745-021-00237-w

Oloya, B., Adaku, C., and Andama, M. (2023). "The cyanogenic potential of certain cassava varieties in Uganda and their fermentation-based detoxification," in *Cassava-Recent Updates on Food, Feed, and Industry* (London: IntechOpen).

Panghal, A., Munezero, C., Sharma, and Chhikara, N. (2021). Cassava toxicity, detoxification and its food applications: a review. *Toxin Rev.* 40, 1159–1171. doi: 10.1080/15569543.2018.1560334

Permatasari, N., Yovi, E. Y., and Kuncahyo, B. (2024). Mitigating heat exposure: Exploring the role of knowledge, risk perception, and precautionary behavior. *Jurnal Sylva Lestari* 12, 11–26. doi: 10.23960/jsl.v12i1.773

Poulton, J. E. (1990). Cyanogenesis in plants. *Plant Physiol.* 94, 401–405. doi: 10.1104/pp.94.2.401

Putri, D. F., Triwahyuni, T., Rahmadhany, T. D., and Nusri, T. M. (2024). Knowledge, community behavior, and environmental factors in relation to the incidence of dengue hemorrhagic fever. *JKM (Jurnal Kebidanan Malahayati)* 10, 51–60. doi: 10.33024/jkm.v10i1.6676

Qiao, S., Tam, C. C., and Li, X. (2022). Risk exposures, risk perceptions, negative attitudes toward general vaccination, and COVID-19 vaccine acceptance among college students in South Carolina. *Am. J. Health Promot.* 36, 175–179. doi: 10.1177/08901171211028407

Rahman, M. M., Islam, A. R. M. T., Khan, S. J., Tanni, K. N., Roy, T., Islam, M. R., et al. (2022). Dengue fever responses in Dhaka City, Bangladesh: a cross-sectional survey. *Int. J. Public Health* 67:1604809. doi: 10.3389/ijph.2022.1604809

Rattay, Michalski, N., Domanska, O. M., Kaltwasser, A., De Bock, F., Wieler, L. H, et al. (2021). Differences in risk perception, knowledge and protective behaviour regarding COVID-19 by education level among women and men in Germany. Results from the COVID-19 Snapshot Monitoring (COSMO) study. *PLoS ONE* 16:e0251694. doi: 10.1371/journal.pone.0251694

Rayani, S., Rayani, M., and Najafi-Sharjabad, F. (2022). Correlation between anxiety and resilience of healthcare workers during COVID-19 pandemic in the southwest of Iran. *Environ. Sci. Pollut. Res.* 29, 21528–21536. doi: 10.1007/s11356-021-17284-x

Raza, S. A., Zhang, X., Oluyomi, A., Adepoju, O. E., King, B., Amos, C. I., et al. (2022). Predictors of COVID-19 perceived susceptibility: insights from population-based self-reported survey during lockdown in the United States. *J. Infect. Public Health* 15, 508–514. doi: 10.1016/j.jiph.2022.03.012

Raza, S. H., Iftikhar, M., Mohamad, B., Pembecioglu, N., and Altaf, M. (2020). Precautionary behavior toward dengue virus through public service advertisement: mediation of the individual's attention, information surveillance, and elaboration. *Sage Open* 10:2158244020929301. doi: 10.1177/2158244020929301

Ren, J., Huang, F., Chen, H., Zhang, H., Sun, J., Zhao, A., et al. (2024). Barriers to the acceptance of tuberculosis preventive treatment: a multicenter cross-sectional study in China. *Biomed. Environ. Sci.* 37, 1303–1309. doi: 10.3967/bes2024.155

Rincón Uribe, F. A., Godinho, R. C. d. S., Machado, M. A. S., Oliveira, K. R. d. S. G., Neira Espejo, C. A., de Sousa, N. C. V., et al. (2021) Health knowledge, health behaviors and attitudes during pandemic emergencies: a systematic review. *PLoS ONE* 16:e0256731. doi: 10.1371/journal.pone.0256731

Rosenstock, I. M. (1974). The health belief model and preventive health behavior. *Health Educ. Monogr.* 2, 354–386. doi: 10.1177/109019817400200405

Saleem, M., Dastgeer, S., Durrani, A. K., Saad, A. A., Manzoor, Z., Hussain, H. N., et al. (2020). Self-control mediates the relationship between psychosocial strengths and perceived severity of COVID-19 among frontline healthcare professionals of Pakistan: a single center experience. *Pakistan J. Med. Sci.* 36:S62. doi: 10.12669/pjms.36.COVID19-S4.2662

Saqlain, M., Munir, M. M., Rehman, S. U., Gulzar, A., Naz, S., Ahmed, Z., et al. (2020). Knowledge, attitude and practice among healthcare professionals regarding COVID-19: A cross-sectional survey from Pakistan. *J. Hosp. Infect.* 105, 419–423. doi: 10.1016/j.jhin.2020.05.007

Scarinci, I. C., Pandya, V. N., Kim, Y. I., Bae, S., Peral, S., Tipre, M., et al. (2021). Factors associated with perceived susceptibility to COVID-19 among urban and rural adults in Alabama. *J. Commun. Health* 46, 1104–1113. doi: 10.1007/s10900-021-00976-3

Shahnazi, H., Ahmadi-Livani, M., Pahlavanzadeh, B., Rajabi, A., Hamrah, M. S., and Charkazi, A. (2020). Assessing preventive health behaviors from COVID-19: a cross sectional study with health belief model in Golestan Province, Northern of Iran. *Infect. Dis. Pov.* 9, 91–99. doi: 10.1186/s40249-020-00776-2

Shinan-Altman, S., and Levkovich, I. (2020). COVID-19 precautionary behavior: The Israeli case in the initial stage of the outbreak. *BMC Public Health* 20, 1–7. doi: 10.1186/s12889-020-09818-8

Siddiqi, A. W. (2024). COVID-19 in social media: the effect of fear appeal messages in Facebook on users' perception of hygienic measures to prevent contracting the disease. *Media Asia* 51, 448–469. doi: 10.1080/01296612.2023.2299106

Siddique, A. B., Omi, N. T., Rasel, S. M., Hoque, S. S. B., Rahman, N., Sarker, S., et al. (2024). Assessment of perceived dengue risk and prevention practices among youth in Bangladesh. *Sci. Rep.* 14:3940. doi: 10.1038/s41598-024-54238-y

Simeonova, F. P., and Fishbein, L. (2004). *Hydrogen cyanide and* cyanides: human health aspects. Geneva: World Health Organization

Son, Y. A., and Jun, J. W. (2024). Effects of risk perception, SNS uses, and personal characteristics on climate change participation behaviors of millennials in South Korea. *Cogent Bus. Manage.* 11:2318793. doi: 10.1080/23311975.2024.2318793

Sonmezer, M. C., Sahin, T. K., Erul, E., Ceylan, F. S., Hamurcu, M. Y., Morova, N., et al. (2022). Knowledge, attitudes, and perception towards COVID-19 vaccination among the adult population: a cross-sectional study in Turkey. *Vaccines* 10:278. doi: 10.3390/vaccines10020278

Ssemakula, G. N., van der Grift, Y. B. R., Otim-Nape, G. W., Acola, G., and Orone, J. (2000). Improvement of local cassava germ plasm in Uganda. *Uganda J. Agricult. Sci.* 5, 8–11.

Stangier, U., Kananian, S., and Schüller, J. (2022). Perceived vulnerability to disease, knowledge about COVID-19, and changes in preventive behavior during lockdown in a German convenience sample. *Curr. Psychol.* 41, 7362–7370. doi: 10.1007/s12144-021-01456-6

Subedi, D., Pantha, S., Subedi, S., Gautam, A., Gaire, A., Sapkota, D., et al. (2021). Perceptions towards COVID-19 vaccines and willingness to vaccinate in Nepal. *Vaccines* 9:1448. doi: 10.3390/vaccines9121448

Sultan, and Wong, H. Y. (2019). How service quality affects university brand performance, university brand image and behavioural intention: the mediating effects of satisfaction and trust and moderating roles of gender and study mode. *J. Brand Manage.* 26, 332–347. doi: 10.1057/s41262-018-0131-3

TAAT Clearinghouse (2022). *Cassava Processing Technology Toolkit Catalogue. Clearinghouse Technical Report Series 013.* Cotonou, Benin: Technologies for African Agricultural Transformation, Clearinghouse Office, IITA.

Thaweewong, and Anuntagool, J. (2023). Change in free cyanide content of bitter cassava during incubation and drying and physical properties of dry-milled cassava flour. *Food Bioprod. Process.* 138, 139–149. doi: 10.1016/j.fbp.2023.01.009

Thoma, V., Weiss-Cohen, L., Filkuková, and Ayton, (2021). Cognitive predictors of precautionary behavior during the COVID-19 pandemic. *Front. Psychol.* 12:589800. doi: 10.3389/fpsyg.2021.589800

Thompson, E. E. (2020). Knowledge and risk perception about an ebola virus outbreak: a comparative study of Ghana and liberia. *J. Commun. Healthc.* 13, 271–283. doi: 10.1080/17538068.2020.1803644

Thompson, R. R., Jones, N. M., Garfin, D. R., Holman, E. A., and Silver, R. C. (2024). Contrasting objective and perceived risk: predicting COVID-19 health behaviors in a nationally representative US sample. *Ann. Behav. Med.* 58, 242–252. doi: 10.1093/abm/kaad055

Trevethan, R. (2017). Deconstructing and assessing knowledge and awareness in public health research. *Front. Public Health* 5:194. doi: 10.3389/fpubh.2017.00194

Tumwesigye, S. K. (2014). *Three Decades of Toxic Cyanide Management in Uganda*: *Doing and Communicating more with Minimal Strategies. Has it Been Possible* (Gent: Ghent University), 4–9.

UBOS (2022) *Annual Agricultural Survey 2020 Report*. Uganda Bureau of Statistics (UBOS); Kampala, Uganda.

ul Haq, S., Shahbaz and Boz, I. (2020). Knowledge, behavior and precautionary measures related to COVID-19 pandemic among the general public of Punjab province, Pakistan. *J. Infect. Dev. Ctries* 14, 823–835. doi: 10.3855/jidc.12851

Valencia-Jiménez, N. N., Ortega-Montes, J. E., and Cordero-Valencia, A. (2024). Relación de los conocimientos, prácticas y participación en la prevención del dengue con los factores individuales y del contexto en el Departamento de Córdoba, Colombia. *Revista de la Universidad Industrial de Santander. Salud* 56:e24014. doi: 10.18273/saluduis.56.e:24014

Venema, T. A., and Pfattheicher, S. (2021). Perceived susceptibility to COVID-19 infection and narcissistic traits. *Pers. Individ. Dif.* 175:110696. doi: 10.1016/j.paid.2021.110696

Wang, H., Ma, B., Cudjoe, D., Bai, R., and Farrukh, M. (2022). How does perceived severity of COVID-19 influence purchase intention of organic food? *Br. Food J.* 124, 3353–3367. doi: 10.1108/BFJ-06-2021-0701

Winters, M., Jalloh, M. F., Sengeh, Jalloh, M. B., Zeebari, Z., Nordenstedt, H., et al. (2020). Risk perception during the 2014–2015 Ebola outbreak in Sierra Leone. *BMC Public Health* 20, 89. doi: 10.1186/s12889-020-09648-8

Wise, T., Zbozinek, T. D., Michelini, G., Hagan, C. C., and Mobbs, D. (2020). Changes in risk perception and self-reported protective behaviour during the first week of the COVID-19 pandemic in the United States. *R. Soc. Open Sci.* 7, 200742. doi: 10.1098/rsos.200742

Wu, M., Long, R., Chen, H., and Wang, J. (2023). The influence of risk perception on climate change communication behavior: a dual perspective of psychological distance and environmental values. *Nat. Hazards* 118, 785–806. doi: 10.1007/s11069-023-06028-4

Yovi, E. Y., Nastiti, A., and Kuncahyo, B. (2023). Heat-related knowledge, risk perception, and precautionary behavior among Indonesian forestry workers and farmers: implications for occupational health promotion in the face of climate change impacts. *Forests* 14:1455. doi: 10.3390/f14071455

Zhong, Y., Liu, W., Lee, T. Y., Zhao, H., and Ji, J. (2021). Risk perception, knowledge, information sources and emotional states among COVID-19 patients in Wuhan, China. *Nurs. Outlook* 69, 13–21. doi: 10.1016/j.outlook.2020.08.005