

Evidence-based outreach/service-learning to improve health-related self-efficacy through STEMM education

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Evidence-based outreach/service-learning to improve health-related self-efficacy through STEMM education

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Editorial: Evidence-based outreach/service-learning to improve health-related self-efficacy through STEMM education

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Editorial on the Research Topic

[Evidence-based outreach/service-learning to improve health-related self-efficacy through STEMM education](#)

Health professions institutions, including medical schools, have long been involved in outreach and service learning to simultaneously serve the local community and provide hands-on educational opportunities for health professions students (1, 2). Many such programs seek to enhance public health, foster an interest in science for K-12 students, or provide pathways to health professions schools for individuals traditionally underrepresented in science and medicine. The need for such programs remains, especially with continued health disparities evident in rural and low socioeconomic status communities (3), the lack of parity in the physician workforce (4), and growing skepticism of science and public health since the COVID-19 pandemic (5).

There is a critical need to apply a scholarly approach to the development, implementation, and programmatic assessment of outreach and service-learning programs, followed by intentional dissemination of these programs and their outcomes so that the field can generate evidence-based best practices in outreach and service-learning. To help fill this gap, we created the Research Topic “Evidence-based outreach/service-learning to improve health-related self-efficacy through STEMM education” in *Frontiers in Public Health*. As Guest Editors for this Research Topic, we are delighted to present the collection of innovative articles comprising this Research Topic. This Research Topic unites diverse research that leverages science, technology, engineering, math, and medicine (STEMM) education and community engagement to empower both individuals and

communities while enhancing public health. This editorial summarizes the papers within the Research Topic, exploring four key themes, each highlighting a critical aspect of how evidence-based outreach and service-learning programs enhance health literacy, promote equity, and inspire the next generation of health professionals (Figure 1).

Theme 1: The need for evidence-based outreach and service-learning programs

Two studies lay the foundation by underscoring the importance of structured, evidence-based outreach and service-learning initiatives. (1) [Restini et al.](#) present a framework for developing effective programs that resonate with diverse populations. “*Empowering the future: improving community wellbeing and health literacy through outreach and service-learning*” demonstrates how targeted programs foster health-related self-efficacy, equipping individuals and communities with the knowledge and confidence to manage their health. (2) [Porter-Stransky et al.](#) investigate the relationship between socioeconomic factors and perceptions of science, emphasizing the need for inclusive outreach to bridge gaps in STEMM engagement.

Theme 2: Outreach programs to improve public health

A substantial portion of this Research Topic focuses on outreach programs addressing important public health challenges. Several studies showcase innovative community-based interventions initiated during the COVID-19 pandemic. For instance, [Ban et al.](#) and [Bekele et al.](#) illustrate how tailored approaches improved vaccine uptake among underserved groups in Missouri and Atlanta, respectively. Similarly, [Johnson et al.](#) and [Pichon et al.](#) demonstrate the power of outreach paired with technology to improve medical access for vulnerable populations. Other papers, such as [Kai et al.](#) and [Holcomb et al.](#) highlight scalable models for health and cancer screening. Finally, [Belkora et al.](#) demonstrate how service learning strengthens public health infrastructure, providing a model for workforce development.

Theme 3: Programs to enhance STEMM education and career opportunities

This theme combines evidence of programs that explore health and science education to empower individuals to pursue

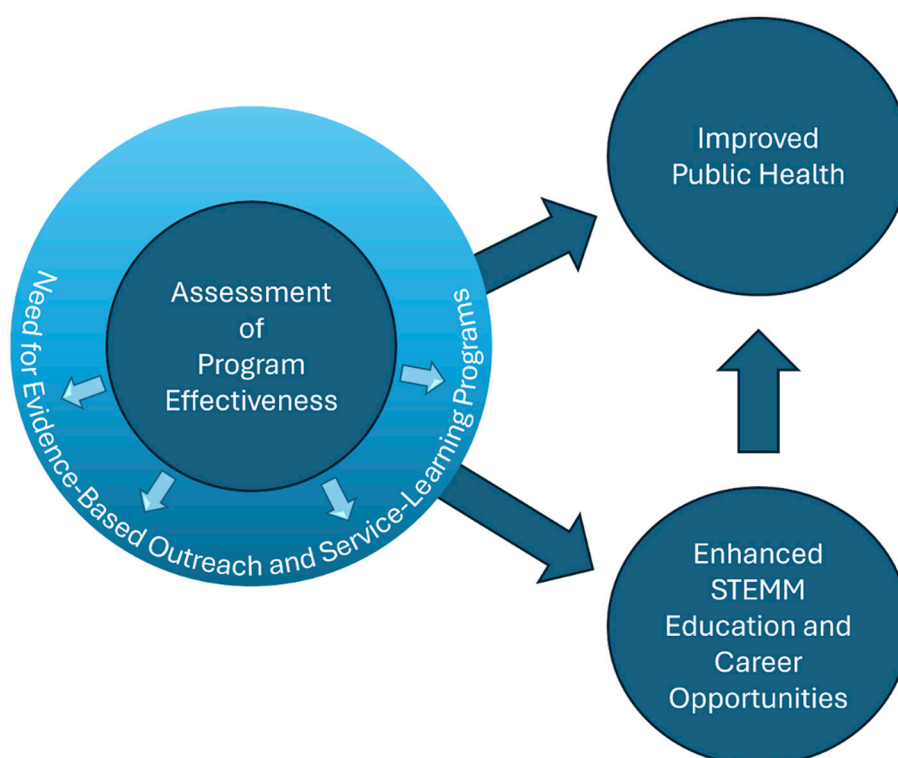


FIGURE 1

Relationships among themes represented in research collection. Evidence-based outreach and service-learning programs benefit from constant and consistent evaluation and assessment. Effective programs can lead to enhanced STEMM education and career opportunities for individuals, while simultaneously contributing to the improvement of public health in communities as a function of individuals collectively improving their health self-efficacy. Individuals that enter STEMM healthcare careers can also improve public health awareness and practices in the communities of their service and work.

STEMM career paths, ranging from elementary school to medical school. [Butterfield et al.](#) taught elementary school children basic anatomy, physiology, and nutrition, fostering an early interest in health and STEMM. [Imeh-Nathaniel et al.](#) educated middle schoolers on stroke risk factors and interventions. Similarly, [Mytting et al.](#) showcased healthcare career options to inspire rural youth to become health professionals serving rural British Columbia. [Anders et al.](#) developed a summer program for students underrepresented in STEMM in a rural, low-income state to increase biomedical research career interest and opportunity. Finally, [Salas et al.](#) developed an innovative pilot program whereby preclinical students develop STEMM outreach curricula, enhancing their learning while serving the community.

Theme 4: Effectiveness of health and science outreach, service-learning, and pathway programs

This last theme focuses on the importance of evaluating the impact and effectiveness of such programs. [Vollbrecht et al.](#) demonstrated multiple methods to assess whether outreach and service-learning programs are meeting their stated goals. [Affini et al.](#) examined demographic characteristics of participants in a health profession recruitment and exposure program in Chicago. [Naik et al.](#) and [Kemp et al.](#) used quantitative methods to parse the relationships between educational experiences and strategies that improve college readiness and self-efficacy for STEMM. [Ha et al.](#) used qualitative methods to assess parents' views on the acceptability of a physical literacy program, and [van Dongen et al.](#) used mixed methods to investigate the impact of an intervention to enhance physical activity and a healthy diet in secondary schools. Finally, [Prabhakar et al.](#) investigated medical student engagement during teaching science through community-based outreach programs, with the goal of improving communication skills and engagement.

Conclusion

This Research Topic illustrates the transformative potential of evidence-based outreach and service-learning in improving career opportunities and public health through engagement in STEMM across the educational continuum. By addressing health literacy, equity, and career development, these studies offer actionable insights for educators, public health practitioners, and policymakers. The findings highlight the importance of culturally tailored, data-driven and evidence-based programs that empower communities both through direct intervention and by inspiring future healthcare professionals. As we move forward, these models can guide efforts to build healthier, more equitable societies through STEMM education.

We thank the authors for their contributions and the *Frontiers in Public Health* editorial team for their support of this Research

Topic. We hope this Research Topic inspires continued innovation in public health outreach and education.

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Extending the Population Health Workforce Through Service Learning Internships During COVID: A Community Case Study

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This report arises from the intersection of service learning and population health at an academic medical center. At the University of California, San Francisco (UCSF), the Office of Population Health and Accountable Care (OPHAC) employs health care navigators to help patients access and benefit from high-value care. In early 2020, facing COVID-19, UCSF leaders asked OPHAC to help patients and employees navigate testing, treatment, tracing, and returning to work protocols. OPHAC established a COVID hotline to route callers to the appropriate resources, but needed to increase the capacity of the navigator workforce. To address this need, OPHAC turned to UCSF's service learning program for undergraduates, the Patient Support Corps (PSC). In this program, UC Berkeley undergraduates earn academic credit in exchange for serving as unpaid patient navigators. In July 2020, OPHAC provided administrative funding for the PSC to recruit and deploy students as COVID hotline navigators. In September 2020, the PSC deployed 20 students collectively representing 2.0 full-time equivalent navigators. After training and observation, and with supervision and escalation pathways, students were able to fill half-day shifts and perform near the level of staff navigators. Key facilitators relevant to success reflected both PSC and OPHAC strengths. The PSC onboards student interns as institutional affiliates, giving them access to key information technology systems, and trains them in privacy and other regulatory requirements so they can work directly with patients. OPHAC strengths included a learning health systems culture that fosters peer mentoring and collaboration. A key challenge was that, even after training, students required around 10h of supervised practice before being able to take calls independently. As a result, students rolled on to the hotline in waves rather than all at once. Post-COVID, OPHAC is planning to use student navigators for outreach. Meanwhile, the PSC is collaborating with pipeline programs in hopes of offering this internship experience to more students

from backgrounds that are under-represented in healthcare. Other campuses in the University of California system are interested in replicating this program. Adopters see the opportunity to increase capacity and diversity while developing the next generation of health and allied health professionals.

Keywords: service learning, population health, COVID-19, telehealth, undergraduate, navigation, internship, workforce innovation

INTRODUCTION: DESCRIPTION OF THE NATURE OF THE PROBLEM BEING ADDRESSED AND RATIONALE FOR THE PROPOSED INNOVATION

This case study reports on a collaboration that represents the intersection of two major trends: service learning in education (1–4) and population health in health care (5, 6). Service learning programs involve students in experiential learning outside of classroom settings. Population health programs target an entire population or panel of patients and attempt to address their health and wellness in an integrated and holistic fashion. The past decade has seen a steady increase in the proportion of patients cared for under accountable care or other risk sharing programs. Such programs create alignment for all parties for the provision of high quality and affordable health care, and create opportunity for health systems to innovate with new models of care delivery.

In early 2020, population health programs faced an influx of demand from patients who were potentially exposed to coronavirus infection and who needed help with testing, treatment, and tracing services related to COVID-19 (7). Meanwhile, undergraduate institutions have launched service learning programs to ensure that students are exposed to high impact practices such as internships (8–11). Students benefit from internships and other experiential learning opportunities because they allow students to apply knowledge, gain skills, interact with role models and mentors, and work on interprofessional teams (2, 12–14). Internships also present challenges, as well as opportunities, in terms of equity and access (15). This case study describes one such innovative internship at an academic medical center where students helped increase the capacity of a COVID hotline.

CONTEXT (SETTING AND POPULATION) IN WHICH THE INNOVATION OCCURS

The setting for this case study was the University of California, San Francisco (UCSF). UCSF includes schools of medicine, nursing, pharmacy, and dentistry; as well as UCSF Health, a health delivery system. UCSF has over 26,000 employees and sees 45,000 hospital admissions and 1.7 million outpatient visits annually. Within UCSF, key parties to this case study included UCSF's Patient Support Corps (PSC) and the Office of Population Health and Accountable Care (OPHAC); and UCSF patients and employees concerned about obtaining testing, treatment, tracing, and return-to-work services relevant to COVID-19.

The Office of Population Health and Accountable Care

In 2015, UCSF established its Office of Population Health and Accountable Care (OPHAC) to provide high-value care to defined populations of patients. In accountable care arrangements, public and private payers agree to share financial risk with a delivery system so that incentives are better aligned to focus on quality, not volume, of care. OPHAC employs 28 licensed professionals and 15 unlicensed navigators who provide care to 100,000 covered members. Along with analysts and other staff, this team helps patients access care related to cancer screenings, chronic obstructive pulmonary disease, depression, diabetes, end-stage renal disease, heart failure, hypertension, immunizations and other acute and chronic conditions.

In early 2020, in response to the pandemic, UCSF's Chief Medical Officer (author JA) tasked OPHAC with navigating patients and employees to established pathways for testing, tracing, treatment, and return to work. This led OPHAC to establish an employee- and patient-facing COVID telephone hotline. The volume of calls to this hotline quickly absorbed the capacity of existing staff navigators, who were redeployed from other population health assignments. Meanwhile, UCSF had implemented a hiring freeze. In hopes of expanding navigator capacity, OPHAC's director, author GI, responded to an email from UCSF's Chief Medical Officer (author JA), introducing OPHAC to author JB, director of the Patient Support Corps. In view of the COVID pandemic, JB had written to JA inquiring whether UCSF's pandemic response team could make use of student interns as workforce extenders.

The Patient Support Corps

The Patient Support Corps is a service learning program in which UC Berkeley pre-health students serve as unpaid patient navigators while earning academic credit. A formal affiliation agreement between UCSF and UC Berkeley addressed parties' concerns about training, risk management, insurance, security, privacy and confidentiality, academic content, and academic credit. Since 2012, the Patient Support Corps has trained and deployed 137 undergraduates earning academic credit through UC Berkeley's Undergraduate Research Apprentice Program.

Until the 2020 pandemic, UCSF's participating clinical sites consisted of adult ambulatory care clinics. In 2020, the director (author JB) began a series of discussions with OPHAC leaders and staff about adding Population Health to the roster of clinical sites that host student interns.

UCSF Patients and Employees Exposed to Coronavirus Infections (Hotline Callers)

The purpose of the Population Health collaboration with the Patient Support Corps was to better serve patients and employees exposed to Coronavirus infections. The institution directed patients and employees to call the COVID hotline to access testing, tracing, treatment, and return-to-work resources. OPHAC physicians authored branching logic instructions for hotline staffers to administer in guiding callers to the appropriate resources (16, 17). The instructions took the form of a base set of flowcharts, supplemented by a daily bulletin with modifications. Authors MH, HS, TT, GT, and FL made changes as new information emerged about the virus, testing, tracing, and treatment.

PROGRAMMATIC ELEMENTS

Program Plan

In July 2020, OPHAC signed a memorandum of understanding with PSC, providing 1 year of financial support for the administration of the Patient Support Corps' recruitment, onboarding, training, deployment, and supervision of students. The PSC agreed to provide 15 students working half-day shifts on the COVID hotline. The agreement also foresaw that OPHAC would evaluate whether students could be deployed as workforce extenders for other population health tasks and assignments. Both sides entered the agreement hoping that the arrangement would lead to OPHAC becoming a long-term clinical site hosting PSC student interns.

Author JB articulated a program plan for the new internship. The program plan consisted of five sub-plans: the strategic direction (vision, purpose, mission, values, and goals); the service delivery plan (how callers would interact with student navigators); the operational plan (what resources students would access to deliver services); the evaluation plan; and the financial plan (18).

For the service delivery plan and operational plan, we relied on two principles of lean design: prototyping and iteration (19). The prototype phase consisted of having two students act as trailblazers during summer 2020, with the plan to expand the number in Fall 2020 based on lessons learned from the summer pilot. The iteration phase included recruitment and larger scale training for the Fall rollout; competency checking and deployment of students; supervised practice; and program expansion.

Program Implementation

We now summarize, chronologically, our program implementation. In later sections, we will offer reflections on lessons learned.

Initial Training and Test Deployment

Author HT, a Clinical Manager in OPHAC, initially trained the two trailblazing students (authors JM and SK) on July 29, 2020. Topics included: the purpose of the hotline; the multiple workflows for patients calling regarding testing and symptom evaluation; the use of Cisco Finesse and Jabber telephony

systems; and the documentation of telephone encounters on ApeX (UCSF's electronic health record) and Qualtrics (an online survey system). Author JB recorded this initial training so that future students could access it asynchronously.

Contents of Training on Service Delivery and Operational Plans

The initial training addressed the overall functioning of the COVID hotline as follows. The purpose of the UCSF COVID hotline was to answer caller questions about COVID-19, and to provide protocol-driven telephone triage and disposition for symptomatic and/or exposed UCSF patients. OPHAC created the hotline to refer callers to appropriate levels of care and direct them to resources such as the Center for Disease Control and San Francisco Department of Public Health website.

Callers called the UCSF COVID hotline and selected if they were a patient or employee. The Cisco Finesse system routed callers to a navigator who picked up the incoming call on their Cisco Jabber softphone interface.

For students to serve on the hotline, they needed to be onboarded, trained, and badged as UCSF affiliates. Students configured their personal laptops to comply with UCSF's information technology security requirements. They also installed enterprise software that encrypted their devices; provisioned them for remote wiping in case of theft or loss; and provided access to the Cisco Finesse and Jabber software applications, as well as UCSF's electronic health record and Qualtrics data collection platform.

Using Jabber, each student was able to transfer calls; merge two calls; place a call on hold; and message colleagues in the Jabber chat room. Navigators interacted with callers and followed scripts with branching logic created by physicians as part of a larger effort to triage patients and employees at UCSF (16, 17).

Navigators accessed the scripts on a shared Box folder. Hotline leaders updated a daily bulletin notifying navigators of changes, and changed the scripts or add new branching logic as needed, for example when a large employer contracted with UCSF for employee support. Hotline leaders hosted online meetings before the hotline opened each day to inform navigators of changes and gather feedback relevant to updating the scripts and branching logic.

Navigators documented each call in the patient's medical record by creating a telephone encounter record. In the documentation section of the telephone encounter, the navigator noted the patient's responses to the branching logic questions. Some outcomes of the branching logic resulted in the navigator routing the record of the telephone encounter to a nurse team or a scheduling team.

In addition to documenting their notes in the caller's electronic health record, navigators also entered data about each call into a data collection form hosted on the Qualtrics survey system. Here, navigators entered the caller's affiliation to UCSF; the main reason for calling the hotline; if the patient was adult or pediatric; if they were an employee; the patient's medical record number; the outcome of the call; and the name of the navigator completing the form.

Observation and Supervised Practice

On July 30 and 31, 2020, JM and SK devoted 6 h shifts to observing an experienced navigator take calls on the UCSF COVID patient hotline. On August 1 and 2, 2020, JM and SK simulated calls and protocols with each other, alternately playing the role of caller or hotliner. During the week of August 3, JM and SK fielded calls on the hotline under the observation of experienced health care navigators for 9 h while being given feedback on health care navigator competencies.

Formal Competency Check

The formal competency check consisted of experienced navigators, authors GT and FL, observing JM and SK take calls on the hotline via Zoom. GT and FL evaluated the students based on a competency checklist which included the measures listed below. If the intern successfully met these competencies, they were cleared to take calls independently:

- **Box:** locates Daily Bulletin, Schedule, and most recent Algorithms [scripts with branching logic], searches Daily Bulletin
- **Jabber:** Updates status w/phone number, sends message, creates group chat
- **Language interpreting services:** finds preferred language in chart, inserts SmartPhrase at top of note
- **Transfer call to another agent**
- **Check eligibility:** find a caller's Primary Care Physician or Specialist in their medical record
- **Use of SmartPhrases in notes**
- **Use of Algorithm** [script with branching logic] to determine disposition
- **Routing notes about telephone encounter to Schedulers,** with appropriate routing comments
- **Qualtrics:** properly documenting the call.

After passing the competency check, JM and SK began fielding calls independently on the hotline on August 11, 2020, completing over 100 h on the hotline through August 25, 2020.

Recruitment

Following the summer test, authors JB and TW proceeded with the plan to scale up in the Fall. Since 2013, the Patient Support Corps has recruited students in partnership with two UC Berkeley organizations. The first partner is UC Berkeley's Undergraduate Research Apprentice Program (URAP). Each semester, URAP allows researchers at UC Berkeley and other sites to post internship opportunities on a website portal accessible to UC Berkeley students. Students then apply through the portal, submitting essays and transcripts, and requesting to be interviewed. Those accepted then sign a learning contract and register for up to three units of academic credit in the course Undergraduate Interdisciplinary Studies 192. At the end of each semester, author JB assigns pass/fail grades based on student participation and performance in the program and in written and verbal critical reflections. Thus URAP is a crucial partner in the PSC's overall service learning endeavor, as it provides a mechanism for soliciting student applications, and registering students to earn academic credit via coursework.

The second partner in PSC recruiting is a student organization. In 2013, the first PSC students participating via URAP formed UC Berkeley's Patient Advocacy Student Group (PASG). Among other duties, student group leaders advertise the URAP application process; screen applicants; interview finalists; and recommend a slate of students for consideration by PSC leaders JB and TW.

The URAP deadline was August 31, 2020, at which point 269 applicants submitted their essays and transcripts for consideration. In consultation with JB and TW, JM and SK instructed the application reviewers to search for applications that demonstrated the following competencies.

Patient centered competencies:

- **Humanism**—caring about people as people, regardless of how different they may be;
- **Remain neutral and focused on serving and advancing the patient agenda;**
- **Interact by telephone with clear volume and enunciation so that older or hard of hearing or Limited English Proficiency patients have the best chance of understanding;**
- **Paraphrase and summarize complex information concisely**

Teamwork competencies:

- **Follow complex instructions rigorously;**
- **Continuous improvement:** discuss errors without covering up or worrying about losing face;
- **Coordinate with other team members in pursuit of the mission,** without worrying about who gets credit or who is noticed;
- **Possibility of multi-year commitment as we put so much effort into training students**

Pre-requisites included facility and flexibility with technology; and ability to type over 40 words per min.

Application reviewers used a Google Sheets document to record their notes and rankings of 269 applications. JM and SK identified 93 finalists to interview based on the application rankings. Interviewers completed interviews between September 4 and September 7, 2020, again recording their notes and ratings in a Google Sheet. On the evening of September 7, the interviewers convened online to discuss their impressions and ratings. After facilitating the process to consensus, JM and SK loaded the top-ranked applicants into 40 internship positions based on matching each candidate's availability with the internship shifts that needed to be filled. JM and SK assigned 11 of the 40 applicants into COVID hotline shifts. Nine returning student interns also slotted into COVID hotline shifts. Overall this process resulted in 10 pairs of students being slotted into morning or afternoon shifts for every day of the week, representing a capacity of 2.0 full-time equivalent navigators being added to the COVID hotline.

On September 8 and 9, PSC program leaders JB and TW called the applicants recommended by the student leaders to verify their suitability, offer them positions, and advise on next steps for accepting the positions. TW sent each new offeree, and all returning student interns from the previous year, the URAP learning contract and UCSF affiliate agreement for signature.

The learning contract specified the conditions for student participation, including the terms of the affiliation agreement between UCSF and UC Berkeley. By signing this contract, students agreed to devote 11 h a week to their internship responsibilities. The affiliate agreement included a Student Responsibility Statement, in which students agreed to follow all applicable regulations and policies, including those governing privacy and confidentiality (e.g., protecting patient information) and information technology security (e.g., using UCSF-encrypted devices for all program purposes.)

By September 11, all the offerees had accepted and signed their learning contracts and affiliate agreements. We then embarked on the task of training 18 students to join the two trail-blazing students on the COVID hotline.

Larger Scale Training

JM and SK led initial COVID hotline training sessions for 18 students on September 19th and September 26th 2020 via Zoom. Trainees first listened to the recording of the orientation given by HT about the purpose of the hotline, technology used, and workflows.

JM and SK then demonstrated how to field incoming calls on Cisco Finesse, use Cisco Jabber call functions, create and route a telephone encounter on the electronic health record system (ApeX), and track calls on Qualtrics.

Next, JM and SK reviewed the hotline caller workflows and demonstrated how navigators use the Cisco Jabber chat room to communicate in real-time with the nurse escalations team and consult with the hotline lead navigators.

On the second training day, JM and SK explained the various types of calls received on the hotline including non-UCSF patients inquiring about testing; patients calling to schedule their COVID test appointment; patients misdirected to the hotline; and patients exposed to COVID-19 positive individuals.

Students role-played the standard workflows and practiced documenting telephone encounters and using smart phrases with pre-populated questions in a test patient record. Finally, JM and SK assigned the interns to practice the workflows with a partner and submit a recording for evaluation.

Meanwhile, JM and SK expanded from their regular one shift to two half-day shifts per week on the hotline on 10/12, 10/19, and 11/2. They invited each new student to sign up for hourlong slots within these shifts. During these slots, JM and SK opened a Zoom session on their computer, sharing their sound and screen. In this way, the trainees could observe and hear JM and SK interacting with callers. Each new student observed JM and SK for a total of 1 h during the weeks of 10/5 and 10/12. Then JM and SK used Zoom to observe the trainees taking calls, for a total of 2 h each during the weeks of 10/19 and 11/2. JM and SK instructed trainees to place the patients on hold and consult with JM and SK when necessary. In complex cases, JM and SK could escalate questions to the Jabber chat room or message lead navigators.

Competency Checking and Deployment

As experienced navigators, authors FL and GT administered competency checks to determine whether trainees were ready to field calls on the hotline independently. FL and GT competency

checked nine trainees the week of October 26, 2020, and approved six for independent work the week of 11/2. Since the 12 remaining trainees were not ready to field calls independently, they used their pre-assigned shifts time to practice alongside FL and GT or other experienced navigators on the hotline, either observing them or being observed via Zoom screen-sharing.

Supervised Practice During Suspension of Competency Checks

Between November 16 and December 10, 2020, lead navigators FL and GT suspended competency checks as they felt students needed more time observing and practicing. They suggested that students should shadow or be observed for 10 h before being competency checked. JM and SK arranged for students to practice under the supervision of the existing competency checked students, and to shadow the more experienced navigators on the hotline. Interns continued this training, spending ~5 h per week shadowing and precepting until the resumption of competency checks.

Resumption of Competency Checks

FL and GT resumed competency checking on December 11, 2020, and by December 31, 2020, 14 of the 20 interns were competency checked and able to take calls independently. By end of February, 2021, all 20 interns were taking calls independently. Through February, 2021, program records indicate that 20 interns worked 1,240 h on the hotline after being competency checked.

Program Expansion

Occupational Health

In mid-December, 2020, author MH identified the need to create a system for responding to employee questions about COVID exposure, testing, tracing, treatment, and return to work. Five students helped set up a process whereby employees could direct a voicemail or email message to UCSF's Occupational Health department, reporting contacts and exposures; positive test results; symptoms; adverse reactions to being vaccinated; or the need for return to work orders. Occupational Health navigators (including the 5 students) would then follow scripts and branching logic to either forward the emails or route notes about the voicemails to the appropriate Occupational Health staff who could address the employee questions. Five students devoted 270 h to Occupational Health between December 23, 2020 and January 21, 2021, a period corresponding to their winter break from school.

Population Health Outreach

In late 2020, the OPHAC shifted some navigator capacity from the COVID hotline back to regular care management activities, including outreach to patients with chronic conditions. Author JB contacted the Outreach Manager to see if students might help as workforce extenders in this arena. JB asked author SK to recruit one other student and work with the Outreach Manager to define a role for students in Population Health Outreach.

From January 7 to 11, 2021, the Outreach Manager and navigators oriented the two students to Population Health Outreach initiatives surrounding diabetes, child wellness,

and hypertension. Then, from January 11 to 27, 2021, the students engaged in supervised practice with more experienced navigators. The students learned to conduct chart reviews to identify patients due for health maintenance exams, or who might be suffering from care gaps such as missing eye exams, blood pressure checks, and blood tests (e.g., Hemoglobin A1C lab). The students also learned how to schedule patients for appointments with a primary care doctor for diabetes follow up appointments. They learned how to pend orders for blood pressure cuff, HbA1C lab, and microalbumin lab and how to pend referrals to ophthalmology for diabetic eye exam.

Between January 27 and March 3, 2021, the students worked on outreach tasks relevant to patients with hypertension. They learn how to case-find and then contact patients for hypertension follow up, documenting their outreach encounter in the medical record, and scheduling patients for appointment in the next 2 weeks with their primary care physician. The students coached patients to bring their blood pressure medications, take blood pressure readings, and bring their blood pressure cuff to their appointment.

On March 3, 2021, author SK began independently performing chart review and outreaching to patients with diabetes, and the next week SK worked on screening and depression.

DISCUSSION SECTION THAT SHARES PRACTICAL IMPLICATIONS, LESSONS LEARNED FOR FUTURE APPLICATIONS

Lessons Learned From Test Deployment

Our goal in launching with just two students was to test our program plan over the summer before scaling it up in the fall. This worked well. Key success factors included starting with two experienced students who could pair up for training, reflection, and peer support. However, using experienced students as trail-blazers meant that we underestimated the difficulty of training less experienced students. Also, hotline leaders had more bandwidth in the Summer to train two students than they did in the Fall to train 18 more.

Lessons Learned From Recruitment

Our goal in the recruitment phase was to find 11 new students who would be immediately effective in joining 9 returning students, all learning to be COVID hotline navigators. This worked reasonably well but was extremely time consuming. To save time, we now recommend advertising 10 half-day shifts, and inviting candidates to apply for specific shifts. We could then save time by simply conducting interviews until we filled each shift. This search strategy is known as “satisficing”—spending resources (e.g., interviews) until a “good enough” solution is found, rather than interviewing all applicants to find the optimal candidates.

Lessons Learned From Larger-Scale Training

Our goal in the larger-scale training was to get 18 students who were new to the COVID hotline up to speed without unduly burdening existing staff navigators. The hotline was experiencing very high call volumes and staff navigators were needed on the hotline. Therefore, we had to launch the navigators in waves rather than all at once. Now that the program is launched, each year we will have returning students who can serve as peer mentors and train new students, reducing the training burden placed on staff navigators. In addition, we plan in the future to institute a call recording feature. With other clinical sites, the Patient Support Corps has used call recordings to good effect as a way of accelerating training (20). For example, we have trainees transcribe calls, which is a way of having them absorb and reflect on dialogue in slow motion, through their fingertips.

Lessons Learned From Competency-Checking and Deployment

Our goal with competency-checking and deployment was to ensure that only students who were well-qualified would be cleared to work independently on the COVID hotline. A key lesson here was that we attempted competency checking too early for some students who needed more time observing navigators, and practicing under supervision.

Lessons Learned From Program Expansion

Our goal in the program expansion phase was to explore whether students could contribute to OPHAC in other internship roles, post-COVID. We conducted a test with the Outreach team, in which two students again blazed the trail by learning new and practicing new roles. From this test, we learned that students could contribute to outreach tasks, starting immediately with easier tasks (such as case-finding) and progressing to more challenging tasks (such as coaching patients to close key care gaps.) Overall, we concluded that the COVID hotline was an unusually intense way to launch a new program, as students had to be interacting in real time with patients in the stressful environment of a pandemic response. Deploying students to work on outreach tasks should be more straightforward. As author MH, Population Health Manager, said on a debriefing call, “We’ve proven that we can do this in a crisis. Now that we have time to actually develop something, we could do it 20 times better!”

Implications for Future Service Learning Collaborations With Population Health Program

Next Steps at UCSF

We have identified some key next steps at UCSF. First, we are renewing and extending the memorandum of understanding for the collaboration between OPHAC and PSC. OPHAC will provide 3 years of funding to support part-time effort by the PSC faculty director and program coordinator. In turn, the Patient Support Corps will recruit, train, and supervise 20–40 students

per year working to extend OPHAC's navigator capacity. We expect to bring on new students in their first or second year of college, and retain most students for 3 or 4 years.

Second, we are joining efforts to increase the diversity of students accessing our internship program. We will increase our outreach to pipeline programs, including those at local community colleges, to attract more students from under-represented backgrounds.

Opportunities for Other Population Health Programs

Each of the five medical centers in the University of California system has a Population Health program, and their leaders participate in a system-wide population health council. Student interns can provide an immediate boost to capacity, while also creating a pipeline of qualified candidates for future employment in these programs. Other academic medical centers outside of the UC system could likely benefit from similar internship programs, as could population health programs in community settings. The health care workforce must continue to evolve in order to reflect the diversity of our patient populations and to accommodate the novel ways in which patients will interact with the health care system. This program provides important training and a potential pipeline of future health care staff and professionals.

STRENGTHS, LIMITATIONS, AND CONCLUSIONS

We have described the launch, under crisis conditions, of a novel population health internship program. This program increased the navigator capacity in our institution's population health program from 15 to 17 full-time equivalents—an increase of 13%. We relied on weekly group calls and *ad hoc* individual communications to monitor student growth. By these accounts, consistent with a prior study (21), students reported tremendous growth in core competencies including medical knowledge, patient care, systems-based practice, practice-based learning and improvement, interpersonal skills and communication, and professionalism. In future iterations of the program, we hope to record calls and survey students and callers as part of our evaluation.

In conclusion, our report provides a detailed description of a successful service learning internship program that contributed to our institution's COVID response. We are now investing in the continued expansion of this program. We anticipate that population health internships will contribute to increased capacity for delivering high-value care to patients; and that these internships can also help train more students from under-represented backgrounds in health care.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

JB outlined and drafted the manuscript. TW, JM, and SK reflected on programmatic adaptations and other lessons learned from the Patient Support Corps perspective and contributed to corresponding sections of the manuscript. HT, TT, FL, GT, MH, and GI reflected on programmatic adaptations and other lessons learned from the Population Health perspective and contributed to corresponding sections of the manuscript. JA reflected on lessons learned from the institutional leadership perspective and contributed to the introduction and discussion. All authors contributed to the article and approved the submitted version.

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A Pilot Outreach HIV Testing Project Among Homeless Adults

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Background: The Memphis metropolitan statistical area (MSA) represents a Deep Southern U.S. city disproportionately affected by the ongoing transmission of new HIV cases as well as those diagnosed in late-stage disease. This region is a subset of nine states, including Memphis, Tennessee (project site), driving the epidemic in the United States. Memphis ranks 4th among all U.S. MSAs for new HIV infections and has been identified in the CDC's Ending the HIV Epidemic Initiative as a high HIV burden geographic focus area. The Memphis Ryan White Part A Program conducted a pilot project among adults seeking services in Memphis emergency and transitional housing shelters to offer on-site, rapid HIV testing. In this paper we describe the results from this aforementioned pilot study, including the rate of HIV test acceptance and potential factors associated with a history of HIV testing in Memphis.

Methods: Community-engaged research approaches were employed *via* a partnership between the local health department, a federally qualified faith-based health center, and an academic university. An interviewer-administered survey to measure potential factors associated with HIV testing history and voluntary HIV testing services were offered to adults living in transitional housing establishments. Bivariate chi-square analyses were performed to determine the association between predisposing, enabling, and need variables with HIV testing history in the past 12 months.

Results: Survey respondents ($n = 109$) were mostly cisgender male ($n = 96$; 88.1%), African American ($n = 79$; 72.5%) and reported engaging in condomless sex in the past 12 months ($n = 55$; 50.5%). Acceptability and uptake of HIV testing was high ($n = 97$; 89.0%).

Conclusions: Implementing rapid HIV testing programs outside of traditional health care settings is a strategy that can be used to engage high-risk individuals and those unaware of their HIV status to get tested. To our knowledge, this study represents the first that documents HIV testing acceptance rates offered outside of traditional health care settings for homeless and transitionally housed adults in a Deep Southern state.

Keywords: HIV testing, homelessness, Ryan White part A, behavioral model for vulnerable populations, service utilization

BACKGROUND

According to the Centers for Disease Control and Prevention (CDC), an estimated one-in-seven persons living with HIV in the United States in 2018 are unaware they are infected (1). The National HIV/AIDS Strategy (NHAS) cites this estimate as a challenge to reducing HIV transmission and acquisition since persons unaware of their status may unintentionally expose others (2). In 2010, the NHAS first recommended early testing and treatment as a primary strategy for reducing HIV incidence, and the updated NHAS 2020 Strategy includes specific guidelines, suggesting all HIV-negative people at high risk for infection should be tested at least annually (3). The NHAS 2020 also calls for ongoing support for the Ryan White HIV/AIDS Program (RWHAP), which works with cities, states, and local community-based organizations to provide a comprehensive system of care for those who do not have sufficient health care coverage or financial resources to cope with HIV disease (2). While the majority of RWHAP funds support primary medical care and essential support services, activities related to “early intervention services” are allowed to facilitate access to the HIV care system using HIV testing, referral services, health literacy, and care linkage to bridge medication access and treatment adherence (4).

Southern states accounted for ~51% of all people in the US with HIV at the end of 2018 (5). The Memphis Metropolitan Statistical Area (MSA) represents a Southern city disproportionately affected by the ongoing transmission of new HIV cases as well as those diagnosed in late-stage disease. In 2018, the Memphis MSA represented the third-highest rate of new HIV diagnoses in the United States (6). In 2007, The Memphis Area RWHAP was first awarded Part A and Minority Initiative AIDS funding by the Health Resources and Services Administration (HRSA) to provide primary medical care and essential support services for people living with HIV who were uninsured or underinsured within a seven-county area surrounding Memphis, spanning across Tennessee, Mississippi, and Arkansas (7). By 2011, the program had grown to serve over 4,500 persons living with HIV or AIDS; however, an estimated additional 2,000 individuals were infected but unaware of their positive status at the end of 2010 (8). In response to the large estimates of those unaware of their HIV status as well as HRSA requirements mandating early intervention strategies for all RWHAP nationwide, the Memphis Area RWHAP identified several vulnerable populations on which to focus early detection and treatment resources. These populations included homeless and transitionally housed populations (9). This strategy was corroborated by results from an annual point-in-time survey conducted by the Memphis and Shelby County Department of Housing and Urban Development, where 2% of homeless adults self-identified an HIV positive status (10). Furthermore, no HIV testing services were provided specifically for the homeless in concentrated, routine outreach efforts in Memphis.

Homeless and unstably housed individuals represent subpopulations at high risk for HIV infection, due in part to higher prevalence of alcohol dependence, illegal substance use, and sexual risk behaviors (11–13). Research estimates of HIV prevalence among unstably housed populations vary widely by geographic region and sampling methodologies. Further, a meta-analysis that included 43 studies conducted in the U.S. found prevalence rates of HIV among those with unstable housing ranged from 0.3 to 21% (14). Studies throughout the U.S. have concluded that community-based rapid HIV testing is feasible, acceptable, and effective for homeless populations, but these studies have not been documented in Southern states, and few describe the rates of HIV test acceptance through on-site screening programs (15, 16). The Memphis RWHAP conducted a pilot project among adults seeking services in Memphis emergency and transitional housing shelters to offer on-site, rapid HIV testing as well as an interviewer-administered survey to measure potential factors associated with HIV testing history. In this paper we describe the results from this aforementioned pilot study, including the rate of HIV test acceptance and potential factors associated with a history of HIV testing.

METHODS

A total of 116 adults receiving services from emergency and transitional housing providers in Memphis were recruited using posted flyers in facilities and constituted a cross-sectional, convenience sample. Inclusion criteria required participants to report they were currently sleeping at a housing shelter or had no place to sleep and were at least 18 years of age. Upon completion of a written informed consent form, participants were asked to complete an interviewer-administered survey and then were offered voluntary HIV testing services. Survey data collected from seven participants were excluded due to incomplete data or non-eligibility, resulting in a final sample of 109 participants for data analysis. Participants received a \$5 gift card to a local grocery store for completing the survey.

Application of the Behavioral Model for Vulnerable Populations with relation to use of HIV testing services guided the implementation of the pilot study (17, 18). This model addresses predisposing, enabling, and need factors relevant to understanding the health and health-seeking behaviors of vulnerable populations and has been applied in other studies to identify challenges in obtaining needed services for the homeless (19, 20). Use of HIV testing services was documented in two ways: the interviewer-administered survey included a question to document self-report of HIV testing within the past 12 months, and interviewers also recorded whether or not the participant accepted or refused voluntary HIV testing services following completion of the survey.

Assessment of predisposing variables included socio-demographic factors (gender, age, race, and education), duration of homelessness, history of incarceration, alcohol abuse or dependence, and general physical and mental health status. We also used the Alcohol Use Disorders Identification Test—Consumption (AUDIT-C), a validated (i.e., AUROC.891),

Abbreviations: MSA, metropolitan statistical area; CDC, Centers for Disease Control and Prevention; NHAS, National HIV/AIDS Strategy; RWHAP, Ryan White HIV/AIDS Program; HRSA, Health Resources and Services Administration; AUDIT-C, alcohol use disorders identification test.

three-item screening tool, to assess alcohol abuse or dependence (21). To evaluate general physical and mental health status, a standardized measure included self-report response options of excellent, very good, fair, or poor. Enabling factors were defined as those that affect health education opportunities and HIV-risk assessment. These variables included current health insurance coverage, when and where the participant last accessed a doctor, and whether or not the participant had one person considered as a personal doctor or health care provider. To evaluate factors related to need for HIV testing, participants were asked to describe self-perceived susceptibility and risk behaviors. Perceived susceptibility for HIV infection was evaluated using a scale from zero to four, where zero represented the participant was “not worried at all” about being infected, and four indicated the participant was “extremely worried.” This scale has previously been used in research studies with homeless adults and has been assessed for internal reliability and predictive validity (22). The Fogg HIV Screening Questionnaire was employed to assess HIV-risk behaviors in the 12 months prior to the survey. This instrument has been evaluated for reliability (Cronbach's 0.72–0.90; test-retest 0.56–0.86) within homeless populations; it includes eight self-report questions to assess specific sexual risk behaviors and two additional questions to assess injection drug use and diagnosis of a sexually transmitted infection (23).

The survey instrument was qualitatively pilot tested with a subset of the priority population. Participants were asked five brief questions about the difficulty, similarity, length of the survey, comfort level answering the questions, and suggestions to improve the survey. Data entry was performed by the lead epidemiologist and verified by the graduate assistant. Use of HIV testing services are described as a percent of participants (a) ever tested for HIV, (b) tested within the past 12 months, and (c) accepting HIV testing at the time of the survey. Bivariate chi-square analyses were performed to determine the association between predisposing, enabling, and need variables with the individual's HIV testing history in the past 12 months. All analyses were performed using the SAS Statistical Analysis package (SAS Institute version 9.3).

A community engaged partnership approach was employed between a local health department, university, and a community federally qualified health center to develop the study design, co-create the survey instrument, administer surveys, and disseminate study findings (24). The community health center was identified as a viable research partner given the range of medical and supportive services it provided for persons living with HIV/AIDS, prior experience in providing outreach HIV testing services for the homeless population, and long-standing partnership with the local health department. Each member of the data collection team received training in research ethics and study procedures, participated in interview role plays, and observed in the field to maintain quality control and receive immediate corrective feedback. Approval of an Institutional Review Board was obtained from the University of Memphis (Protocol #2049). Free confidential HIV testing was offered to all participants but not required for survey participation.

RESULTS

Among the 109 participants, the majority of our study's respondents were male ($n = 96$; 88.1%), African American or Black ($n = 79$; 72.5%), had a history of incarceration ($n = 91$; 83.5%), and reported their overall physical health ($n = 77$; 70.6%) and mental health ($n = 79$; 72.5%) as either good, very good, or excellent. Participants between 40–49 years ($n = 41$; 37.6%) and 50+ years ($n = 39$; 35.8%) accounted for the two largest age groupings. Almost half of the participants reported short-term homelessness, where 47.7% ($n = 52$) indicated they had been homeless for <12 months. Less than half screened positive for alcohol dependence or abuse ($n = 48$; 44.0%) on the AUDIT-C tool. Sex without a condom ($n = 55$; 50.5%), sex while drunk or high on drugs ($n = 52$; 47.7%), and sex with an unknown person ($n = 26$; 23.9%) emerged as the three most prevalent risk behaviors in the 12 months preceding the survey administration. Chi-square analyses found no significant associations between predisposing, enabling, and need variables with HIV testing history in the past 12 months (Table 1).

The large majority of participants accepted HIV testing following survey administration ($n = 97$; 89.0%). While 73.4% ($n = 80$) participants reported ever having an HIV test in the past, only 29.4% ($n = 32$) had been tested for HIV in the 12 months prior to the survey. Nearly three-quarters of the study participants reported no health insurance coverage, or they didn't know if they had coverage; however, 72.5% ($n = 79$) reported seeing a doctor in the past 12 months. Among the 79 participants self-reporting a doctor visit in the 12 months prior, only 34.1% ($n = 27$) reported they had been tested for HIV during the same time period. For those reporting a doctor's visit or HIV test within the past 12 months, the type of facility is displayed in Table 2. A hospital or emergency room accounted for both the largest number of participants reporting the location of last doctors' visit ($n = 25$; 31.6%) and last HIV test ($n = 7$; 21.9%). The second and third most frequently cited locations for last doctors' visit included public health clinics/health departments ($n = 15$; 19.0%) and the Veterans Affairs hospital ($n = 14$; 17.7%). Public health clinics/health departments accounted for the second most frequently cited location among participants reporting an HIV test in the past 12 months ($n = 7$; 21.9%), while outreach mobile clinics accounted for the third most frequently cited location ($n = 5$; 15.6%).

DISCUSSION

Implementing rapid HIV testing programs outside of traditional health care settings is a strategy to target high-risk individuals and those unaware of their HIV status. To our knowledge, this study represents the first that documents HIV testing acceptance rates offered outside of traditional health care settings for homeless and transitionally housed adults in a Southern state. Two studies have demonstrated the rate of acceptance for rapid HIV testing in community-based outreach programs and ranged from 60% to 75%, varying by geography and venue for recruitment (15, 25). The acceptance of HIV testing following our survey administration was higher than expected based upon the

TABLE 1 | HIV testing history by predisposing, enabling and need variables.

Variable*	No HIV test in past 12 months (<i>n</i> = 77)		Tested for HIV in past 12 months (<i>n</i> = 32)		Total Sample (<i>n</i> = 109)		
	<i>N</i>	%	<i>N</i>	%	<i>n</i>	χ^2 -statistic	<i>P</i> -value
Predisposing variables							
Gender						0.59	0.44
Male	69	71.9%	27	28.1%	96		
Female	8	61.5%	5	38.5%	13		
Age						3.85	0.15
19–39	19	65.5%	10	34.5%	29		
40–49	26	63.4%	15	36.6%	41		
50+	32	82.1%	7	17.9%	39		
Race						2.92	0.09
Black/African American	52	65.8%	27	34.2%	79		
White	24	82.8%	5	17.2%	29		
Duration of homelessness						0.05	0.83
<12 months	36	69.2%	16	30.8%	52		
1 + years	37	71.2%	15	28.8%	52		
Education						2.60	0.27
Less than GED/high school diploma	21	75.0%	7	25.0%	28		
High school diploma or equivalent	33	63.5%	19	36.5%	52		
Some college/graduate	23	79.3%	6	20.7%	29		
History of Incarceration						1.67	0.20
Yes	62	68.1%	29	31.9%	91		
No	15	83.3%	3	16.7%	18		
Alcohol dependence						0.02	0.89
Yes	34	70.8%	14	29.2%	48		
No	39	69.6%	17	30.4%	56		
Physical health						2.20	0.14
Fair, Poor	25	80.6%	6	19.4%	31		
Good, Very Good, Excellent	51	66.2%	26	33.8%	77		
Mental health						1.07	0.30
Fair, Poor	19	63.3%	11	36.7%	30		
Good, Very Good, Excellent	58	73.4%	21	26.6%	79		
Enabling variables							
Health insurance coverage						0.14	0.71
Yes	19	67.9%	9	32.1%	28		
No/Unknown	58	71.6%	23	28.4%	81		
Last doctor visit						2.63	0.11
< 12 months ago	52	65.8%	27	34.2%	79		
1+ years ago	23	82.1%	5	17.9%	28		
Regular source of care						0.08	0.77
Yes	29	69.0%	13	31.0%	42		
No	48	71.6%	19	28.4%	67		
Need variables							
Perception of HIV risk						0.06	0.97
Not at all	36	70.6%	15	29.4%	51		
Little/slightly/somewhat	17	70.8%	7	29.2%	24		
Extremely	19	73.1%	7	26.9%	26		
HIV-risk behaviors (<i>in the past 12 months</i>)**						1.85	0.60
Sex without a condom	40	72.7%	15	27.3%	55		
Sex while drunk or high on drugs	35	67.3%	17	32.7%	52		

(Continued)

TABLE 1 | Continued

Variable*	No HIV test in past 12 months (n = 77)		Tested for HIV in past 12 months (n = 32)		Total Sample (n = 109)		
	N	%	N	%	n	χ^2 -statistic	P-value
Sex with an unknown person	19	73.1%	7	26.9%	26		
Five or more sex partners	9	56.3%	7	43.8%	16		
Used a needle to inject drugs	6	75.0%	2	25.0%	8		
Sex with IDU (IV Drug User)	5	71.4%	2	28.6%	7		
Diagnosis of STD	2	50.0%	2	50.0%	4		
Traded sex for drugs or money or something else needed	2	66.7%	1	33.3%	3		
Sex with a man who has had sex with a man (MSM)	2	100.0%	0	0.0%	2		
Sex with someone who is HIV positive	1	100.0%	0	0.0%	1		
Total	77	70.6%	32	29.4%	109		

*Missing and unknown data are excluded from chi-square statistic tests; thus, variable category totals may not equal column totals.

**HIV-risk behaviors are not exclusive and participants had the option to elect more than one response. Chi-square statistic test only included the four highest frequency risk behavior categories, including sex without a condom, sex while drunk or high on drugs, sex with an unknown person, and five or more sex partners. Bold values are the total number of participants i.e., 77 reporting no HIV test in past 12 months, 32 reporting HIV test in past 12 months, and 109 total sample. Italic values in the last column are the non-significant p-values.

TABLE 2 | Site of last doctor visit and Last HIV test within 12 months prior to survey*.

Site	Participants reporting doctor visit in past 12 months (n = 79)		Participants reporting HIV test in past 12 months (n = 32)	
	N	%	N	%
Hospital/emergency room	25	31.6%	7	21.9%
Public health clinic/health department	15	19.0%	7	21.9%
Veterans affairs	14	17.7%	0	0.0%
Private doctor office	10	12.7%	1	3.1%
Outreach mobile clinic	6	7.6%	5	15.6%
Prison/jail	2	2.5%	3	9.4%
Shelter	2	2.5%	0	0.0%
Drug rehab facility	0	0.0%	1	3.1%
Blood bank	0	0.0%	2	6.3%
Unknown/other site	5	6.3%	6	18.8%

*P-value > 0.05.

results of the aforementioned studies. When offered the option to receive an HIV test following completion of our survey interview, almost 90% agreed to be tested. This acceptance rate would seem to indicate that rapid HIV testing might be well-accepted among this population given the option onsite at locations offering services to homeless and transitionally housed adults.

Almost three-quarters of our participants had a doctor visit within the 12 months prior to our survey, but only 34% of these individuals had also been tested for HIV during this same period. This disparity, coupled with the high acceptance of HIV testing in this pilot outreach testing project, potentially demonstrates missed opportunities to implement early testing strategies supported by the NHAS in a variety of health care settings. The majority of participants reported the site of last doctor visit was received at hospitals/emergency rooms or public health clinics, indicating these venues as important points of health care access for this population. For our pilot project we

recruited participants from venues serving homeless populations, such as emergency shelters, transitional housing, and drop-in centers where meals were provided. The high acceptance rates of HIV testing following the survey administration indicates these sites as potential venues to provide mass HIV testing outside of traditional health care access points.

Although no significant associations were identified between or among any predisposing, enabling, or need variables and a history of HIV testing in the 12 months prior to the survey, the reported high-risk behaviors are not without warrant. Over two-thirds of the sample reported engaging in at least one high-risk behavior in that 12-month time period. The most frequently cited behaviors within the past 12 months included engaging in sexual activity with unknown persons, being under the influence of alcohol or drugs, and having sex without using condom. High risk behaviors such as the aforementioned may be attributed to survival sex to secure goods, services, and maintain housing (26).

Nevertheless, these results still highlight the need to prioritize routine and early testing strategies for this at-risk population.

This study is not without limitations. With respect to assessing a history of HIV testing, we did not document if other health care providers offered testing for regular office visits and if our participants declined. Likewise, homeless adults from these facilities self-selected to participate in the survey and thus may view issues related to HIV testing differently from non-participants. We did not conduct *post hoc* analysis to assess the psychometric properties of the survey. However, we administered the survey to a sub-sample from the priority population to qualitatively assess readability and comfortability. Finally, we did not assess same sex behaviors and survival sex among our mostly cisgender male sample, which could potentially provide additional risk for HIV acquisition.

CONCLUSIONS

Offering on-site, rapid HIV testing for unsheltered populations is paramount as the Memphis community works toward developing a local plan for the U.S. Ending the HIV Epidemic Initiative (27). Housing and economic instability will remain barriers to reaching benchmarks for prevention and testing pillars. These two social determinants of HIV are associated with viral suppression (28). Permanent housing for those living with HIV increases medication adherence, retention in care, and access to supportive services to better achieve viral suppression (29). Similarly, housing stability could facilitate other prevention goals such as testing and access and adherence to PrEP for those engaging in condomless sex. The current pilot project demonstrates acceptability of non-traditional testing and potential factors to consider as facilitators of HIV testing behaviors in emergency shelters.

With the recent onset of COVID-19 and the subsequent effect that the pandemic will have on housing and economic instability, it remains essential to maintain HIV testing outside of traditional health care settings (30). More and more Black Americans living in the South will no longer have reliable and consistent employment to maintain stable housing or health insurance coverage to seek HIV preventive services. Lack of Medicaid expansion to an already vulnerable southern city alongside threats of disruption of coverage under the Affordable Care Act will exacerbate existing disparities (31, 32). Furthermore, our health care systems will likely see an uptick in use of hospital or emergency rooms for primary health care for mostly preventable illness post COVID-19 (33, 34).

The findings from this pilot HIV testing intervention in non-traditional settings has significant public health implications for future prevention and testing goals to curb the epidemic in the South. The high acceptability and uptake of HIV screening support the utility of community-engaged approaches and strategies to successfully partner with the local public health department and federally qualified health centers to increase HIV testing rates among particularly at-risk populations. It also provides context to the feasibility of offering testing in transitional housing locations with limited disruption to facility

operations. Finally, the practicality of involving frontline staff in the research design and implementation of an HIV testing research study strengthens the acceptability of community-based projects and community participation. We recommend future studies use rigorous study designs with a comparison group, follow participants overtime, and conduct exploratory analyses to understand the impact of testing adherence and housing status.

DATA AVAILABILITY STATEMENT

The dataset generated and analyzed during the current study are not publicly available due to our lack of non-data sharing agreement during the acquisition of data but are available from the corresponding author on reasonable request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The University of Memphis Institutional Review Board. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LP, KR, TC-M, LK, JK, and AC made substantial contributions to the conception of the work, co-wrote sections of the paper and have read and approved the final manuscript. All authors have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated.

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Adoption of an Evidence-Based Intervention for Mammography Screening Adherence in Safety Net Clinics

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Through an academic-community partnership, an evidence-based intervention to reduce mammography appointment no-show rates in underserved women was expanded to safety net clinics. The partnership implemented four strategies to improve the adoption and scale-up of evidence-based interventions with Federally Qualified Health Centers and charity care clinics: (1) an outreach email blast targeting the community partner member clinics to increase program awareness, (2) an adoption video encouraging enrollment in the program, (3) an outreach webinar educating the community partner member clinics about the program, encouraging enrollment and outlining adoption steps, and (4) an adoption survey adapted from Consolidated Framework for Implementation Research constructs from the Cancer Prevention and Control Research Network for cancer control interventions with Federally Qualified Health Centers. The development of academic-community partnerships can lead to successful adoption of evidence-based interventions particularly in safety net clinics.

Keywords: adoption, evidence-based intervention, safety net, mammography, appointment adherence

INTRODUCTION

Widespread adoption and implementation of evidence-based interventions (EBIs) is critical to improve health outcomes by increasing community demand and access to healthcare services. Unfortunately, widespread scale-up adoption of EBIs in public health practice remains elusive, especially with community and healthcare organizations that serve underserved communities (1–3). The purpose of this community case study is to document four strategies by an academic-community partnership to improve adoption and uptake of a mammography screening evidence-based intervention (EBI) in Federally Qualified Health Centers (FQHCs) and charity care clinics serving underserved women in the Greater Houston area.

BACKGROUND AND RATIONALE

Breast cancer is the most common cancer in the United States and the second leading cause of cancer mortality among women in the United States, with roughly one in eight developing breast cancer during their lifetime (4). Substantial breast cancer-related morbidity and mortality

disparities persist among underserved communities including those who are uninsured and African American women (4). These breast cancer-related disparities are attributed to a lack of access to mammography screening services, an increased likelihood of a later stage cancer diagnosis, and lack of culturally appropriate care across the cancer continuum of care (5–8). Knowledge and beliefs about both breast cancer and mammograms' impact a woman's willingness to be screened (5). Fear of having the screening test performed and the possibility of pain or discomfort can deter underserved women from receiving a mammogram (6, 7). There are also women that would rather not know about the presence of cancer in their bodies (6, 7). In addition to cognitive barriers, underserved women report missing scheduled appointments due to logistical barriers, lack of transportation, child care, and the ability to take time from work (5, 6). While the average no-show rates from mammogram appointments is 6.2%, African American women who make up a good portion of underserved women, have a no-show rate 2.6 times higher than the 6.2% on average (9).

FQHCs and other safety net clinics in the United States are uniquely situated to reach women in the most need for breast cancer screening. More broadly, safety net clinics provide healthcare services to those who are uninsured or a Medicaid recipient, living in immigrant and minority communities, and those who are unable to afford health care services elsewhere. FQHCs are federally designated community-based safety-net providers that provide a comprehensive set of healthcare services including primary care and preventive care regardless of a patient's ability to pay (8, 9). Similarly, charity care clinics provides free or reduced cost care to patients without health insurance. Despite their importance, these clinics need assistance in adopting and implementing EBIs as many do not have staff with expertise or experience in this area or capacity to implement them on their own (8–10). Recent systematic reviews have identified some strategies shown to improve the adoption and scale-up of EBIs at clinical and system levels (11, 12). These include conducting educational meetings with clinical providers, developing incentive or penalty structures, and addressing human resource and cost barriers (11, 12). However, there is still much to learn in terms of which adoption strategies are feasible and most effective to support EBI scale up for breast cancer and other cancers, particularly in settings such as Federally Qualified Health Centers (FQHCs) that care for underserved communities.

Research shows complex health issues like breast cancer require a collaborative approach (13). Effecting positive change in the prevention of breast cancer requires patient support beyond an appointment referral or reminder from a health care provider. Creating a space for community organizations, clinical providers, and academic research entities to problem-solve as equal partners builds trust and facilitates the placement of appropriate EBIs. Collaboration and partnerships positively affect mammography screening behaviors and breast cancer disparities among underserved communities (13). Collaborations of organizations with complementary expertise has been shown to result in the creation of common goals, to fill health care gaps, and to promote efficiency (14).

Context

The PMP intervention was implemented in FQHCs and charity clinics in the Greater Houston area through an academic-community partnership with The University of Texas Health Science Center at Houston (UTHealth) School of Public Health and the Breast Health Collaborative of Texas (BHCTexas) alongside three local mobile mammography providers who provided mammography screening assistance (15, 16). BHCT is a 501(c) (3) nonprofit statewide member network of over 600 individual and organizational breast health advocates. BHCT has a unique mix of members – ranging from breast cancer survivors, advocates whose lives have been touched by breast cancer, health care professionals working in breast health [e.g., clinicians, nurses, community health workers (CHWs), healthcare managers and administrators] and organizations providing breast health services. BHCT includes a member network of local FQHC and charity clinic members in the Greater Houston area who provide free or reduced cost care to underserved populations. The local clinic organizational members are represented by individual clinic leadership and staff at the frontlines of providing health care to underserved communities. This Collaborative is a member-driven organization and, as a unique organization in the state of Texas, unites the breast health community to educate, advocate, navigate and maximize resources with the vision of ensuring quality breast health care. BHCTexas administration and CHW staff had experience and expertise in collaborative leadership with extensive knowledge of the system of care for breast cancer in Texas and of issues facing underserved women in safety net clinics. This background made BHCTexas an ideal partner for facilitating intervention adoption. The academic researchers brought in BHCTexas as an equal partner to assist in the facilitation of intervention adoption into the mammography screening appointment process in the local FQHCs and charity care clinics comprising the BHCTexas member network.

Peace of Mind Program (PMP) Programmatic Elements

The Peace of Mind Program (PMP) is an EBI adapted from a National Cancer Institute Research program to reduce mammography appointment no-show rates in underserved women (3, 15, 16). In the intervention, patient navigators provide tailored reminder phone calls based on the Transtheoretical Model of Change to counsel women through cognitive and system barriers to scheduled mammography appointments (3, 15, 16). In the development of the EBI, interviews and focus groups were conducted with African American women who had missed a mammography appointment within the last six months (17). The intervention was then tested within a mobile mammography practice setting with underserved African American women in the Greater Houston Area (3). For the adoption of PMP in FQHCs and charity clinics, patients reviewed and provided feedback on reminder phone call scripts (15, 16). The previously developed intervention protocols were then adapted to include adoption and implementation strategies to support expansion to the FQHCs and charity clinics (15, 16).

Conceptual Framework

A conceptual framework using selected constructs from across the five domains in the Consolidated Framework for Implementation Research (CFIR) and five phases from The International Association for Public Participation (IAP2) spectrum was created to guide stakeholder engagement with the safety net clinics in the PMP (16). The conceptual framework was used across adoption, implementation, and sustainment of the PMP. In terms of adoption, the researchers and BHCTexas recruited potential sites to PMP in the Inform IAP2 phase by first educating clinic staff about the strength and quality and relative advantage of the intervention. These activities targeted CFIR constructs in the Intervention Characteristics domain. In the Consult IAP2 phase, we sought feedback about the implementation climate and readiness of the clinic to adopt and implement PMP. These activities targeted CFIR constructs in the Inner Setting domain. The complete conceptual framework description has been reported elsewhere (16).

Adoption Strategies

An adoption planning group – consisting of the academic research team and BHCTexas administration and CHWs – developed four adoption strategies that aligned with the Inform and Consult IAP2 phases in the stakeholder engagement conceptual framework (16, 18). The strategies included: (1) an outreach email blast targeting BHCTexas member clinics to increase program awareness, (2) an adoption video encouraging clinic enrollment in the program, (3) an outreach webinar educating BHCTexas members about the program, encouraging enrollment and outlining adoption steps, and (4) an electronic adoption survey adapted from CFIR constructs from the Cancer Prevention and Control Research Network (CPCRN) for cancer control EBIs with FQHCs (15, 19–22). A CPCRN work group developed a comprehensive set of measures to identify and promote the uptake of evidence-based approaches in cancer prevention and control (21, 22). The work group has reported the operationalization of the measures across CFIR constructs from all CFIR domains and their psychometric properties elsewhere (21). The measures across CFIR constructs demonstrated good discriminant validity and internal consistency when tested within the context of colorectal cancer screening in FQHCs (22). The survey consisted of 75 statement items measuring potential barriers and facilitators to intervention adoption across 12 constructs in three domains of the CFIR (See **Supplementary Material** for the full survey). For each survey statement, individual respondents rated the statement on a Likert scale from 5 (completely agreed with the statement) to 1 (completely disagreed with the statement).

The strategies reached the PMP target population through multiple modes. More than 50 people participated in the outreach webinar to receive continuing education units (CEUs). The adoption outreach video was sent to over 600 individual and organizational BHCTexas members and reach was tracked by Google Analytics to ensure members were viewing the video. The adoption survey was sent to all registered BHCTexas clinic members across Texas, which encompassed representatives of 20 local FQHC and charity care clinics providing free or reduced

cost care to underserved communities, including mammography screening services, in the Greater Houston Area. These local clinics serve a diverse community of African American, Hispanic, Vietnamese, and white women between the ages of 40 to 64 years old, who were at or below 200% of the Federal Poverty Level for a family of four and who lacked health insurance. A total of 372 individual survey completion attempts were made including 50 attempts from the clinic leadership and staff at the 20 local clinics in the Greater Houston area. Out of the 43 local individuals who completed the question about employment, most had worked for the clinic for two years or less (34; 79%). Out of the 44 local individuals who completed the question about clinic role, most were clinic administrators (17; 39%) and CHWs/patient navigators (12; 27%). Out of the 20 total local clinics who took the adoption survey, 15 clinics adopted (75%) and five did not adopt (25%) PMP following exposure to the strategies.

Across the individual responses for each clinic, a mean score (M) between 1 and 5 was created to measure clinic member level of agreement with each statement item. Higher ratings of survey statements relating to the complexity of the intervention, trialability, and culture/stress in the clinic environment were associated with lower likelihood of adoption. The clinic members who did not adopt PMP had a higher level of agreement for complexity statement items such as, “It will be hard to train providers and staff to implement the PMP” (M = 2.8) and, “Using the PMP will require our clinic to make substantial changes to our way of doing things” (M = 3.3) compared with those who did adopt (respectively, M = 2.3 and 2.69). For trialability, those who did not adopt PMP had a higher level of agreement with survey statements such as, “Once we try the PMP it will not be easy to go back to our old way of doing things, even if we do not like it” (M = 3.6) compared with those who did adopt (M = 3.34). The clinic members who did not adopt had a higher level of agreement with survey statements relating to the stress-related cultural aspects present in the clinic environment than those who adopted: staff stress and strain (M = 3.1 vs. 3.06), heavy workload (M = 3.0 vs. 2.5), individual job stress (M = 2.5 vs. 1.90), and staff frustration (M = 3.3 vs. 2.21). On the other hand, cultural aspects such as openness, problem solving ability, job satisfaction, collegial trust and team spirit, in addition to a positive implementation climate and survey items measuring readiness for change, increased the likelihood of adoption in clinics. In regards to readiness for change, the clinic members who adopted had a higher level of agreement about survey statements relating to clinic leadership ensuring that there was time (M = 4.14 vs. 3.5) and systems (M = 4.34 vs. 3.7) in place to implement the PMP compared with those who did not adopt.

DISCUSSION

Several lessons emerged from this academic-community partnership, and the execution of adoption strategies to promote the uptake of an evidence-based intervention (EBI) in Federally Qualified Health Centers (FQHCs) and other safety net clinics:

- **Relationships are critical.** The research team leveraged established relationships to recruit clinics to participate in

the PMP intervention. Initial meetings to talk about PMP adoption was a “warm” encounter with a trusted community organization. This helps with garnering commitment and addressing any reservations about working with the researchers or adopting the intervention.

- **Clinic input is key to successful adoption and implementation.** Though the researchers planned to randomly assign implementation start dates, it proved beneficial for sites to determine their start dates. With an accurate description of program and implementation requirements, sites were in the best position to determine when a successful launch was most likely to occur as they were most familiar with their current and future capacity to meet those requirements and had the autonomy to make necessary adjustments.
- **Staff turnover is pervasive.** A transfer of staff among both the clinic management and frontline implementers, the community partner, and the research team was observed. Since commitment to the program is vital to adoption, the loss of personnel that agree with adoption, support the program, and commit to providing time and system resources for the program decreases the likelihood of continued adoption. Initial adoption discussions should include upper management, middle management, and frontline implementers (i.e., patient navigators). Having commitment at multiple levels eases the threat of loss of commitment and establishes a culture of acceptance when staff turnover occurs.
- **An adoption survey can help researchers use time and resources more efficiently.** Researchers can focus efforts on prepared participants or identify concerns before continuing adoption discussions. The survey can help identify barriers and facilitators to adopting or implementing an intervention. The survey can also be used to identify positive and negative indicators for adoption in other interventions or scaling up a pilot program. In this case study, the adoption survey provided data on moderators to adoption and potential determinants that could be targeted in the development of post-adoption implementation strategies.

While this project was focused on the adoption and implementation of an EBI to improve mammography appointment adherence among underserved women in the Greater Houston Area, the implications of this work are relevant to community-academic partnerships and EBI adoption and implementation efforts in diverse settings and other health issues. Our experience in the adoption and implementation of the PMP intervention emphasized the importance of partnership, multiple engagement strategies, and flexibility throughout the research period. The academic-community partnership collectively allowed for open discussion, various communication methods and styles from which to share the program components, and multiple contacts for questions and clarity. Academic researchers, aided by BHCTexas administration and certified community health workers (CHWs), afforded the clinic staff a comfortable understanding of the EBI theory and methods and the logistics of the PMP intervention which aided in overall intervention adoption. The adoption, implementation,

and sustainment of EBIs is often a years-long process, and staff turnover, unexpected life events, and natural disasters should be anticipated from the outset. To ensure success, broad collaboration, multiple engagement strategies, and commitment at multiple levels are key. Our experience using an adoption survey demonstrated early efforts to assess the implementation context, provide critical information on readiness to adopt an EBI, and might be useful tool in large-scale implementation efforts. While complex, development of academic-community partnerships can lead to successful uptake of EBIs to improve population health and reduce disparities in underserved communities.

DATA AVAILABILITY STATEMENT

Due to use of identifying information, only de-identified data may be requested. Data requests may be sent to the authors and will be considered upon reasonable request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Committee for the Protection of Human Subjects at The University of Texas Health Science Center at Houston (UTHealth). The Ethics Committee waived the requirement of written informed consent for participation.

AUTHOR CONTRIBUTIONS

LH conceived the study, led the study, oversaw data collection, analysis, contributed to manuscript writing and editing, and approved the final version. GW assisted with study design, led data collection in the field, and contributed to manuscript writing and editing. JH led manuscript development including data analysis. GF assisted with data analysis, manuscript writing, and program management. IR assisted with field data collection, data analysis, and manuscript writing.

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Building community capacity to stimulate physical activity and dietary behavior in Dutch secondary schools: Evaluation of the FLASH intervention using the REAIM framework

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Background: Building community capacity in secondary schools is a promising strategy for the sustainable implementation of school-based health promotion. The Fit Lifestyle at School and at Home (FLASH) intervention explored how building community capacity works for the prevention of overweight following four strategies: leadership, participatory school culture, tailored health-promotion activities, and local networks. This study evaluates the intervention's impact on community capacity and capacity-building processes over a period of 3 years, as well as its effects on adolescents' BMI and waist circumference.

Methods: A mixed-methods design guided by the RE-AIM framework was used. Impact on community capacity was evaluated with semi-structured interviews at the start and end of the intervention and analyzed using an anchored coding scale. Capacity-building processes were evaluated using interviews, journals, questionnaires, and the minutes of meetings. The effects on BMI z-scores and waist circumference were evaluated using a quasi-experimental design comparing an intervention (IG) and reference group (RG), based on multi-level analyses.

Results: Community capacity improved across all intervention schools but varied between capacity-building strategies. Leadership recorded the greatest improvements, aided by the appointment of Healthy School Coordinators, who increasingly focused on coordinating processes and fostering collaborations. Participatory school culture also improved through the adoption and implementation of participatory methods and a general increase in awareness concerning the importance of the Healthy School approach. Although additional health-promotion activities were implemented,

stakeholders struggled with tailoring these to the specific dynamics of their schools. Limited improvements were observed in setting-up local networks that could help schools encourage healthy behavior among pupils. Differences in BMI z-scores between IG and RG over the total sample were negligible whereas waist circumference increased slightly more in IG (0.99 cm, 95% CI [.04; 1.93]). However, differences were inconsistent over time and between cohorts.

Conclusions: This study highlights the potential of building community capacity. It emphasizes that this is a process in which stakeholders must become acquainted with new leadership roles and responsibilities. To navigate this process, schools need support in improving communication, establishing local networks, and sustaining capacity-building efforts in school policy.

Trial registration: ISRCTN67201841; date registered: 09/05/2019, retrospectively registered.

KEYWORDS

community capacity, health-promoting schools, implementation, mixed methods, adolescents, physical activity, dietary behavior

Introduction

Adolescence is a critical period for stimulating healthy physical activity (PA) and dietary behavior, given the vulnerability of adolescents to unhealthy behaviors that are important determinants of chronic conditions, including obesity, cardio-vascular disease and diabetes (1). Moreover, obesity established during this period often tracks into adulthood (2). Schools are important settings for promoting healthy behavior among adolescents, as they spend large amounts of time in these locations, which serve as their primary settings for learning and development (3, 4). Schools are increasingly applying integral whole-school approaches to health promotion, combining classroom health education, school health policies, a physical and social environment that stimulates healthy choices, and relationships between school, home, and the local community—all with the objective of supporting healthy behavior (5). The sustainable implementation of an integral approach in day-to-day practice remains challenging for schools, as staff members, pupils and parents often feel only a limited sense of ownership over specific activities or interventions (6, 7). In addition, schools have difficulty tailoring evidence-based interventions to their own specific contexts and populations (8).

The application of a community-based approach based on the principles of an integral approach could potentially foster sustainable implementation of interventions and decrease the prevalence of overweight and obesity among adolescents (9, 10). Community members are encouraged to cooperate in the creation of a healthy school community, where health-promotion activities and interventions can be embedded within the complex, dynamic systems of their specific schools (11). To implement such an approach, stakeholders need to build community capacity to ensure continuous improvement (12). Building community capacity entails developing knowledge, skills, ownership, leadership, structures, and systems at the individual and organizational level (13, 14). Such efforts have proven effective in school settings for decreasing the prevalence of overweight and obesity among Australian adolescents (15). However, little is known about whether and how building community capacity in the school setting works as a strategy for overweight prevention in other countries (16).

In the Netherlands, many secondary schools apply the integral Dutch Healthy School approach, a translation of the whole-school approach for the Dutch context advocated by the WHO. Schools can earn theme certificates on health topics by providing health education and having health policies, a healthy physical and social environment, and a referral system in place (17). Schools most often work on health topics concerning physical activity and nutrition (18). Despite the initial success of this approach, issues regarding ownership, participation, and tailoring of interventions remain barriers to sustainable implementation (19).

The Fit Lifestyle at School and at Home (FLASH) intervention was developed to identify ways of building

Abbreviations: FLASH intervention, Fit Lifestyle at School and at Home intervention; PA, Physical Activity; PE, Physical Education; HSC, Healthy School Coordinator; BMI, Body Mass Index; CRC method, Community Readiness to Change method.

community capacity in Dutch schools in order to design and implement integrated health-promoting activities on healthy dietary and physical activity behaviors of adolescents. This intervention involved four secondary schools, each operating under a different context (20). Processes of co-creation between research and practice were a central component of this intervention, thereby ensuring exchange between evidence-based intervention strategies and the contextual opportunities of each school. Based on the limited research on strategies for capacity-building in school communities, we used the Community Readiness to Change (CRC) method to focus on four specific capacity-building strategies. This method assists communities in the implementation of effective and broadly supported programs, recognizing the need for changes within and between individuals and organizational structures (21). The strategies involved are: (1) identifying and motivating leaders who are able to take charge of the process of creating a Healthy School; (2) promoting a participatory school culture in order to develop broadly supported goals for the Healthy School; (3) designing and implementing tailored health-promotion activities that fit within the Dutch Healthy School approach in order to achieve these goals; and (4) creating a local network of collaborations and resources to ensure continuation.

In this study, we assessed the impact of the FLASH intervention on community capacity and evaluate the capacity-building processes for each intervention school, thereby generating insight into contextual factors that affect the adoption and implementation of this community-based approach. In addition, we investigated the effects of the intervention on the BMI and waist circumference of adolescents.

Methods

Study design

We adopted a mixed-methods design to evaluate the FLASH intervention to encompass not only the impact on changes in community capacity and health outcomes in adolescents, but also to gain insight in capacity-building processes. The FLASH intervention took place between September 2016 and July 2019 in four secondary schools in the Netherlands, each with their own dynamic and specific context. The evaluation study was conducted from September 2016 through March 2020. The process of building community capacity for creating a healthy school community, as well as its evaluation, followed an adaptive approach to enable changes in the system to be captured and accommodated, and to allow for feedback and emergent outcomes (22).

This evaluation was guided by the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework, focusing on design, dissemination and implementation processes (23). Within this framework,

there is an growing focus on the value of qualitative data in addition to quantitative data to provide a better understanding of what happened as well as the “how” and “why”, which is also in line with the purpose of the current study (24).

Impact on community capacity was evaluated with semi-structured interviews based on the CRC method (21). Interviews were held at the start and end of the intervention, and they were analyzed using an anchored coding scale in order to create a score for community capacity. Capacity-building processes were evaluated using interviews, journals, questionnaires, and minutes of meetings held throughout the intervention period. The intervention's effect on the BMI and waist circumference of adolescents was evaluated using a quasi-experimental design comparing the intervention group to a reference group. The main results of the intervention are described in this paper. Elsewhere, we will elaborate on the capacity-building processes and on lessons learned on how to encourage these processes in secondary schools. Ethical approval was provided by the Dutch Medical Research Involving Human Subjects Act (Medical Ethics Committee of Amsterdam UMC, reference number 2016.352).

Setting and population

The FLASH intervention builds on the integral Dutch Healthy School approach (25). Stakeholders in the school community are pupils, staff, and parents. The intervention was aimed specifically at the lower educational tracks, as a relatively large share of pupils who are at risk for unhealthy PA and dietary behavior are enrolled in these (26). In the Dutch context, these tracks (also known as “streams”) are jointly referred to as pre-vocational secondary education (*vmbo*)¹ (27). Four schools belonging to the same regional educational partnership in the northeastern region of the Netherlands were recruited. Schools were eligible to participate if they were willing to commit to the intervention and evaluation for 4 years. In addition, the school board needed to be willing to facilitate new health-promotion activities and to appoint a staff member to coordinate the FLASH intervention. For the quasi-experimental study, four reference schools were recruited based on characteristics matching those

1 Explaining the Dutch education system: Pupils entering secondary education in the Netherlands are streamed according to aptitude into one of three forms of schooling: pre-vocational (*vmbo*), professional (*havo*), and pre-university (*vwo*). About 60% of all pupils are tracked into the *vmbo* stream, which consists of a four-year program (ages 12–16 years) intended as a route into secondary vocational education and training (*mbo*). After a two-year common basic curriculum, the *vmbo* track splits into sub-streams (i.e., “learning pathway” and “profile”), with selection according to ability, interests, and ambitions. Individual schools that provide more than one form of schooling (*vmbo/havo/vwo*), are classified as comprehensive schools.

of the intervention schools (e.g., surroundings, size, educational streams, and familiarity with the Healthy School approach). To prevent contamination of the results during the intervention, schools belonging to the same educational partnership as the intervention schools were excluded.

FLASH intervention

The focus of the FLASH intervention was to implement the four capacity-building strategies into the daily practice of four intervention schools. The intervention was designed based on the logical model in Figure 1 (20). Building community capacity was considered a continuous and context-specific process for each intervention school, because schools in the Netherlands have a lot of autonomy and can differ for example in educational vision, culture, number of students (28). Based on a needs-assessment among pupils, school personnel and parents to map their context-specific situation, stakeholders in each school community were supposed to act on identifying and motivating leaders, promoting a participatory school-culture, designing and implementing tailored activities and creating an active network. By working on these strategies, we expected community capacity of schools to increase (output) (29). Increased community

capacity potentially leads to the creation of (improved) health-promotion activities that are tailored to the needs, opportunities and context of a school, follow the principals of the whole-school approach, and can be sustained over time. Building community capacity and implementing tailored health-promotion activities were treated as two reciprocal processes that can influence each other: successful activities can increase community capacity, and increased community capacity can help the school community to replace or adjust less successful activities. Moreover we hypothesized that this will eventually lead to changes in behavior of pupils in the intermediate term and in anthropometric measures in the longer term (outcome).

To empower intervention schools in capacity-building processes, several inputs were provided: time allocated to an employee who served as a Healthy School Coordinator (HSC), a start-up budget for implementing activities supported by the school community, and coaching for the HSC provided by two local experts in the field of health promotion and education. These experts had knowledge of evidence-based interventions involving the Healthy School approach, and they had local connections to organizations related to health promotion. The experts and research team collaborated closely in the coaching of HSCs, thereby establishing an iterative process of co-creation. Coaching consisted of both individual and group sessions

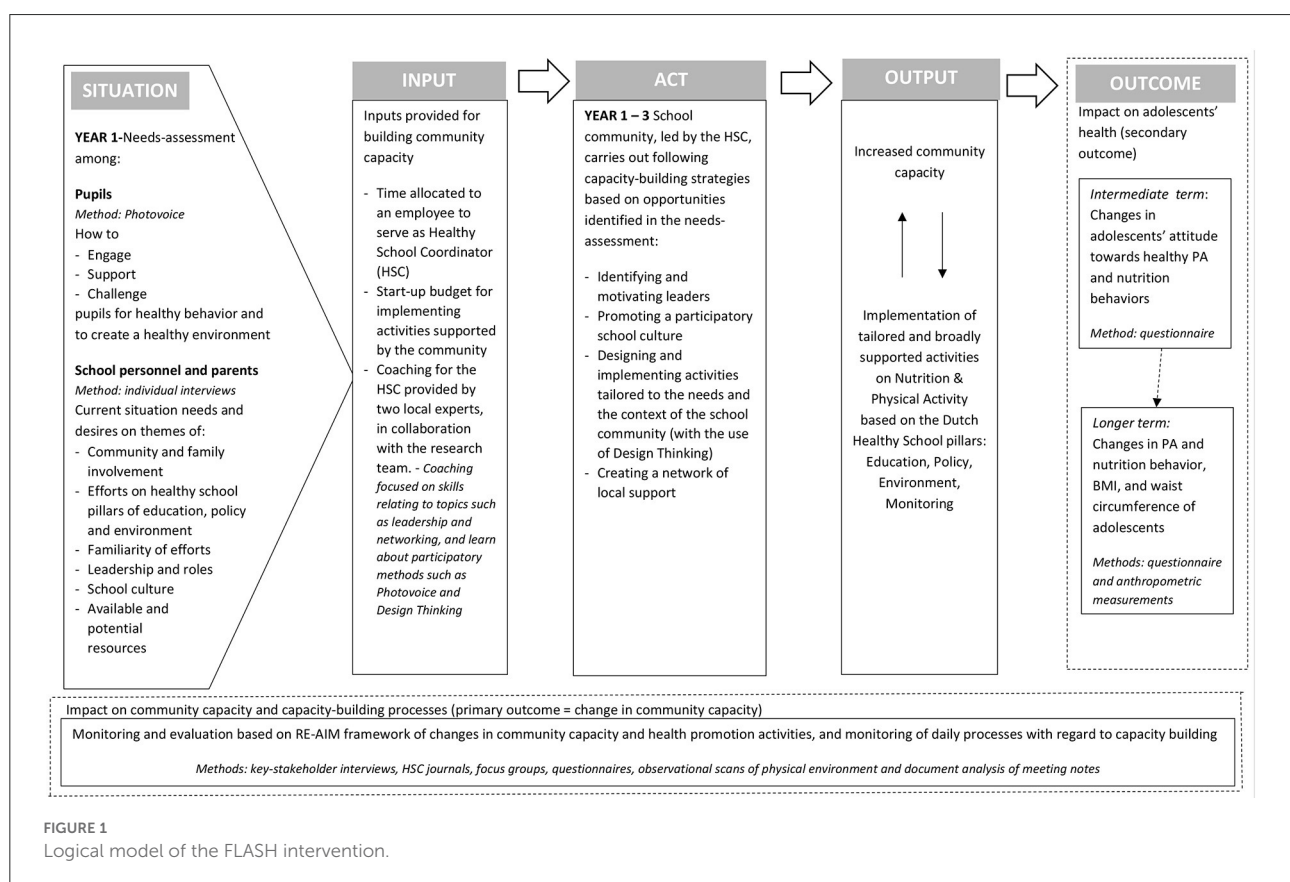


FIGURE 1
Logical model of the FLASH intervention.

where HSCs could exchange experiences, learn skills relating to various topics (e.g., leadership and networking), and learn about methods for participation (Photovoice and Design Thinking). Both experts had experience with supporting schools in the Dutch Healthy School approach as this was part of their regular job-description. Their additional and new task in the FLASH intervention was to guide the HSC specifically in the process of creating a healthy school community.

Schools engaged in capacity-building processes throughout three phases. In the first phase, stakeholders in the school community started to establish and appoint leadership roles, had conversations about the responsibilities of leaders, and set up networks that could support leaders. These efforts continued throughout the entire intervention (Years 1–3). At the same time, the needs and wants of pupils, staff, and parents were mapped using interviews and Photovoice, including the identification of opportunities for health-promotion activities (Year 1). In the second phase, the HSCs were stimulated to organize Design Thinking sessions with community members in order to create context-specific solutions and action plans that make use of evidence-based techniques and fit within the Dutch Healthy School approach (Year 2). In the third phase, leaders were responsible for carrying out and evaluating action plans and activities (Year 3). The schools were also encouraged to discuss how working activities could be sustained or adjusted [for a detailed description of FLASH see (20)].

Reference schools were allowed to participate in the regular Dutch Healthy School approach. All Dutch schools are encouraged to voluntarily adopt this approach and make use of the support of a regional health promotion expert. Central in this approach is the execution of health-promotion activities based on four pillars (education, environment, policy, and signaling) on a chosen health topic such as nutrition or PA. The difference with intervention schools mainly lies in the process of building community capacity in order to create a broadly supported and tailored healthy school community.

Mixed methods

Evaluation outcomes were based on the RE-AIM framework (23). An overview of the outcomes, methods, and analysis for each element is provided in Table 1. All participants signed an informed consent form when they entered the study. Pupils were only allowed to participate if their parents/guardians provided written consent as well.

Community capacity interviews

In each intervention school, six to eight semi-structured interviews were held at the start and end of the FLASH intervention based on the CRC-method (21). Following this method, we included stakeholders with varying roles who had

knowledge about the school community. By including a cross-section of individuals in the school community in in-depth interviews, a multi-faceted and detailed picture of the schools' situation was obtained (30). At both time-points, the following stakeholders were recruited: HSC (T1:N = 4, T2:N = 4), school directors or managers (T1:N = 4, T2:N = 4), teachers (T1:N = 8, T2:N = 9), support staff (e.g., canteen employees or janitors) (T1:N = 4, T2:N = 4), and parents (T1:N = 3, T2:N = 3). Purposive sampling was applied with the assistance of the HSCs, who were acquainted with key stakeholders in their communities. All interviews were audio-recorded and transcribed verbatim.

The CRC method was used to operationalize the four capacity-building strategies that are central to the FLASH intervention (Table 2). This method differentiates six dimensions of community readiness: activities, visibility of activities, knowledge about local prevalence to prioritize activities, leadership, community culture/climate, and resources/local collaborations (21). Strategies 1 (leadership), 2 (participatory school culture), and 4 (local networks) correspond directly to specific CRC dimensions. Strategy 3 (tailored activities) combines the three CRC dimensions—activity, visibility, and local prevalence—as they all relate to the design and implementation of context-specific health-promotion activities, as well as to the existing Dutch Healthy School approach to the development of structural activities.

HSC journals and interviews

Each HSC filled out a digital journal approximately once every 2 months during the first two years of the intervention. Questions related to attendance at coaching sessions, time investment of allocated hours, and experiences with the role of HSC. At the start of the intervention, HSCs answered questions about their schools' current Dutch Healthy School efforts. The status of the food environment was recorded using a canteen scan (31). Each HSC participated in an interview at the start and end of the intervention concerning the school context, characteristics, expectations, experiences, and reflections throughout the intervention. All interviews were audio-recorded and transcribed verbatim.

Minutes of meetings

Minutes were kept of the following meetings: project team (the research team and two local experts), coaching sessions, and contact moments between researchers and HSCs or experts. These data sources provided in-depth qualitative information about experiences throughout the FLASH intervention.

TABLE 1 Overview of outcomes, methods, and analysis for each RE-AIM element.

RE-AIM Element	Outcomes	Methods	Analysis
REACH — <i>potential reach based on number of pupils throughout the intervention</i>	Overview of characteristics of intervention schools: school size, type of population, school environment	<i>HSC journals and interviews</i> : Questions about starting position with regard to the Dutch Healthy School approach and school characteristics	Descriptive analysis and thematic coding
EFFECTIVENESS — <i>impact on community capacity and pupils' health</i>	Changes in: - Overall community capacity score for each school - Each of the six dimensions of community capacity Changes in: - BMI, BMI z-scores and waist circumference - Health behavior	<i>Community Capacity interviews</i> : Semi-structured (topics on the 6 dimensions of the CRC method), with 6–8 key stakeholders per school at the start and end of the intervention <i>Quasi-experimental study</i> : 4 intervention schools and 4 control schools; measurement rounds in 2016, 2017, 2018, and 2019	Anchored coding scale Longitudinal multilevel analysis and descriptive analysis
ADOPTION — <i>willingness to work on capacity-building strategies based on intervention inputs</i>	<i>Strategy 1: Leadership</i> - Willingness to facilitate an individual as HSC <i>Strategy 2: Participatory school culture</i> - Willingness to use participatory methods <i>Strategy 3: Tailored activities</i> - Willingness to create action plans based on ideas from Design Thinking session - Willingness to initiate new tailored activities <i>Strategy 4: Local networks</i> - Willingness of local experts - Willingness to organize coaching sessions	<i>Minutes of meetings</i> : Overview of the availability of the HSC throughout the intervention <i>Minutes of meetings</i> : Records with regard to willingness of schools to organize a Design Thinking session and Photovoice lessons <i>Minutes of meetings</i> : Records on whether schools were willing to create action plans based on ideas from Design Thinking sessions. Records on whether schools were willing to create new activities or adjusted existing activities that fit within the Dutch Healthy School approach <i>Minutes of meetings</i> : Overview of the availability of the local expert and the number of coaching sessions initiated by these experts	Thematic coding Thematic coding Thematic coding Thematic coding
IMPLEMENTATION — <i>extent to which intended actions about each capacity-building strategy were implemented</i>	<i>Strategy 1: Leadership</i> - Extent to which the hours available to HSCs were used - Extent to which HSCs were able to motivate community members for leadership roles - Extent to which HSCs used coaching from local experts (individual and group coaching sessions) <i>Strategy 2: Participatory school culture</i> - Extent to which community members participated in the creation of tailored ideas during Design Thinking sessions - Extent to which pupils participated in the creation of tailored ideas during Photovoice sessions	<i>Community Capacity interviews</i> : Questions about experiences relating to motivating stakeholders to take up leadership in general, as well as in specific activities <i>HSC journals and interviews</i> : Questions about their experiences in this role throughout the intervention <i>Minutes of meetings</i> : Records about the extent to which Photovoice lessons and Design Thinking sessions were implemented, including attendance and ideas arising from these methods	Thematic coding Thematic coding

(Continued)

TABLE 1 Continued

RE-AIM Element	Outcomes	Methods	Analysis
	<i>Strategy 3: tailored activities</i> - Extent to which action plans were carried out as intended in each school - Extent to which Healthy School activities were initiated or adapted	<i>Community Capacity and HSC interviews:</i> Questions about the use of the implementation budget and how this activity came to be, as well as questions about other Healthy School activities relating to each pillar that took place during the intervention <i>Minutes of meetings:</i> records about the process of developing action plans and rewarding implementation budget	Thematic coding
	<i>Strategy 4: Local networks</i> - Extent to which schools initiated collaborations with local partners	<i>Community Capacity interviews:</i> Questions about whether collaborations with local organizations were initiated and the relative success of these collaborations <i>HSC journals and interviews:</i> Questions in journals about HSCs' attendance at and rating of coaching sessions, as well as interview questions about how their perceptions of individual coaching	Thematic coding
MAINTENANCE— <i>extent to which stakeholders intend to continue working with a community-based approach</i>	Extent to which management and HSCs are planning to continue new activities and/or inputs	<i>Community capacity interviews:</i> Questions added to the interviews with HSCs and managers at the end of the intervention about potential continuation	Thematic coding
	Extent to which local health (and/or other) organizations are willing to continue supporting schools	<i>Maintenance interviews with local experts:</i> Semi-structured interviews with stakeholders in organizations, who are responsible for continued support and who were involved in the FLASH intervention; conducted in the third year	Thematic coding

Maintenance interviews with local experts

In the third year of the intervention semi-structured interviews were held with the two experts concerning their coaching experiences, as well as with managers in the organizations of these experts ($N = 5$) about embedding components of the intervention and the coaching role into their organizations. The interview guide was based on the Measurement Instrument for Determinants of Innovations framework, a systematically designed tool to measure determinants of innovations that may affect their implementation (32). The interviews were audio-recorded and transcribed verbatim.

Quasi-experimental study

A quasi-experimental study was conducted among pupils enrolled in secondary vocational education in four intervention and four reference schools. Participants were recruited among

second-year pupils in September 2016 (Cohort A), September 2017 (Cohort B), and September 2018 (Cohort C). Informed written consent was obtained from both parents and pupils. Four measurement rounds were conducted, with participants being followed over time until they graduated (fourth-year on average) or until the end of the study. Anthropometric measurements (secondary outcomes) including weight (nearest 0.1 kg), height, and waist circumference (both nearest 0.1 cm) were assessed among participants, as measured by trained research assistants according to a protocol. Weight and height were used to calculate BMI (kg/m^2) and transformed into z-scores based on Dutch reference values (33). In addition, a self-reported questionnaire, partly based on a validated tool (34), was administered digitally during school hours to obtain information on demographics and health behavior. Outcomes included were: PA behavior based on compliance to the Dutch norm of healthy PA, screen time, dietary behavior based on consumption of water, sugar sweetened beverages, breakfast,

TABLE 2 CRC method as indicators for community capacity strategies.

Strategy	Indicator(s) based on CRC method	Example questions
S1: Leadership	Leadership dimension: Readiness of leaders and other influential stakeholders in the school community to commit to and facilitate actions on this theme ^a	- Who are leaders in your community, and are they willing to support action/take action? - How are responsibilities distributed between leaders and collaborations on this theme organized and facilitated?
S2: Participatory school culture	Culture/climate dimension: Attitude of community members toward the importance of this theme and their readiness to facilitate participation when designing solutions that suit the needs of their communities	- According to community members, how important is it to take action on this theme? - Are community members involved in the design of actions and activities? Are they willing to participate in designing these actions and activities?
S3: Tailored activities	Activities dimension: Extent to which structural activities take place (fitted to the Healthy School approach) for which the community has a sense of ownership regarding this theme Familiarity dimension: Extent to which community members are familiar with actions and activities taking place regarding this theme Knowledge about the prevalence dimension: Extent to which actions and activities are based on local prevalence and knowledge about this theme	- Which activities take place in this school (i.e., education, the physical environment, and policy pillars)? - How long have these activities existed and to what extent do they suit this school? - To what extent are community members familiar with the Healthy School approach and activities on this theme (social environment pillar)? - What actions does this school take to enhance familiarity? - Is a system in place to monitor the health, behavior, and knowledge of pupils (signaling pillar) in this specific school on this theme? - To what extent is this information used to tailor actions and activities on this theme?
S4: Local networks	Resources and local collaborations dimension: Extent to which local collaborations and resources are in place to sustain the actions and activities on this theme	- Are resources or collaborations with local organizations in place that can ensure continued support for activities, either by providing information, guidance, or means (e.g., funding, materials)?

^aTheme refers to promoting healthy physical activity and dietary behavior among *vmbo*-pupils.

fruit, vegetable and snacks, and attitude toward these behaviors (see [Appendix I](#) for these secondary outcomes). For a detailed description see (20).

Analyses

Anchored coding to assess community capacity

The anchored coding system of the CRC method was used to create a community capacity score for each intervention school. This system has previously been used and validated as an indicator of community capacity (15, 21). Coding was performed independently by two researchers and results were discussed. A third researcher was consulted if no consensus was reached. Reflective diaries were kept in order to evaluate subjective views.

Each interview was coded on segments that reflected the current status of the community for each indicator (Table 2). Segments were scored on a stage of readiness, ranging from 1 (no awareness) to 9 (high level of community

ownership) (Figure 2). For each interview, coded segments were converted into an average score for each indicator that reflected the community's stage of readiness. If consensus between researchers was reached, the individual scores for each indicator were summed and divided by the number of respondents at each school. For each school, the average scores for each indicator were summed and divided by six at both measurement points to create an overall score for community capacity. This yielded a score for change in community capacity for each indicator and overall for each school.

Thematic coding to assess impact on daily capacity-building processes

Thematic analyses, based on the elements of the RE-AIM framework, were conducted on qualitative data derived from interviews and minutes of meetings using MAXQDA 2018. Coding was done independently by two researchers. Coding and results were discussed by the researchers and the research team.

Quantitative analysis to assess changes in adolescents' health

The impact of the FLASH intervention on BMI z-scores and waist circumference was analyzed using multilevel linear regression analyses in STATA-16. Analyses were performed on the total sample and on each cohort separately, with data collected at baseline, follow-up (T1) and a secondary follow-up (T2). Longitudinal multilevel analyses were performed on the total sample and on Cohorts A and B separately, adjusted for baseline differences. To assess the effects of the intervention over time, an interaction term for time was added to each model as a categorical variable. To correct for cluster effects at the school level and for repeated measurements within participants, a three-level hierarchical data structure was applied. The goodness of fit of the models were compared using the likelihood-ratio test. For the analyses on Cohort C, a multilevel analysis was performed, based on a two-level hierarchical data structure (pupils within schools), adjusted for baseline differences.

Adjusted models included sex (male/female), educational level ("learning pathway"/"profile;" see Note 1), and migration background (no migration or Western migration background vs. non-Western migration background). Non-Western migration background was defined as at least one parent had a migration background from countries in Africa, Latin-America, Asia, or Turkey (35). Results are described as mean differences over time with 95% confidence intervals. For outcomes concerning physical activity and dietary behavior, descriptive statistics were calculated using IBM SPSS Statistics 26.

Results

At the start of the FLASH intervention, all intervention schools were acquainted and working with the integral Dutch Healthy School approach to varying degrees, with Schools 1–3 being further along than School 4. Detailed information including contextual factors operating in each school throughout the intervention is provided in [Appendix II](#). All schools reported having more difficulty with activities focusing on healthy dietary behavior than with those focusing on PA. An overview of the FLASH intervention's impact on each school is provided in [Table 3](#), broken down by RE-AIM element.

Reach

- Throughout the intervention and evaluation, Reach proved difficult to define in absolute numbers, because this intervention was aimed at instigating desired but unpredictable changes in the school community. Due to the dynamic and complex nature of such systems, adjustments were made to the operationalization in the original design

of this study, redefining Reach as "potential reach based on number of pupils".

At the start of the intervention, Schools 1, 2, and 4 had approximately 200 *vmbo*-pupils each, and School 3 had approximately 500. School 1 and 2 were comprehensive schools with a larger potential reach of 305 pupils (School 1) and 711 pupils (School 2) in total. Stakeholders mentioned that changes to the environment or policy changes will be aimed at the total pupil population. Pupil numbers varied throughout the intervention period, due to pupils leaving school and the influx of new pupils. The number of pupils in School 1 remained stable, while Schools 2 and 3 experienced an increase (+35% total/+29% prevocational and +18% respectively) and School 4 experienced a decline (−30%).

Effectiveness

- Effectiveness was defined as impact on community capacity and pupils' health.

Changes in community capacity

The overall capacity score at the start of the FLASH intervention varied between Stage 3 (vague awareness) and Stage 4 (pre-planning) (see [Figure 2](#)). After the intervention, the overall scores had increased to approximately Stage 5 (preparation) in all schools.

For Strategy 1 (leadership) and Strategy 2 (participatory school culture), Schools 1 and 2 scored at approximately Stage 4 (pre-planning), with Schools 3 and 4, respectively, scoring between Stage 3 (vague awareness) and Stage 4 (pre-planning) at the start of the intervention. For Strategy 1 (leadership), the end scores for Schools 1–3 had increased to between Stage 5 (preparation) and Stage 6 (initiation), with those for School 4 increasing to Stage 4 (pre-planning). For Strategy 2 (participatory school culture), the scores for Schools 1–3 had increased to approximately Stage 5 (preparation), with School 4 increasing to Stage 4 (pre-planning).

For Strategy 3A (activities), the initial scores for Schools 1–3 were between Stage 5 (preparation) and Stage 6 (initiation), with School 4 scoring at Stage 4 (pre-planning), reflecting that school's starting position with the Healthy School approach. After the intervention, all schools scored at Stage 6 (initiation). For Strategy 3B (visibility of activities), Schools 1 and 2 scored around Stage 4 (pre-planning), and Schools 3 and 4 scored around Stage 3 (vague awareness). After the FLASH intervention, the scores for Schools 3 and 4 had increased to between Stage 4 (pre-planning) and Stage 5 (preparation), while the scores for Schools 1 and 2 remained approximately the same. For Strategy 3C (knowledge about local prevalence to prioritize activities), the initial scores for all schools were

TABLE 3 Overview of results based on RE-AIM elements.

	School 1	School 2	School 3	School 4
Reach—school population:				
<i>School environment</i>	Comprehensive school, located in rural area (see Appendix II for contextual information)	Comprehensive school, located in city center (see Appendix II for contextual information)	Exclusively offers “profiles” sub-stream of <i>vmbo</i> track, located in city center (see Appendix II for contextual information)	Exclusively offers “profiles” sub-stream of <i>vmbo</i> track, located in rural area (see Appendix II for contextual information)
<i>Size of school in N of pupils: total N (N pre-vocational)</i>	305 (219) in September 2016 297 (213) in September 2017 294 (204) in September 2018	711 (221) in September 2016 842 (245) in September 2017 962 (286) in September 2018	520 in September 2016 638 in September 2017 612 in September 2018	228 in September 2016 199 in September 2017 160 in September 2018
Effectiveness—change in:				
<i>Community capacity</i>	Overall capacity change: 4.3 → 5.1 Per dimension: See Figure 2	Overall capacity change: 4.4 → 4.7 Per dimension: See Figure 2	Overall capacity change: 3.8 → 4.8 Per dimension: See Figure 2	Overall capacity change: 3.5 → 4.6 Per dimension: See Figure 2
<i>Pupils’ health & behavior</i>	See Table 4 and Appendix I			
Adoption—willingness to/from:				
Strategy 1: Identifying leadership				
<i>Facilitate HSC</i>	One HSC was facilitated continuously for the duration of intervention.	One HSC was facilitated continuously for the duration of intervention.	One HSC was facilitated continuously for the first two years of the intervention. A change in HSC took place in Year 3. The new HSC was engaged in the intervention for ¾ of Year 3.	One HSC was facilitated continuously in Year 1. A change of HSC took place in Year 2. The new HSC was facilitated continuously in Years 2 and 3.
Strategy 2: Creating a participatory school culture				
<i>Use participatory methods</i>	Design thinking: Yes, start of Year 3 Photovoice: Yes, in Years 1 and 2	Design thinking: Yes, end of Year 2 Photovoice: Yes, in Years 1 and 2	Design thinking: Yes, start of Year 3 Photovoice: Yes, in Years 1 and 2	Design thinking: Yes, end of Year 2 Photovoice: Yes, in Years 1 and 2
Strategy 3: Designing tailored activities				
<i>Develop action plan for implementation budget</i>	Yes, together with colleague, and based on input from DT session	Yes, together with colleague, and based on input from DT session	Yes, but the first action plan was rejected based on limited input from DT session and lack of integral approach. Adjustments were made.	Yes, together with colleague, and based on input from DT session
<i>Facilitate changes for the Healthy School approach</i>	Yes, but resources limited due to small size of the school	Yes, but priorities shifted due to increasing pupil numbers	Yes, by a manager and teacher. Concerns were expressed with regard to willingness of canteen staff.	Yes, but with the note that certain changes require approval of all three schools in the building
Strategy 4: Creating local networks				
<i>From local organizations</i>	Expert from educational organization: Role was facilitated throughout Years 1 and 2 and for 1/3 of Year 3. One person held this position continuously. Expert from municipal health service: One person was facilitated from October through March of Year 1. A new person was facilitated from May in Year 1 until January in Year 3. In all, the experts organized 15 coaching sessions for the HSCs, in collaboration with the principal researchers.			
Implementation—extent to which:				
Strategy 1: Identifying leadership				
<i>HSC hours were used</i>	HSC indicated using allocated weekly hours most of the time	HSC indicated using allocated weekly hours half of the time	HSC indicated often not using allocated weekly hours, due to other priorities	HSC indicated using allocated weekly hours half of the time

(Continued)

TABLE 3 Continued

	School 1	School 2	School 3	School 4
<i>Other leaders were motivated</i>	See Appendix III	See Appendix III	See Appendix III	See Appendix III
<i>Coaching sessions were attended</i>	13 out of 15 (average experience score of 8.3)	15 out of 15 (average experience score of 6.9)	12 out of 15 (average experience score of 7.6)	13 out of 15 (average experience score of 7.5)
Strategy 2: Creating a participatory school culture				
<i>Community participated in Design Thinking sessions</i>	17 participants in total: 3 teachers, 1 school manager, 2 parents, 7 pupils, the HSC, and 1 local expert	13 participants in total: 3 teachers, 1 team leader, 2 parents, 2 pupils, the HSC, and 1 local expert	22 participants in total: 3 teachers, 1 team leader, 1 PR employee, 2 parents, 7 pupils, the HSC, and 1 local expert	5 participants in total: 1 team leader, 2 parents, 1 pupil, the HSC, and 1 local expert
<i>pupils participated in Photovoice</i>	2 second-year classes engaged in 4 2-hour sessions	1 second-year class engaged in 4 2-hour sessions	7 pupils engaged in 3 1-hour sessions	2 second-year classes engaged in 1 afternoon session
Strategy 3: Designing tailored activities				
<i>Action plan was carried out</i>	Plan was not carried out during the intervention, but an adjusted activity was conducted.	Plan was carried out, but the impact remained limited due to implementation issues concerning reach.	Part of the plan was carried out, aimed largely at incidental activities instead of structural changes.	Plan was largely carried out, with revisions necessitated by contextual factors.
<i>Additional Healthy School activities were set up</i>	- A second activity created in the DT session was implemented with school resources. - Changes were made to the school canteen and screen-time policies aimed at reducing sedentary behavior were adopted.	- Changes were made to the nutrition policy. - Successful existing activities were adjusted and continued. - Willingness to facilitate activities in the new pre-vocational school location was limited.	- A water tap was installed. - Changes were attempted in the school canteen and in-house retail shop run by pupils - The school yard was re-designed with school resources.	- A water tap was installed. - Health education and a Healthy School canteen were implemented out in the new location.
Strategy 4: Creating local networks				
<i>Connections were established with local organizations</i>	- Structural contact with sports organizations by the PE teacher - Structural collaboration with local municipal youth team	- Structural contact with sports organizations by PE teacher, who also uses available sports equipment from the Landstede Group as a resource - Conversation initiated with municipality about physical environment, but with limited impact	- Collaboration with organizations for internships, but no connections established with regard to health promotion - School management in contact with local supermarket about waste reduction, but not about health promotion	- Collaboration initiated between the school and neighborhood sports coaches, but additional support needed to make the collaboration more profitable for both parties
Maintenance—willingness to maintain:				
<i>HSC role</i>	Yes, but the tasks are embedded within the existing hours of the care coordinator and biology and PE teachers. No additional funds are available.	Yes. The school leader is continuing to facilitate the HSC for 75%. To build on the lessons learned from the intervention, the HSC will collaborate with a PE colleague.	Yes, depending on financial support received from the Dutch Healthy School approach. A Healthy School working group consisting of teachers remains part of the organizational structure.	Undecided. The current HSC remains involved with the Healthy School approach based on financial support received. There are no immediate plans to appoint a separate HSC specifically for the intervention location.

(Continued)

TABLE 3 Continued

	School 1	School 2	School 3	School 4
<i>Activities</i>	Yes. There is the intention to incorporate the greenhouse project into the curriculum and expand the project by establishing connections with the school canteen. Budget will still be used for standing desks.	Yes. There is the intention to address implementation issues with regard to reach and communication, as well as to have another trial period.	Partly. School leaders made budget available to provide new pupils with water bottles. The biology teacher showed motivation to continue with curriculum adjustments.	Yes. There is the intention to make the staircase challenge an annual event. The biology teacher and the care and welfare teacher are discussing the possibility of extending this with the new curriculum.
<i>Support from local organizations</i>	Educational organization: Limited, due to organizational changes time are needed Other organizations for advisory board: Recognition of the benefits of a community-based approach, but clarity is needed with regard to roles and responsibilities			

around Stage 4 (pre-planning), and the ending scores for all schools increasing to between Stage 4 (pre-planning) and Stage 5 (preparation).

For Strategy 4 (local networks), the initial scores for all schools were around Stage 4 (pre-planning). The ending scores for Schools 1, 3, and 4 reflected a slight increase to between Stage 4 (pre-planning) and Stage 5 (preparation).

Changes in the BMI, waist circumference and health behavior of pupils

Estimated differences in BMI z-scores were small for the total sample and remained stable over time (B-T1: -0.08 , 95% CI $[-0.19, 0.03]$, B-T2: -0.09 , 95% CI $[-0.21, 0.3]$) (see Table 4). The estimated difference for waist circumference overall was 99 cm (95% CI $[0.04; 1.93]$) higher for pupils in intervention schools than for pupils in reference schools, but varied over time (B-T1: 1.40, 95% CI $[0.43; 2.37]$, B-T2: 0.13, 95% CI $[-1.01; 1.27]$). Estimated differences in BMI z-scores and waist-circumference for cohorts separately showed variations between the cohorts for both overall effect and effects over time periods. For example, the estimated difference for the overall effect in BMI z-scores for cohort A was -0.26 (95% CI $[-0.41; -0.11]$), for cohort B 0.08 (95% CI $[-0.12; 0.25]$) and for cohort C -0.02 (95% CI $[-0.17; 0.13]$).

Descriptive analyses of behavioral outcomes indicated that water consumption in the intervention group improved from 2.3 (1.8) to 3.0 (2.1) glasses a day, while consumption in the reference group remained stable although consumption started at a higher level [T1: 2.7(1.8), T4: 2.8(1.8)]. In both groups, adherence to the Dutch standard for physical activity improved, with the intervention group increasing from 4.8 (1.9) days a week to 5.7 (1.9), and the reference group increasing from 5.1 (1.9) to 5.7 (1.9) days a week. Other outcomes (e.g., fruit and vegetable consumption; snacking behavior; attitude) were similar over time for both groups, as presented in Appendix I.

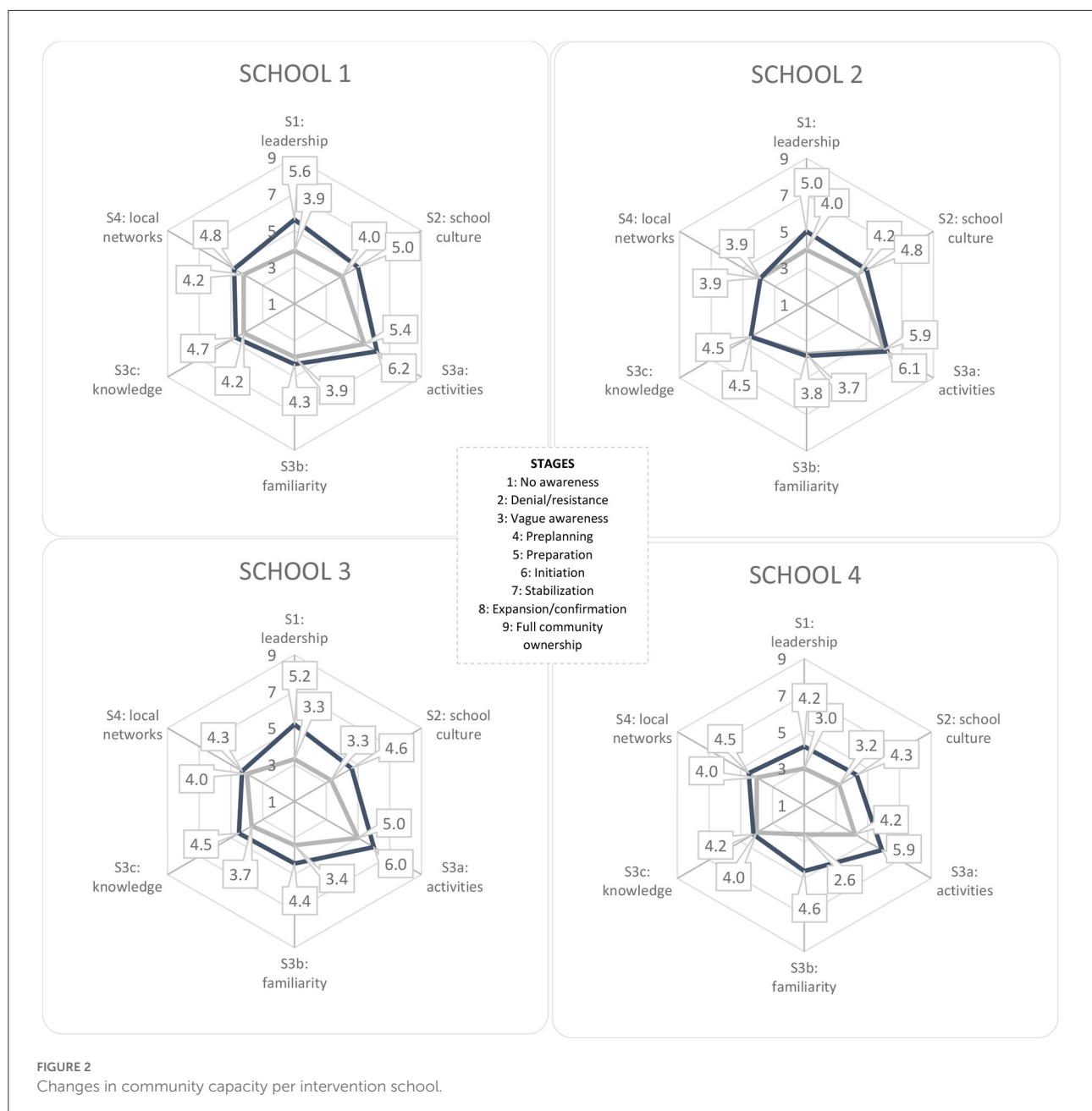
Adoption and implementation

- Adoption and implementation processes were running simultaneously during this intervention. In the original design of this study, adoption was seen as a one-moment decision. However, throughout the intervention adoption turned out to be an ongoing process and was supported by the guidance schools received. Therefore, we redefined adoption from the original design as “the willingness to work on capacity-building strategies based on intervention inputs”. The implementation process was not an independent activity of the school community, but was supported by the local experts, principal researcher and the inputs of the intervention (e.g., start-up budget). Hence, implementation was redefined as “the extent to which intended actions about each capacity-building strategy were implemented”. Adoption and Implementation were also more specifically defined for each strategy.

Strategy 1: Leadership

- Adoption: facilitation of an individual as HSC.
- Implementation: available hours to HSCs, ability to motivate community members for leadership roles, individual and group coaching for HSCs.

Three schools had an HSC throughout the FLASH intervention. In School 3, no HSC was available for the last 3 months. In Schools 3 and 4, the HSC role was transferred to a different person, due to shifting teaching responsibilities. The HSCs reported that the intervention had influenced the way in which they implemented their leadership role. Instead of simply organizing health-promotion activities, their responsibilities shifted toward bringing people together, as they perceived this to be helpful in creating ownership. They remained hesitant to ask colleagues, parents, and pupils to take on leadership roles, due to the anticipated additional work pressure and limited



resources to ease this pressure. For this reason, they were more inclined to seek opportunities within existing leadership structures. The HSCs tried to involve parents and pupils through the existing councils, and they relied on responsible colleagues for entry into these bodies. To inspire other colleagues for leadership roles, the HSCs first turned to those who were already fulfilling health-related tasks (e.g., PE or biology teachers). They also initiated connections with leaders on other societal topics that were important within the school (e.g., climate change).

The experts organized 12 coaching sessions, in collaboration with the researchers. Overall, the HSCs reported having gained

greater confidence in their changing roles as a result of these sessions, and they were particularly appreciative of the interaction with other HSCs. The coaching sessions allowed them to discuss difficulties that they had experienced in motivating leaders and facilitating participation, in addition to obtaining input on how to address difficulties, based on the experiences of others in similar situations. Detailed information on how the individual HSCs experienced their impact on creating leadership during the FLASH intervention is provided in [Appendix III](#).

In addition to coaching sessions, HSCs mentioned that having more in-depth conversations with school leaders about

TABLE 4 Estimated differences in BMI z-scores and waist circumference between pupils of intervention and reference schools.

	Crude			Adjusted ^a		
	β	95% CI	p-Value	β	95% CI	p-Value
Total sample						
BMI z-scores (N = 460)						
Baseline—T1	−0.08	[−0.19; 0.03]	0.159	−0.08	[−0.19; 0.03]	0.142
Baseline—T2	−0.09	[−0.21; 0.04]	0.172	−0.09	[−0.21; 0.03]	0.155
Overall effect	−0.09	[−0.21; 0.02]	0.112	−0.09	[−0.19; 0.02]	0.096
Waist circumference (N = 441)						
Baseline—T1	1.36	[0.41; 2.31]	0.005	1.40	[0.43; 2.37]	0.005
Baseline—T2	0.07	[−1.05; 1.20]	0.898	0.13	[−1.01; 1.27]	0.821
Overall effect	0.93	[0.05; 1.82]	0.039	0.99	[0.04; 1.93]	0.040
Cohort A^b						
BMI z-scores (N = 152)						
Baseline—T1	−0.22	[−0.38; −0.06]	0.006	−0.23	[−0.39; −0.08]	0.003
Baseline—T2	−0.27	[−0.44; −0.10]	0.002	−0.28	[−0.45; −0.11]	0.001
Overall effect	−0.25	[−0.40; −0.10]	0.001	−0.26	[−0.41; −0.11]	0.001
Waist circumference (N = 149)						
Baseline—T1	2.18	[0.29; 4.07]	0.024	2.16	[0.34; 3.97]	0.020
Baseline—T2	1.84	[−0.07; 3.75]	0.060	1.79	[−0.05; 3.64]	0.057
Overall effect	1.95	[0.09; 3.80]	0.040	1.91	[0.16; 3.66]	0.032
Cohort B^c						
BMI z-scores (N = 166)						
Baseline—T1	0.05	[−0.16; 0.28]	0.591	0.06	[−0.16; 0.28]	0.591
Baseline—T2	0.08	[−0.13; 0.30]	0.453	0.08	[−0.13; 0.30]	0.454
Overall effect	0.08	[−0.12; 0.27]	0.455	0.08	[−0.12; 0.28]	0.455
Waist circumference (N = 145)						
Baseline—T1	1.65	[−0.15; 3.47]	0.073	1.70	[−0.01; 3.41]	0.051
Baseline—T2	−1.11	[−2.90; 0.67]	0.222	−1.08	[−2.76; 0.61]	0.211
Overall effect	0.37	[−1.18; 1.93]	0.639	0.44	[−1.06; 1.95]	0.563
Cohort C^d						
BMI z-scores (N = 142)						
Baseline—T1	−0.04	[−0.20; 0.12]	0.623	−0.02	[−0.17; 0.13]	0.775
Waist circumference (N = 147)						
Baseline—T1	−1.04	[−4.11; 2.03]	0.506	−1.14	[−3.63; 1.36]	0.372

^a Adjusted for sex, educational level and migration background.^b Measurement rounds were conducted as follows: Baseline measurement in 2016, T1 in 2017, T2 in 2018.^c Measurement rounds were conducted as follows: Baseline measurement in 2017, T1 in 2018, T2 in 2019.^d Measurement rounds were conducted as follows: Baseline measurement in 2018, T1 in 2019.

their responsibilities in the process of creating a Healthy School and the need for their support to maintain the Healthy School had a positive impact on their leadership position. This provided them with more grounds to ask other colleagues to support the creation of a healthy school community. At the same time, the HSCs also experienced a lack of consistency in school leadership throughout the intervention, noting that changes in leadership are always accompanied by uncertainty regarding whether the new leader will be supportive of the Healthy School.

Strategy 2: Participatory school culture

- Adoption: the use of participatory methods.
- Implementation: the participation in Design Thinking and Photovoice.

Although all of the intervention schools used the participatory methods of Photovoice and Design Thinking, they adopted these methods differently (Table 3). Photovoice was applied to promote a participatory school culture among pupils. Based on experiences from the first year of the intervention that

indicated that Photovoice could be used as a conversation starter in the curriculum as long as it was applied to a specific issue, the HSCs chose to apply it to engage pupils in designing an attractive physical environment that promotes healthy choices. In Schools 1, 2, and 4, this method was implemented in one or two second-year classes, each with approximately 25 *vmbo*-pupils during the second year of the intervention. Teachers and HSCs in these schools were particularly appreciative of the creativity and flexibility of Photovoice and the ideas that it generated for potential changes in the physical environment.

In collaboration with the local expert, the HSCs organized Design Thinking sessions. These sessions were attended by a number of colleagues, pupils and parents, but no support staff members (e.g., canteen employees) were willing to attend. Participant recruitment was most successful through using the informal network, presenting the work of pupils (e.g., Photovoice results), and providing incentives (e.g., offering a healthy meal). For example, in School 1, the HSC motivated people to join the Design Thinking session by serving healthy foods that pupils had prepared during a cooking workshop.

Strategy 3: Designing and implementing tailored health-promotion activities

- Adoption: creation of an action-plan based on Design Thinking session and initiation of new activities.
- Implementation: following through on action-plans and initiation of Healthy School activities.

During the Design Thinking sessions, stakeholders came up with multiple ideas for designing tailored health-promotion activities based on information gathered during interviews and Photovoice regarding the needs of the communities, and baseline information regarding the health behaviors of pupils. For implementation experiences per school regarding activities, see [Appendix III](#). For example, stakeholders in School 2 prioritized the issue of many pupils going to a nearby supermarket to purchase unhealthy snacks. The school was open to improving their healthy canteen to make it a more attractive option for pupils. Stakeholders proposed a solution involving the introduction of a system of punch cards that parents could buy for their children, thereby providing pupils with easier and less expensive access to healthier options in the school canteen, as compared to the supermarket. After a session, all of the HSCs and one or two colleagues created concrete action plans based on the ideas proposed by stakeholders. The local experts and researchers particularly encouraged the HSCs and colleagues to use evidence-based intervention strategies and to include a communication plan to address visibility.

Schools carried out their action plans in the second half of the third intervention year. They were particularly successful in implementing activities that related to education or the physical environment. Examples included organizing a staircase-relay

(School 4) and developing biology lessons about growing your own produce (School 1). The HSCs, teachers, and support staff members expressed that they had found it difficult to implement policy activities, as they had not felt that they had any mandate on overall school policies and the allocation of resources (e.g., money or time). In addition, stakeholders in Schools 1 and 2 mentioned that they had been unsure of how to increase visibility. In contrast, public-relations (PR) employees in Schools 3 and 4 had become involved by sharing news bulletins on their schools' communication platforms. For example, in School 3, the PR employee had prepared a news bulletin on social media when pupils received water bottles on World Water Day.

Strategy 4: Local networks

- Adoption: the availability of local experts and organization of coaching sessions.
- Implementation: initiated collaborations with local partners.

Throughout the FLASH intervention, it became evident that the HSCs assigned less priority to setting up local networks. Although they increasingly saw themselves as playing a mediating role between the local community and the school community, they did not feel ready to utilize these networks, and they were reluctant to approach possible partners, due to limited self-efficacy. All of the HSCs called upon PE colleagues to help them initiate collaborations with local sports clubs, as these teachers often had existing connections. Most of the other organizations that HSCs identified as potential partners were municipal institutions (e.g., youth services or spatial planning committees), but not local food retailers. Multiple stakeholders in Schools 1 and 4, both of which are located in small municipalities, reported successful partnerships with combination youth/health professionals (School 1) and care/sports coordinators (School 4). The HSCs in Schools 2 and 3, both of which are located in larger municipalities, were reluctant to initiate such collaborations, based on previous experiences in which such efforts had been time-consuming, difficult to maintain, and yielded little reward.

Maintenance

- Maintenance was defined as the extent to which stakeholders intent to continue working with a community-based approach.

According to the experiences of stakeholders throughout the FLASH intervention, prior to the intervention, they had been more focused on organizing activities within each pillar of the Dutch Healthy School approach, paying less attention to setting up strong capacity-building processes.

At the end of the intervention, stakeholders seemed to be more knowledgeable about why an integral approach and the involvement of more people offers greater potential than simply trying to meet the criteria of a particular Healthy School theme. Nonetheless, stakeholders in all schools agreed that the process of building community capacity takes time. In order to continue building capacity, the continuation of the HSCs role, as a linking pin and catalyst for the capacity-building process was considered essential. The HSCs and school leaders in all schools were searching for ways to continue this role without the additional FLASH hours after the end of the intervention. HSCs and other stakeholders involved in Healthy School activities expressed a need for continued support from experts in order to professionalize their leadership roles. For example, they reported needing support in finding ways to implement participatory methods into crowded curricula, ensuring proper representation of the community during participation, and identifying opportunities to start collaborations with food providers or municipal partners. Maintenance interviews with the local experts and managers of the municipal health service indicated that some aspects of the FLASH intervention (e.g., Photovoice, Design Thinking, coaching HSCs) have the potential to be embedded into existing tasks of supporting schools with the Dutch Healthy School approach. Proper training and time are important conditions to achieving this potential. Health promotion added that they also need to raise awareness of their own existing networks so that they can fully support in creating a Healthy School.

Discussion

This study evaluated the impact of the FLASH intervention on community capacity, capacity-building processes, and the BMI and waist circumference of adolescents in four intervention schools. Community capacity improved across all intervention schools, but improvements varied between schools and between capacity-building strategies. Particular improvements were observed in terms of Strategy 1: leadership going from “vague awareness”/“pre-planning” to between “preparation” and “initiation”, Strategy 2: participatory school culture going from “vague awareness”/“pre-planning” to “preparation”, and Strategy 3A: the implementation of tailored activities supported by the community going from “preparation” to “initiation”. Limited increases were observed with regard to improving Strategy 3B: the visibility of activities (“vague awareness”/“pre-planning” to “pre-planning”), Strategy 3C: knowledge about local prevalence to prioritize activities, and Strategy 4: local networks (both from “pre-planning” to between “pre-planning and “preparation”). Building community capacity was experienced as a process that takes time. Having an appointed HSC was deemed essential for initiating processes of change and evoking participation. It was also noted, however, that

HSCs needed to grow into their new leadership roles. All of the schools took important first steps in creating a healthy school community in which stakeholders have a sense of ownership. Results concerning BMI and waist circumference showed varying results with only small changes on BMI z-scores and inconsistent changes on waist circumference over time and between cohorts.

To our knowledge, only a few studies have used the CRC method to monitor change in community capacity to assess the impact of community-based interventions (15, 36, 37). Similar to FLASH, the interventions involved in these studies were aimed at strengthening collaborations and promoting ownership and resulted in similar increases in community capacity, with particular improvements in leadership. Comparable to these studies, the FLASH schools started the intervention with an overall capacity score between the vague awareness and pre-planning stages of readiness and increased to approximately the preparation stage over a three-year period. The finding that none of the schools increased to a capacity score above the initiation stage on any of the capacity-building strategies highlights the fact that the school communities might require more time or may need more support to structurally embed their efforts (15, 36, 37).

In line with other studies, we observed the most notable improvements in leadership (15, 36, 37). An essential element of the FLASH intervention was that HSCs were provided with time, which enabled them to take on a leadership role. This finding is in line with the advice of the Dutch Health School approach to spend (part of) a funding impulse that all Dutch schools can apply for on a similar task. Stakeholders in intervention schools responded well to the focus on building leadership as a first action for building a healthy school community. This finding is in line with previous research that concluded that knowledgeable, skilled and motivated leaders are key facilitators for sustainable implementation of public health interventions at school (8, 38). The results of this study indicate that both time and effort are required to build leadership within a community-based approach. The appointment of HSCs who adopt a capacity-building approach toward creating healthy school communities provides a linking pin between stakeholders and structures within the schools' dynamic context, in addition to serving as initiators of change. Given that the role may require a professional identity other than that of a teacher (39), HSCs need time to grow into this changing role. Experiences throughout the FLASH intervention suggest that it is especially important to be able to recognize opportunities within the wider context of a school (e.g., seeking collaborations on topics such as climate change), in addition to being able to act on these opportunities in a creative and flexible way. These experiences are in line with developments in the Schools for Health in Europe network, in which attention to the complexity of navigating the context is gaining momentum (40).

We also observed improvement in a participatory school culture. Our results suggest that enabling community members to share their ideas; keeping participation accessible, easy, and fun (e.g., through Design Thinking sessions); and giving a voice to community members contributed to a sense of ownership over the Healthy School. The experiences of stakeholders highlighted the reciprocal process of building this strategy. When participation is facilitated, activities are better received by community members, and this promotes positive awareness of the Healthy School and the willingness for further participation in the continuous developmental process of a Healthy School. Moreover, as demonstrated by our findings and emphasized in previous studies, it is imperative to have top-down support from members of the management, who set an example for the school culture to build this strategy (41, 42).

Concerning the implementation of health-promotion activities, we observed that schools mainly prioritize activities that they consider feasible and relatively easy or familiar to implement and that cause little discussion among community members. They do not necessarily consider whether activities are theoretically sound or evidence-based. To achieve behavioral change among pupils and improve health, it is important to assist schools in their efforts to obtain support for less popular, but evidence-based activities (43). At the same time, many studies have indicated that the evidence-based interventions that are available are not structurally adopted or followed with a high level of fidelity, such that they have only a limited impact on health behaviors (44–46). Although the Dutch Healthy School approach advocates the use of evidence-based interventions, it can be useful to let stakeholders prioritize fun but less evidence-based activities when schools are still in a stage of readiness where they are still working to improve awareness on healthy physical activity and dietary behavior.

We observed limited improvements in the local network strategy, as stakeholders were uncertain about their role to build networks. Previous studies have found mixed results on this strategy (15, 36, 37). However, these studies focused mainly on helping communities to apply for additional grants, unlike the FLASH intervention where we aimed at encouraging schools to build local and national partnerships that fit within the existing Dutch Healthy School approach. Given that the HSCs were still growing into their role of bringing people together within the school, they did not assign high priority to the complex process of creating networks around the school. Ideas for how local organizations in the fields of public health and education could offer support to schools varied between organizations.

The impact of the FLASH intervention on adolescent's BMI and waist circumference as secondary outcomes showed varying results and estimated differences between intervention and reference group were small. Particularly differences between both groups in waist circumference seemed inconsistent over time and between the different cohorts. We observed similar patterns in pupils behavior and attitudes in both groups.

Because this intervention took place in real-life practice, schools in the reference group were allowed to implement health-promotion activities under the regular Dutch Healthy School approach. This may have had an effect on the difference found in anthropometric measures and lifestyle behaviors of pupils between groups. Additionally, this intervention specifically focused on the school community, whereas lifestyle behaviors of pupils are also influenced by activities outside the school setting, for example in the neighborhood or at sport clubs (47). Moreover, this study showed that the process of building community capacity among stakeholders takes time. Therefore it may have been too early to expect clear changes in behaviors and anthropometric measures of pupils within the study period. We did not collect information on pubertal stage and as this is strongly related to body adiposity, this could also have contributed to the inconsistent differences found in waist circumference between groups and between cohorts (48). Furthermore, the magnitude of measurement error in waist circumference has been reported to be varying (49).

Strengths and limitations

One strength of this study is that it was performed in real-life practice. The process of building community capacity, as well as the evaluation of these processes, followed an adaptive approach to enable changes in the system to be captured and accommodated, and to allow for feedback, adjustments and emergent outcomes (22). We collected information on outcomes regarding the effectiveness of the FLASH intervention, on day-to-day processes, and on contextual factors that influence schools in practice. Because this approach allowed for the complexity of real-life situations, our study is consistent with the line of realistic evaluation (50, 51). The mixed-methods design (i.e., triangulation) and structured use of the RE-AIM elements helped to provide a true and complete picture of the impact of the FLASH intervention in complex real-life settings. Alongside the strengths of this study, it is important to acknowledge the subjective nature of assessing community capacity. We minimized this subjectivity by using two researchers to score interviews, each of whom kept a reflective diary in order to discuss potential subjective views. These reflections were also checked against the experiences that HSCs and local experts recorded in journals and meetings. In accordance with the CRC method we conducted between six and eight in-depth interviews per school (21, 29). Nevertheless, it could be that the participants responses still did not provide a complete picture of the community's readiness for change. We did include a diverse selection of key-stakeholders in different roles which helped obtain a multi-faceted picture of the process of capacity-building. Moreover, the rich data material contributed to a broad understanding of the specific community characteristics and dynamics. Although some efforts are being made to create an

online validated questionnaire for the CRC method (52), these developments cannot yet be applied in the Dutch context. Given that our results demonstrate the promising impact of building community capacity, we recommend further research on how the principals of capacity building can be incorporated into the existing Dutch Healthy School approach, as well as on how a validated online tool could be developed for the Dutch context.

We evaluated the impact of the FLASH intervention at the school level (i.e., changes in community capacity) and at the individual level (i.e., pupils' BMI and waist circumference). It is important to note the limited number of schools and of pupils participating and the quasi-experimental study design. As is common in these types of studies (53, 54), we encountered challenges when involving *vmbo*-pupils in this effectiveness study (including obtaining parental consent). Additionally, we applied a quasi-experimental approach without randomization of schools, which might have resulted in residual confounding for the individual level outcomes.

Implications for practice and research

This evaluation study contributed to a better understanding of the complexity of implementing health promotion in the whole school system, and demonstrate that contextual and dynamic processes, such as abrupt changes in pupil numbers or municipality plans for the physical environment, determine the implementation of the Healthy School approach. In order to support schools in the implementation of an integral whole-school approach, an important step for the sustainable implementation of the international Health Promoting School approach might be to concentrate on teaching stakeholders how to navigate these processes in and around their organizations. As indicated by our results, the focus on building community capacity and creating a broadly supported healthy school community helped schools to become more aware of their own contexts and dynamics, in contrast to a focus on whether an intervention (evidence-based or otherwise) is delivered as intended (55). This is also in contrast to the regular Dutch Healthy School approach where often only one stakeholder focusses on executing health-promotion activities. Stakeholders deemed the presence of a central coordinator charged with connecting people and opportunities within a school community essential to building community capacity, and they therefore suggested that this role should be structurally embedded in school policies. Given the finding that this role was new for the HSCs, future studies should focus on how to empower and support HSCs in this new role. In addition, further exploration of the role of local health-promotion professionals for supporting schools in their efforts to build community capacity would be worthwhile, particularly about the creation of local networks and the adaptation of evidence-based interventions to the local context. Stakeholders in this

study looked at building local networks as an afterthought, while this could potentially also be a promising starting point to make schools feel more supported. It is therefore important to start a dialogue about who can take up which role around the school to best support schools in becoming a Health Promoting School.

Conclusion

The results of this study highlight the potential of building community capacity to create healthy school communities which eventually might lead to a healthier body composition of pupils. Results also indicate that building community capacity is a highly dynamic and contextual process in which stakeholders must become acquainted with new leadership roles and responsibilities. In order to navigate this process, schools need support with improving communication, setting up local networks, and sustaining capacity-building efforts in school policy.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by Medical Ethics Committee of Amsterdam UMC, VUmc location, reference number 2016.352. Written informed consent to participate in this study was provided by the participant and the participants' legal guardian/next of kin.

Author contributions

BD, IV, CR, MR, and IS designed and executed the intervention and study. BD drafted the manuscript. IV, CR, MR, and IS provided input and feedback. MB advised on the experimental study and the analysis and provided feedback on the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

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

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Supplementary material

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Acceptability of a parent-focused program for physical literacy development among parents and children during the COVID-19 pandemic: A qualitative study

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Background: A 3-month parent education program was designed and implemented in Hong Kong to improve physical literacy (PL) among primary school children and their parents during the COVID-19 pandemic. This study aims to probe into the acceptability of the intervention from parental perspectives, providing more insights for future implementation.

Methods: Following the 3-month parent-focused PL program, 16 parents (mean age = 43.73 years, 15 mothers) were recruited to participate in semi-structured individual interviews in June 2021. Interviews were analyzed using thematic analysis in NVivo 12. Two coders analyzed interview transcripts deductively based on the interview guide and social cognitive theory (SCT).

Results: Three themes were identified that captured the acceptability of the program: (1) Addressing needs through appropriate delivery enhances acceptability of intervention; (2) Positive behavioral and psychological changes to families; (3) Appropriate support of environmental factors can enhance the sustainability of program effects. The high levels of acceptability were attributable to the fact that parents were able to learn and be a gatekeeper to impact their children positively. Moreover, the design and contents of the program were appropriate for the participating parents because the program provided adequate learning resources and interactive learning support without being overly rigid, and the online learning mode was feasible and convenient. Consequent to their participation in the program, parents expressed that they became more aware of the importance of PL, established physical activity routines with their children, and modified their parenting styles which resulted in improved parent-child relationships.

Conclusions: The current study provided evidence that engaging parents in the intervention was a feasible and acceptable approach in supporting both

parents and children to establish physically active routines in the family setting. The insights gained regarding the appropriateness and acceptability of the program in this specific context may be used to inform the design, implementation and sustainability of other parent-focused PL programs.

KEYWORDS

online-learning, family, implementation outcomes, social cognitive theory, qualitative research

Introduction

Physical literacy (PL) is defined as “the motivation, confidence, physical competence, knowledge and understanding to the value and take responsibility for engagement in physical activity (PA) for life” (1). Physical literacy is an antecedent to PA participation (2, 3). Researchers suggested that regular participation in physical activities (PA) is beneficial to both physical and mental health, such as reducing the risk of chronic diseases and the incidence of mental health disorders (4, 5). Improvements in PL *via* intervention should fundamentally help sustain the positive effects of PA interventions.

While physical education is essential in helping children gain knowledge of the importance of PA, and learn fundamental movement skills and other sports skills (to build competence) from teachers or sports coaches, parents’ roles in the development of PL for young kids and school-aged children are equally important (3). Evidence indicates that support in the home environment and parenting behaviors are crucial in shaping and promoting children’s PA (6). Parents typically play an essential role in children’s growth development and in shaping their PA behaviors (7) and hence the development of PL. The improvement of parents’ PL could help sustain the effects of PA interventions targeting children or families. Hence parent-focused interventions hold promise for achieving health impact on both parents and children (8). However, in Hong Kong, parents put a large emphasis on children’s academic development (9) and the rate of inactivity in children and parents is high (10). Moreover, since the outbreak of the COVID-19 pandemic in 2019, the everyday lives of people around the globe had been greatly affected. Schools and PA interest classes were suspended for a prolonged period. Parents started to work from home while children were having online classes at home. In turn, children’s PA levels dropped significantly (11). There was an urgent need and a good opportunity to improve parents’ PL. Therefore, we developed and implemented a 3-month parent-focused PL program during the COVID-19 pandemic.

Past studies on PA interventions in the family context (8, 12, 13) were mainly quantitative and were unable to capture the underlying processes or mechanisms in terms of why they might be effective (14). Thus, we adopted a qualitative approach

in this study, aiming to explore the acceptability of the parent-focused program and related factors of sustainability of the intervention. We applied social cognitive theory (SCT) (15), which posits that individuals behaviors and environments are interrelated, to explore participants’ perceptions of the program, facilitators and barriers to PA in the family context before and during the COVID-19 pandemic. Through individual interviews with participants of the program, we aimed to solicitate their views and feedback to specific components of the intervention, and in turn to explain these processes in light of SCT. This study contributes to the understandings of the acceptability and the importance of a parent-focused PL program, which would benefit the nurturance of familial healthy lifestyles and the sustainability of PA interventions in the family context.

Methods

Study design

A qualitative study design was employed in this study to explore parents’ acceptability toward the designed intervention contents through verbal interviews.

Participants and procedures

The parent-focused program described in this study is an initiative under the broader Fun to Move@JC project (10, 16). Fun to Move@JC is a school-based multi-component project launched in 2017 designed to enhance PA of primary school students and their parents. Only families who have taken part in the broader project was invited to take part in the PL intervention program. All parents who completed the PL program were invited to take part in a qualitative research study. Parents were told that they and their children would be interviewed by project staff if they agreed to take part. A total of 16 parents of 16 schoolchildren from 12 Hong Kong primary schools responded to our invitation and took part in this study. Respondents from all four major geographical areas in Hong Kong were included to ensure sample representativeness. Parent participants included mothers ($n = 15$) and fathers ($n = 1$), with a mean age of 43.73 years. Most parents (69%, $n = 11$)

were housewives, and 75% of them had a family monthly income of HK\$20,000–\$60,000 (the median household income of Hong Kong is around HK\$28,000). The majority spoke Cantonese at home (87.5%, $n = 14$; [Table 1](#)).

Individual interviews were arranged with each participating family. Two members of the research team conducted the interviews separately in participants' first language (i.e., Cantonese). Due to the pandemic-related social distancing measures enforced, interviews were conducted *via* Zoom or phone based on participants' preferences and convenience. Each interview lasted ~30 min. At the beginning of each interview, participants consented to the session being audio-recorded. Each parent completed a questionnaire after the interview to collect demographic information, including age, marital status, educational background, monthly family income, and the number of children in their household. After the completion of interviews with this group of participants, there was evidence of data saturation (17). As such, we did not extend our efforts to recruit additional participants to the study.

Intervention contents

The contents of the parent-focused program were designed to improve all facets (i.e., knowledge and understanding, motivation and self-confidence, motor competence, and activity behaviors) of PL in parents. Details of the intervention contents are presented elsewhere (16). In brief, the main intervention was delivered through six 60-min interactive workshops, with each being 2 weeks apart. Hence the total duration of the intervention was approximately three calendar months. Workshops were conducted online amid pandemic-related social distancing measures that were in force. Nonetheless, this delivery approach also allowed parents from all geographical regions of Hong Kong to attend simultaneously. Various topics (e.g., cognitive development, mental health and parent-child relations) related to PA were presented by the lead author during the first halves of workshop sessions. The objectives of these sessions were to enhance parents' awareness, knowledge, and understanding of PA, and to motivate and instill confidence in them to remain physically active with their children.

The final 30 min of each workshop was an activity lesson led by coaches trained by the authors, where parents were invited to do various activities under the guidance of coaches trained by the authors. Coaches demonstrated and led participants to exercises related to physical fitness and fundamental movement skills, and provided recommendations in terms of how parents could lead their children to do similar activities at home. Through these instructions, we aimed to improve parents' competence in fitness and motor skills, and provided more co-activity ideas for parents and children.

TABLE 1 Demographic information of participants.

Characteristics	Mean (SD) or N (%)
Gender	
Male	1 (6)
Female	15 (94)
Age (years)	43.73 (4.62)
Educational attainment	
Up to lower secondary school	1 (6)
Upper secondary school	8 (50)
Associate degree or higher diploma	4 (25)
Undergraduate degree	3 (19)
Employment status	
Housewife	11 (69)
Employed, part-time	1 (6)
Employed, full-time	4 (25)
Language spoken at home	
Cantonese	14 (87.5)
Mandarin	2 (12.5)
Number of children	
1	8 (50)
2	8 (50)
Family monthly income (HK\$)	
<20,000	2 (12.5)
20,000–60,000	12 (75)
>60,000	2 (12.5)

Data analysis

All interviews were audio-recorded and transcribed verbatim. Interview transcripts went through member checking to ensure trustworthiness (18) before being analyzed using the inductive-deductive hybrid thematic analysis (19) *via* NVivo Version 12. First, a preliminary codebook was developed based on the interview guide (20). Two authors worked as coders in the data analysis phase. First, they independently analyzed all the transcripts with the preliminary codebook, adding codes inductively to capture phenomena not included in the preliminary codebook. Third, they compared coding and came to a consensus on all discrepant codes to be added to the codebook. Fourth, codes were connected to identify themes, they made a consensus on the themes and sub-themes, and the final codebook was sent to all the authors for review. The final set of codes and corresponding descriptions for the themes and sub-themes are presented in [Table 2](#).

Results

Elaborations and illustrative quotations to support our analyses are presented below. All transcriptions presented were

TABLE 2 Outline of theme, sub-theme, and codes used in qualitative analysis.

Theme	Sub-theme	Description of codes
1. Addressing needs through appropriate delivery enhances the acceptability of the intervention	Motivation and expectation toward the program	1. School recommendation 2. Do more PAs during the pandemic
	Acceptability of the program	1. Absorb knowledge from the workshop 2. Scope and depth of content of workshops 3. Arrangement and format 4. Accessibility of learning recourses
	Online delivery mode	Positive attitudes: Avoid infection Flexible Convenient Time-saving
	Suggestions and improvements	1. Extend the duration of the workshop 2. Generalize the program to broader families 3. Hybrid mode to deliver the workshop 4. Involvement of children
2. Positive behavioral and psychological changes to families	Perceived behavioral and psychological change	1. More PA/Co-PA time 2. Better quality of sleep 3. Reduce screen time 4. Embedded the rationale of the PA knowledge to daily activities
	Long-term effect	1. Establishing PA habits and family routine 2. Be more aware of the importance of exercise
	Parenting behaviors	1. Parenthood 2. Reflection on parenting style
3. Appropriate support of environmental factors can enhance the sustainability of program effects	Social cognitive factors	Attitudes and values toward PA 1. Perceived PA benefits (physical & mental) 2. Perceived co-activity benefits
		Parent self-efficacy to PA 1. PA/exercise habits 2. Perceived PA barriers
		Parent self-regulation to PA 1. PA goal setting 2. Monitor PA
	Physical environment factors	Hong Kong built environment 1. Sports facilities/venues accessibility 2. Transportation 3. Population density
		Home environment 1. Limited space 2. Unfavorable home setting

translated from Cantonese, which was the language in which the interviews were conducted and transcribed.

Addressing needs through appropriate delivery enhances the acceptability of the intervention

The program delivered PL knowledge to parents, which largely addressed their needs during the pandemic. Parents mentioned that they were initially motivated to participate

because they were affected by the epidemic and realized they needed to do more exercise.

“Lectures on PA have been scarce [in HK]. As this parent program was launched, although the time did not allow me to fully participate [in all sessions], I thought it was good to attend at least the first two workshops.” (Interviewee 2, Mother)

Parents also expressed satisfaction with the program's content and organization in various ways, including the acquisition of theoretical knowledge, the interactive experience

in the sessions, the utility of the learning resources, and the online learning mode. The theoretical knowledge set the fundament of their PL. For example, one mother noted:

"I believe it is important for us to understand why PL is beneficial to children and what problems can arise if we do not engage in PA. We probably would not know as much as we do without the theoretical courses, and the sharing sessions also include educational knowledge, such as to teach children to be persistent in PA and how to manage time to implement the plan effectively." (Interviewee 1, Mother)

To address their needs precisely, we adopted parents' suggestions and recommendations from the first two workshops in subsequent workshops that contributed to parents' satisfaction. One parent stated that:

"I suggested in the third or fourth class that there could be more interactive sessions, and [the organizers] really added more interaction in the next workshop." (Interviewee 3, Mother)

Parents praised the combination of educational content with the activity sessions. They learned some feasible ways to do PA at home at the workshops and then applied them in daily life.

"I learned (from the workshop) that exercising is not limited to outdoor types. Many exercises can be conducted within limited space at home." (Interviewee 12, Mother)

"You used simple materials, e.g., plastic bottles and towels, to do PA (at the workshop). After the workshop, we engaged in these activities, e.g., using towels to stretch, which we would not do before attending the workshop." (Interviewee 11, Mother)

The learning materials we designed, such as the worksheets, also helped parents improve memory and review workshop knowledge, which facilitated the sustainability of the program.

"Some of the questions were about time management, and the graphs allowed us to self-regulate how much time we spent each day doing exercise in our daily lives." (Interviewee 1, Mother)

The online delivery mode of the program was convenient for parents. They could arrange their time flexibly and keep social distance from others during the pandemic, though it also has some disadvantages compared to face-to-face modes.

"The online mode saved transportation time... The face-to-face mode allows people to interact closely with each other, especially for children. The atmosphere would be happier. But it would be the same for adults." (Interviewee 4, Mother)

The online delivery mode ensured their participation during the specific time and is an option to improve the sustainability of the program in the future. One father noted:

"If there are future opportunities to conduct related activities, I believe the learning format can be alternated between face-to-face and online classes." (Interviewee 13, Father)

Positive behavioral and psychological changes to families

This program applied a more holistic approach in the intervention, i.e., focusing on PL and not just PA, so participants could be benefited on physical, cognitive and affective levels. Specifically, parents were not just taught about how to do specific PA with children, but also about the importance of PA on other aspects, such as children cognitive development, parent-child relations. Intervention contents were also specifically designed to encompass each area of PL. Parents elaborated on three main aspects of changes after engaging in the program, namely perceived behavioral changes, psychological changes, and reflections on parenting behaviors. Health and wellbeing, psychological symptoms (e.g., depression, anxiety), changes in sleep pattern and weight, more PA time, and less screen time were mentioned in terms of behavioral and psychological change. The PL knowledge was considered interesting and down to earth so could be applied in daily life and changes be seen, in both parents and children.

"After participating in the workshops, I was particularly impressed by the workshop on family routines, which is the starting point for changing or trying to change and control the lifestyle habits." (Interviewee 8, Mother)

"I think what the speaker said was practical. I saw substantial effects in children. They became willing to get off the bus one station before the destination to walk more. Previously they asked if they could take a taxi when going out on hot days. Now they offered to walk. They could persist. The effects could be seen." (Interviewee 6, Mother)

Strong emphasis was placed on parent-child co-activity throughout intervention design and implementation. When parents were asked about the transformation that occurred after participating in the program, the most frequently mentioned point was the improvement in parent-child relationships. Through the program, some parents have begun to reflect on their parenting behaviors and became aware of the importance of establishing PA and co-activity routines.

“The workshops were highly beneficial to me. As I previously stated, sometimes the parent-child relationship is strained, and I am unsure of what and how to teach my child. Without these classes, I would have continued to discipline my children in my way and demanded more and more of him.” (Interviewee 15, Mother)

Appropriate support of environmental factors can enhance the sustainability of program effects

Apart from the characteristics of this PL program fitting the special pandemic circumstance contributed to the sustainability of the program, general environmental factors could also influence the sustainability of PA intervention based on parents' statements.

In terms of the social environment factors, parents expressed positive attitudes and values toward PA. They recognized that regular PA is essential to physical and mental health, and co-activity with children is an important part of their family routine, which helps to strengthen family bonds in regular time. However, parents stated that they did not set up a PA routine for themselves or their children, such as arranging a specific activity at a certain time of day. On weekends, nonetheless, the majority of families frequently participated in outdoor activities together.

Regarding parental efficacy, parents claimed that they have some exercise habits, such as hiking, jogging, cycling, etc. However, they did not identify themselves as “sportspersons.” Moreover, parents expressed that their own PA knowledge and related skills needed to be improved. Despite knowing that parental support was necessary, they lacked confidence in their ability to support their children's PA. Parents also believed that at this stage, children's academic performance is of great importance. Children have to finish their homework first before doing sports or participating in PAs. They also expressed the difficulties in balancing homework and PA time for their children. One mother stated:

“In Hong Kong, it is challenging to find time to play with children. Although children are not at school the whole day, they have to take online classes when they get home, and after school, it is nearly 4:00 pm, and then they must do their homework. They have to prepare for exams or do other revisions over weekends, making it difficult to find time to participate in PA.” (Interviewee 6, Mother)

In terms of the physical environment in the local context, almost all parents stated that their living space is relatively small, with insufficient space for PA indoors. Some parents considered the community has a relatively good physical environment and sufficient facilities and space for children to exercise.

“In the community, the parks around are convenient [for doing PA]. But the home environment may not be spacious enough, for example, for a four-person family like us.” (Interviewee 11, Mother)

However, some other parents have expressed concerns that although some sports venues are free to the public, in practice, it is frequently impossible to book venues due to high demand. Besides, parents also stated that the distribution of sports resources varies by district.

“Generally, I think there is not enough support [from the community and school] to support parent-child co-activity. We have tried but failed to book badminton courts. The chance to succeed is zero.” (Interviewee 7, Mother)

“If you want to do sports, such as riding a bike, you must travel to a different district that is further away.” (Interviewee 3, Mother)

Though the current program satisfied participants' needs of doing PA at home during the pandemic, in the long term, for the sake of the sustainability of this and other programs, the social and physical environment factors need to be concerned and improved by researchers and policymakers.

Discussion

This study explored participants' perceptions of a parent-focused PL intervention and facilitators and barriers to physical activity in the family context before and during the COVID-19 pandemic. Our results suggested that intervention on parents' PL was feasible and sustainable in supporting both parents and children to establish physically active routines in the family setting.

Acceptability of the program under the COVID-19 pandemic

The purpose and design of this parent-focused PL program were well-matched with the situation of the COVID-19 pandemic. Both parents and children became physically inactive upon the influence of the COVID-19 (21, 22). Particularly, schools and many workplaces were closed, resulting in transitioning activities that once took place outside of the home to virtual implementation in the home environment. For children, this transition meant adapting to online learning without physical encounters with teachers, friends, and a supportive school environment. However, under these circumstances, the marginalization of school physical education has become even more evident (23). As such, PA support provided by parents have become even more important.

For many parents, stay-at-home orders meant they had to navigate their work responsibilities and home chores, assist children with online learning, and juggle the stress of an indefinite pandemic at home. Apart from the potential stress associated with handling daily activities of children, parents' anxiety toward the pandemic may also negatively impact their tendency of allowing their children engage in outdoor activities (24). The provision of a timely education or reminder on the importance of PA is therefore of great importance. As a response, our PL workshops were designed to improve parental knowledge and skills and enhance PL among parents and children. Parent education training sessions may have a favorable impact on parenting practices related to PL. In the current study, parents expressed that their PL was improved and consciously carried out parent-child activities. As such, this finding of the study holds promise, given the potential scalability of the program.

The high levels of acceptability were attributable to the fact that parents were able to learn and be a gatekeeper to impact their children positively. Moreover, the design and contents of the program were appropriate for the participating parents because the program provided adequate learning resources, interactive learning support without being overly rigid, and the online learning mode is feasible, efficient, convenient, and offers parents the accessibility of time and place. The current program is not a one-time intervention but a gradual intervention in 3-month. Unlike other studies (25), the PL knowledge was delivered in several workshops rather than one single session. This may help parents to take in the knowledge step-by-step and be reminded of the intervention regularly. In the long run, parents expressed that the program was meaningful as they became more aware of the importance of PL, gained essential knowledge and skills, established PA routines, and allowed them to reflect on their parenting styles and further improved parent-child relationships. All these should facilitate the sustainability of the intervention afterward.

In addition, the online learning mode is feasible. Under the effect of the COVID-19 pandemic, delivering the intervention *via* the online real-time mode can avoid direct interaction between people during the pandemic. Furthermore, online learning is more adaptable, flexible, and comfortable for parents compared to face-to-face engagement (25). Most parents benefit from online learning because it provides an alternate exercise opportunity. It can be challenging to require parents to commit to attending the face-to-face sessions regularly when they have hectic day-to-day work and lives. However, delivering the program in a feasible online manner can increase their motivation to participate. To some extent, the online training mode is not only applicable to the current pandemic situation but also promising for future implementation of parent education programs.

Parents' recognition and improvement of PL

According to the SCT, this study adds to the existing literature by probing into parental perceptions and activities that may facilitate or impede children's PA in behavioral, cognitive, and environmental contexts (15). Many parents had favorable attitudes toward the PL program. They recognized the benefits of parental PA support and considered it necessary, consistent with prior research (26). Parents underlined the benefits of PA involvement in terms of physical and mental health and the psychosocial implications. Parents especially enjoyed the interactive activity sessions led by members of the research team. Fundamental movement skills, physical fitness, home-based PAs, and parent-child activities were all covered in this engaging activity program. These parent education sessions provided parents with creative ideas of using their leisure time or living space. Making full use of available environmental resources, such as doing PA with their children together at home. This has been shown to subsequently influence children's PA behaviors favorably and may also help parents and children connect more actively. As PL is a multifaceted construct of physical, cognitive and affective area, the improvement of parents' physical literacy not only facilitate their PA (27) and physical health but also facilitate their children's (27, 28). In the current program, some parents and their children form habits of doing PA in daily life by following instructions in workshops. We hope that *via* parents' modeling and instructions, children's PL will be improved (6, 7). This would also help improve or sustain the effect of family-based or even school-based physical activity interventions in the family context (12).

Environmental factors influencing PA engagements

Participants' perceptions may provide insights into sustaining PA interventions after the pandemic for researchers and policymakers. Parents identified general barriers, i.e., social and physical environments, to PA engagement, such as exhaustion, lack of time and family support, inclement weather, and the Hong Kong built environment, which are consistent with earlier studies (29–31). Most importantly, in keeping with previous findings (32), the participating parents often lack prior education and training in PL and other aspects of their sports parenting skills. Although they recognize the benefits of PA, they have insufficient basic knowledge and skills to support them in establishing a PA routine. Given that sports parenting is more complicated and influenced by various factors when attempting to encourage parents' participation in PA, it cannot be the case that parents are simply informed what they should or should not do; instead, it is crucial to understand and remove their

obstacles to facilitate a PA-friendly environment. For example, researchers should deliver public lectures on PL to families. Policymakers should improve PA facilities in communities.

Strengths and limitations

To our knowledge, this is the first study to explore the acceptability of a parent-focused PL intervention. In this regard, we sought to determine the program's acceptability in the context of the COVID-19 pandemic and grasp the subsequent influence on parents' and children's lives and draw lessons for the future. Besides, a major strength of the current study is that it helps to address the critical need for more work focused on parents' experiences to inform the implementation of parent education training sessions in diverse settings. Moreover, parent workshops and materials were delivered *via* online mode. This is an exploratory attempt to understand the uniqueness and acceptability of online learning and training in the impact of the current pandemic and future practice. Another strength of the study is its rigorous methodology, including a theoretically-informed interview guide and preliminary codebook, inductive-deductive hybrid thematic analysis, two coders' independent coding, and member checking process. Lastly, family-based interventions showed mixed effects. Some showed small to moderate effects whereas some showed no effects (33, 34). We hope the results of this study could help to understand why some interventions are not successful in the family context. For example, parents might not be aware of the purpose or importance of PA interventions so no parental support may not be provided after the intervention (34).

Some limitations should be considered. One limitation is that almost all participating parents were mothers. Although we invited all the parents who had participated in the parent-led program to attend, we still lacked fathers' participation. Since mothers and fathers may have different experiences and perspectives of the program, future research could explore more about fathers' perceptions. Furthermore, to have a more holistic understanding of the implementation process and the impact on each family, further work is needed to explore the program's sustainability and quantitatively evaluate the behavioral change of participants to inform the expansion of parent-led programs.

Conclusions

This study explored parents' perceptions of a parent-focused PL program during the COVID-19 pandemic. Parents' PL was generally improved from the learning experience and the commitments that came with establishing physically active lifestyles in the family setting. Some of their children's PL was also improved. The parent-focused PL program strongly emphasizes parent role modeling and co-participation in PA, making it the ideal candidate for long-term implementation

via online delivery. The insights gained about the program of acceptability in this specific context, and general environmental factors influencing participants' PA, may be used to inform the design, implementation and sustainability of other parent-focused PL programs.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

AH, QH, CC, and JN conceived of, designed, and supervised the study. TZ and QH conducted the analysis. TZ drafted the manuscript with input from QH, YF, JN, and AH. TZ and JN revised the manuscript. All authors contributed to the interpretation of data, revision of the manuscript for important intellectual content, and have read and approved of the final version of the manuscript.

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Conflict of interest

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

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The Community Health Response Team: a culturally and linguistically tailored community response to COVID-19 addressing barriers to testing and vaccinations for refugee, immigrant and migrant communities in Atlanta, Georgia

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The International Rescue Committee (IRC) in Atlanta and Community Organized Relief Effort (CORE) established a Community Health Response Team in May 2020. The team members represented refugee, immigrant and migrant populations and had expertise in health care and public health. These 18 individuals were recruited from IRC Atlanta's Career Development program, had a variety of backgrounds and spoke 20 languages. They implemented a community-centered COVID-response intervention model of pairing education and outreach efforts with testing and vaccination clinics. Due to their team makeup, the Community Health Response Team conducted tailored outreach and education that was culturally and linguistically congruent with their target communities. They administered over 16,000 COVID-19 tests at mobile community sites within the first 6 months. Once COVID-19 vaccinations were available, the Community Health Response Team coordinated a total of 834 vaccination events in communities with a high number of refugees and in partnership with refugee- and immigrant-trusted community-based organizations, resulting in 31,888 vaccinations. Hiring staff from refugee, immigrant and migrant populations created a sustainable staffing model. Also, embedding culturally specific strategies in their model of pairing education and outreach led to long-term relationships and greater trust with community members. This approach of engaging and empowering community members to create tailored public health responses should serve as guidance for future public health campaigns.

KEYWORDS

refugees, immigrants, migrants, Community Health, vaccines, health promotion, minority health and health disparities

1 Introduction and context

Historically, refugees face poorer health outcomes than host populations (1). When the COVID-19 pandemic began, International Rescue Committee's (IRC) Atlanta office and Community Organized Relief Effort (CORE) initiated a pandemic response effort for the communities they serve. The primary communities that IRC Atlanta and CORE serve are refugee, immigrant and migrant communities (RIM). The pandemic response effort initially focused on Clarkston, often described as "the most diverse square mile in America" (2) where the city has welcomed over 60,000 refugees since 1980 (3). As IRC Atlanta and CORE's partnership was established, the response effort expanded to larger DeKalb County in Atlanta with a focus on areas with more RIM communities. DeKalb County's population of 762,820 in 2022, with foreign born people making up 16.4% of the population (4).

With support and funding from Georgia Department of Public Health and the DeKalb County Board of Health, IRC Atlanta and CORE established a Community Health Response Team. The team was members of refugee, immigrant, and migrant populations with expertise and experience in health care and public health. The National Resource Center for Refugees, Immigrants, and Migrants (NRC-RIM) provided technical assistance to the IRC Atlanta office in carrying out various COVID-19 response work. The approach to building this team, responding to community health needs, and its resulting strength in trust-building with newcomers to the United States is described below as an example for future models for public health programs and responses to public health emergencies.

2 Key programmatic elements

IRC Atlanta implemented a COVID-response model involving a community-centered COVID response team. The intervention model of pairing education and outreach efforts with vaccination clinics effectively increased vaccination rates of the target community, and has potential applications for future public health emergencies.

2.1 Developing a community health response team

In May 2020, IRC Atlanta and CORE initiated a pandemic response for the refugee, immigrant and migrant communities they serve throughout the DeKalb County area. To serve this population, a team was hired to educate the community about COVID-19, disease prevention strategies, how to isolate and quarantine, as well as understanding and accessing COVID-19 testing. This partnership relied on the trust that IRC had already built with refugee communities and the operational resources that CORE had in place for COVID-19 testing.

The response team was strategically hired through IRC Atlanta's Career Development program. Because recruitment efforts targeted those looking for careers in science, technology, engineering, and mathematics (STEM), nearly all members of the Community Health Response Team had degrees or work experience in STEM fields. The hired team consisted of 18 multilingual individuals

that collectively spoke 20 different languages including Arabic, Amharic, Burmese, French, Keren, Lingala, Oromo, Spanish, Swahili (Kiswahili), and Zulu. This method of recruitment ensured that staff not only had linguistic congruence with the communities served, but also similar lived and cultural experiences. Among the 18 staff members were three Youth Ambassadors (Figure 1) that were identified as recent high school graduates pursuing a higher education degree in public health or health care and had a unique role as young people serving as cultural and linguistic liaisons for their communities.

All members of the Community Health Response Team were onboarded and trained as full-time staff, shadowed existing COVID-19 testing and vaccination clinics, additionally trained in the following topics:

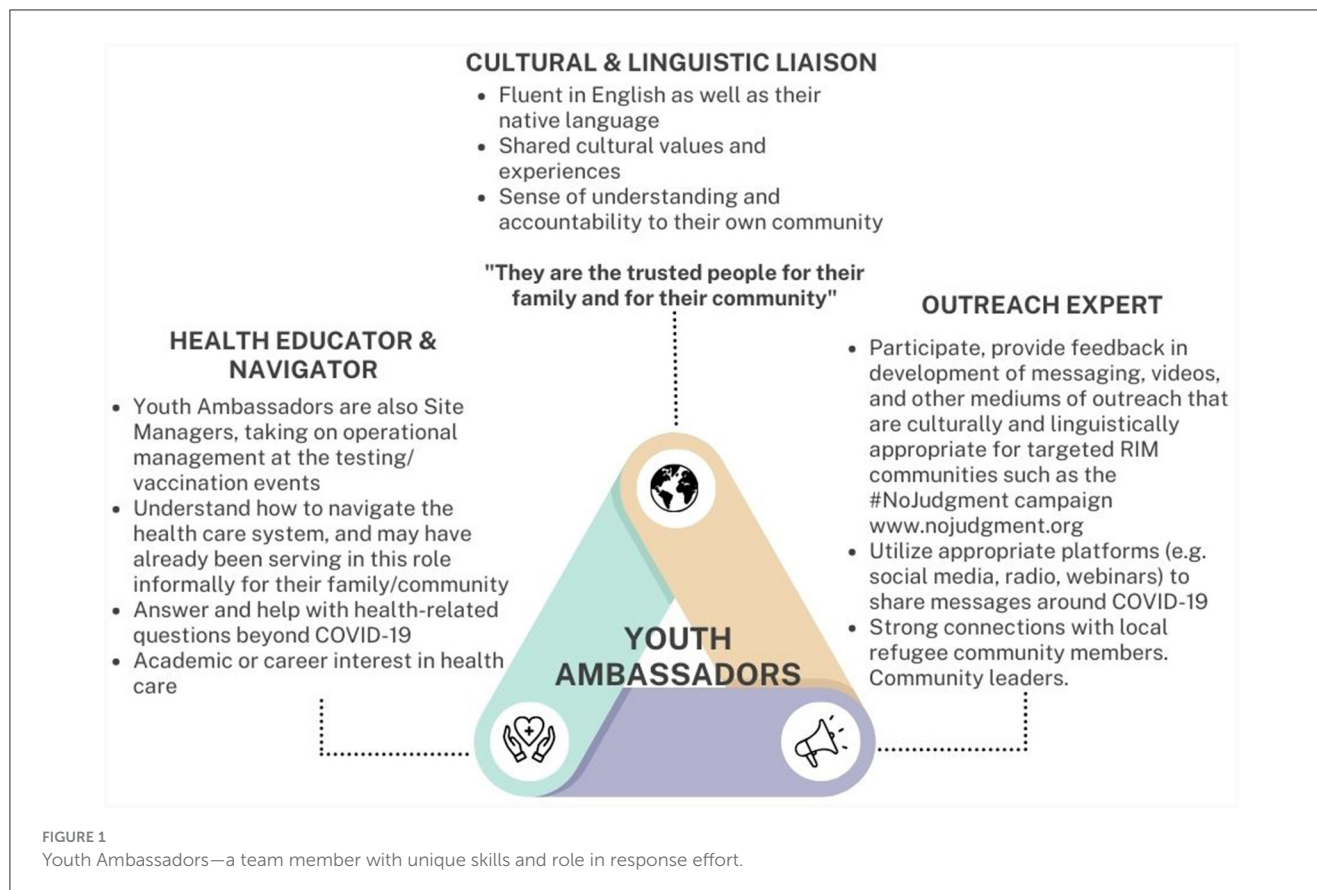
- Protocols on safely collecting and entering personal information from testing and vaccination patients.
- Health Insurance Portability and Accountability Act (HIPAA) compliance training.
- Health education and health promotion trainings on COVID-19, and other relevant health issues with considerations for potential cultural concerns of the RIM community.
- Blood-borne pathogen training.
- Protocol for testing kits including updated trainings when needed.
- Standard operating procedures and clinical requirements for clinic set up at various sites.

This team was developed to be able to respond quickly and effectively to community needs around COVID-19, as well as protocol or policy changes around testing and vaccination through team communication and the ability to communicate with community partners. Recognizing that strategies that serve the majority of the population in the United States would not be effective for the refugee communities, IRC Atlanta developed a team that could effectively conduct outreach, educate and build relationships with RIM communities during a public health emergency.

2.2 Developing a model for testing and vaccination

The Community Health Response Team understood the barriers refugee, immigrant and migrant communities face in trusting new government institutions, navigating a new language and health system, and accessing health care. So, COVID-19 testing services were only offered after education and outreach was conducted as shown in Figure 2. The team knew that, without the education and outreach prior to the clinical services, fewer people would get tested and vaccinated.

Although some outreach was conducted virtually (i.e., text/calls and webinars), the Community Health Response Team also did much of its work in-person to garner trust. When having in-person conversations, the team always worked in groups for personal safety and remained in contact with each other during outreach campaigns. They also followed protocol as determined by



the Centers for Disease Control and Prevention regarding social distancing, sanitizing and personal protective equipment (or PPE).

To ensure that testing and vaccination sites were established in the areas of DeKalb County with the most need, CORE and IRC Atlanta utilized the following criteria:

- Identifying census tracts that had high Social Vulnerability Index (5) values.
- Reviewing data around hospital bed utilization or “hot spots” with high COVID-19 infection rates.
- Reviewing Georgia Department of Public Health data around regions in the state with low vaccine uptake.
- Anecdotal information from partners as shared during community meetings such as the Clarkston Health Equity Coalition.
- Assessing community site readiness to host clinics in terms of capacity of space and clinical operation requirements.

Once COVID-19 vaccines were approved in April 2021, the testing sites were converted to vaccination sites. The IRC Atlanta and CORE staff in DeKalb County shadowed the Fulton County CORE team, which had begun holding mobile vaccination clinics in February 2021. To operationally prepare for vaccinating, they learned how to set up a site, manage clinic flow and what to communicate to patients. The team continued to grow and streamline operations and, in July 2021, it divided into three groups to cover more of DeKalb County.

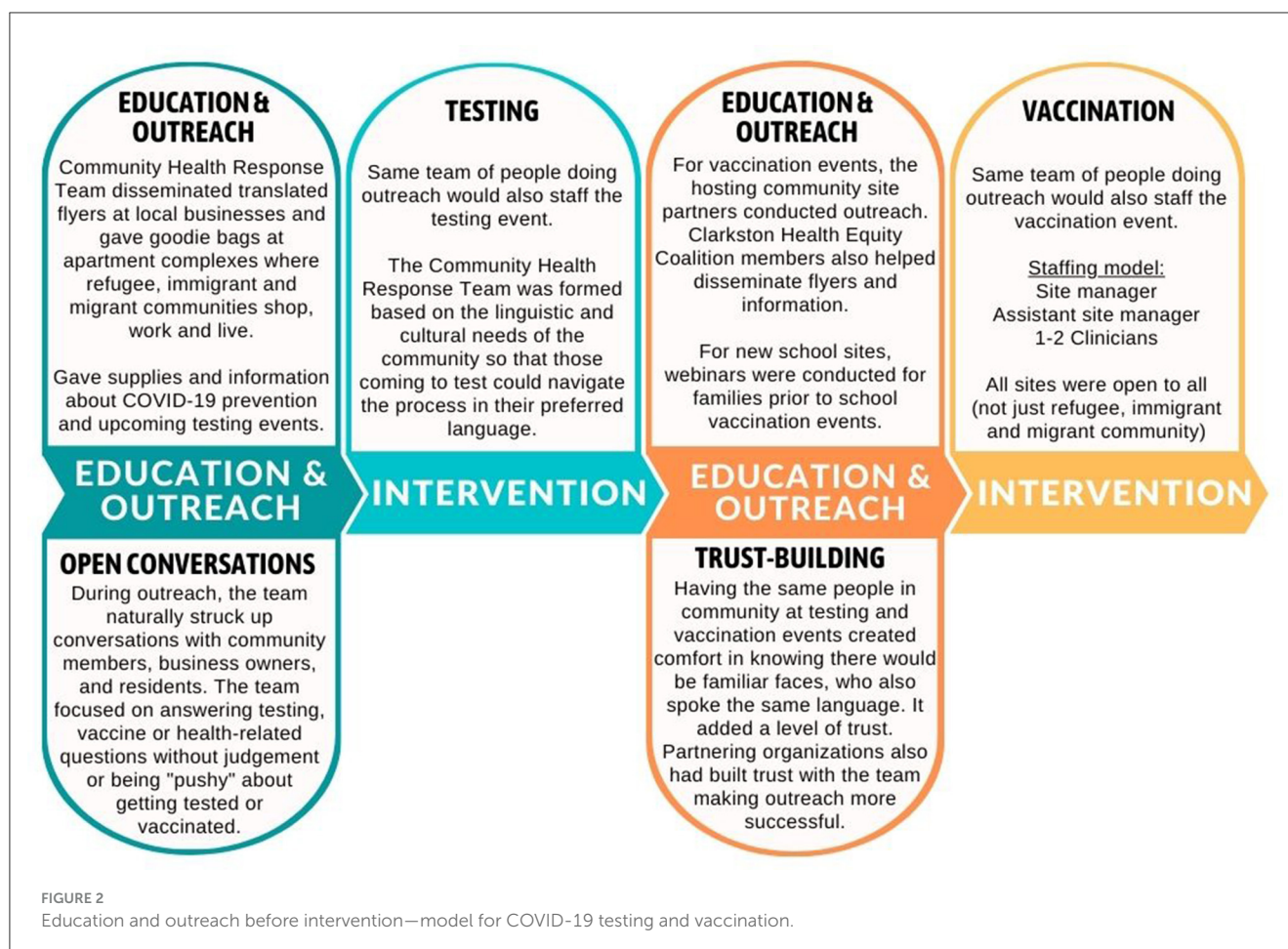
As the reach of the Community Health Response team grew, they continued to be responsive to community needs. This included assessing language needs and cultural concerns prior to testing or vaccination during education and outreach efforts in the community. Over time, the Community Health Response team adjusted clinics based on community needs such as expanding clinic hours outside of standard working hours, and sites with strong community presence hosting repeated and regular clinics.

2.3 Tailoring outreach strategies

The Community Health Response Team tailored its strategies to address each refugee, immigrant, and migrant community’s specific barriers to testing and vaccination.

Some strategies used to provide education and allay concerns of various refugee, immigrant and migrant communities were:

- (1) Calling IRC Atlanta clients to talk one on one about vaccination, help with scheduling, and answering any questions.
- (2) Holding webinars on health topics with community experts and religious leaders (e.g., Imam and pastor) to answer any community questions and concerns in their native



language and deliver information through trusted and respected sources.

- (3) Hosting Facebook Live events with community members to share personal vaccination stories with the larger community and help alleviate anxiety around vaccination.

In addition, partner organizations were able to conduct outreach through the preferred channels of their community members. Some examples include, texting, calling, social media (e.g., Facebook and WhatsApp), and in-person conversations at community events.

Multilingual flyers were widely used to promote vaccination using three distribution methods. First, translated flyers about upcoming vaccination clinics and current eligibility requirements were disseminated through all IRC partners and staff via weekly emails. They included QR codes and URLs for easy access to event information. Especially when eligibility requirements were changing frequently, it was important to provide updated information. Second, flyers were posted at key local businesses with additional copies given to the owners to distribute. Finally, knowing that certain refugee communities live in specific apartment complexes, the response team worked with leasing offices to distribute vaccination information in "goodie bags" for residents. This also created opportunities for in-person conversations and gaining trust with residents.

To address transportation barriers experienced by RIM communities (6), the team contracted with ride-share services to provide transportation to and from vaccination events.

Beyond the operational support of the testing clinics themselves, the Community Health Response Team was available to provide language support for public health contact tracing conducted when people tested positive for COVID-19. This effort of continued communication strengthened RIM community trust with the team, and as a result, they could better address misinformation and any fears that community members had around COVID-19.

All activities conducted by the Community Health Response Team included clearly visible branding with the IRC Atlanta and CORE logos, because of the existing positive reputation that these organizations have in the RIM community. This reputation helped increase the potential for people to trust the information that the team provided to address existing misinformation or fears around COVID-19. For example, IRC Atlanta delivers furniture and other supplies to refugees when they find housing, so community members have an existing positive association with the IRC Atlanta truck and know that the organization provides resources and support. Because of this reputation, this truck with large IRC Atlanta branding was present at every testing and vaccination site. As clinics continued, branding included IRC Atlanta, CORE, and DeKalb Public Health, expanding that network

of trusted organizations through the partnerships that established the Community Health Response Team.

3 Impact metrics

The Community Health Response Team successfully reached many refugees, immigrants, and migrants in DeKalb County through COVID-19 outreach, education, testing, and vaccination.

From April 2021 to August 2022, more than 3,500 calls were made or 250 families were contacted through IRC Atlanta's list of clients from the last 5 years. These calls served to conduct health and wellness checks, share community resources, provide education on COVID-19 prevention, and check in on their vaccination status. With the influx of new arrivals from Afghanistan, many of those reached were newly arrived refugees, and for all contacts, English was not the preferred language.

Although conversations from phone calls and in-person outreach conducted before every testing and vaccination event, the Community Health Response Team also conducted digital outreach in the form of weekly emails with education and translated materials to over 160 partners and entities, as well as holding over 15 Facebook Live and webinar events from 2021 to 2022.

Outreach efforts of the Community Health Response Team were strengthened by the existing community trust in IRC Atlanta as the resettlement agency that had already supported much of the RIM community in the region. Because of the outreach and education conducted, the team performed over 16,000 COVID-19 tests within the first 6 months of testing in mobile sites in the community (May 2020; August–December 2020).

Between April 2021 and November 2022, the Community Health Response Team hosted 834 total vaccination events in partnership with various community organizations and entities. These events included the following types:

- Pop-up clinics (e.g., health fairs).
- Faith-based events (e.g., mosque, temple, or church).
- Community center events (e.g., cultural centers or led by ethnic community-based organizations).
- School-based vaccination events.
- Cultural events (e.g., cultural holiday events or festivals).

The team held vaccination events in locations (Figure 3) that would best serve those in need of the tailored response provided. As shown in Figure 3, most of the vaccination events were held in census tracts with high Social Vulnerability Index (5) scores. The index measures 16 factors, including poverty, lack of vehicle access, and crowded housing, that indicate “social vulnerability.”

These events were the outcome of partnerships that were developed through the Clarkston Health Equity Coalition. This coalition was a result of the efforts of IRC Atlanta and CORE bringing together a task force to respond to the rapidly evolving COVID-19 information and public health recommendations in the early phases of the pandemic. These partnerships range from schools and religious centers to local businesses and community organizations. Through this coalition and other community relationships, there were 165 community partners that held testing and vaccination events since May 2020. In addition, about 45

community partners supported these efforts through outreach through various methods such as dissemination of flyers, social media, and word of mouth.

As a result of the 834 events held from April 2021 to November 2022, they were able to administer 31,888 vaccinations. The strategies and approaches of the Community Health Response Team contributed to the vaccination rate in the DeKalb area being 20% higher than comparable areas in Georgia (7). The impact of these targeted campaigns to test and vaccinate RIM communities is especially significant given the findings of Georgia State University's Prevention Research Center seeing poorer outcomes in every measure of health and welfare for refugees vs. non-refugees through a community needs assessment conducted in Clarkston, Georgia (8), thus indicating a greater need for these services.

4 Discussion

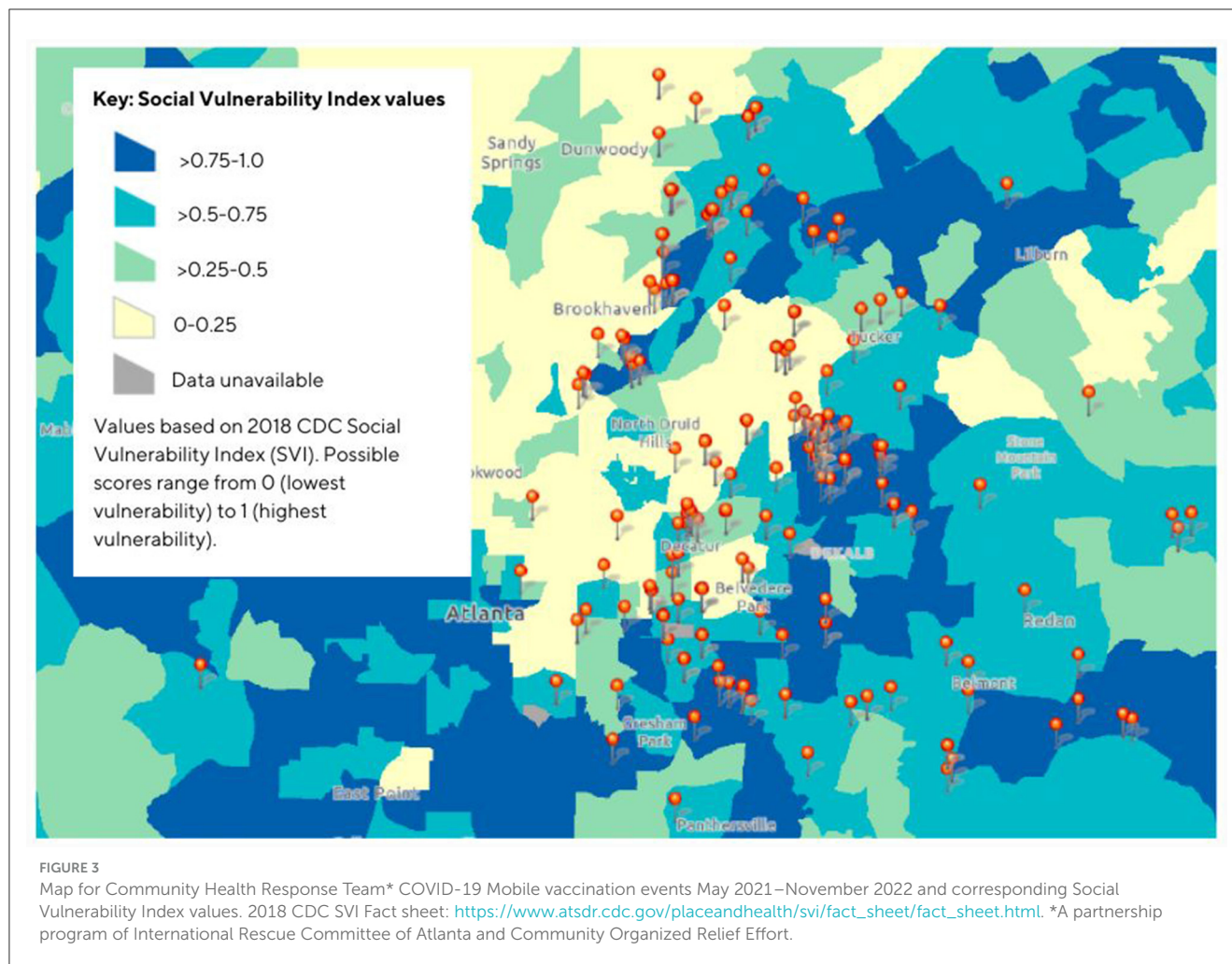
4.1 Keys to success

Hiring staff from the refugee, immigrant and migrant community set the foundation for a strong team with the skillset to appropriately respond to community needs. In a time where there were so many unknowns around COVID-19 and the nature of the disease, having trusted people to turn to when there were questions helped the community stay healthier and close gaps in health outcomes. Having shared lived experiences with the communities served gave the team insight into how to effectively build trusting relationships with people. This trust helped combat misinformation, fears, and stigma around COVID-19. Not only did hiring from the refugee, immigrant and migrant community strengthen the public health campaign to educate, test and vaccinate this community, but it also helped *build community capacity* to respond appropriately to meet their own needs during a public health emergency.

Among the team members, one unique type of staff role to highlight were the Youth Ambassadors, who were able to serve as a bridge between their home culture and the culture and systems of the United States (Figure 1). To hire these members, IRC Atlanta identified and recruited young community leaders who may have already been serving this role informally within their communities, had the linguistic and cultural knowledge, and also had interest in health care (Figure 1).

The Community Health Response Team maintained the same core staffing throughout the COVID-19 pandemic, even when future funding was uncertain. Team members already had connections to their communities and interest in public health; they were not only looking for experience in the field but also felt accountable to the communities they were serving. With this *sustainable staffing model*, the same individuals navigated throughout all phases of the COVID-19 pandemic, internal communication was clear, and changes could be made quickly. For example, when the bivalent booster replaced the monovalent booster in one day, the team quickly addressed fears that the original booster had been discontinued because it was dangerous or had expired.

In developing these approaches, the Community Health Response Team recognized that inequities in COVID-19



vaccination rates resulted from many factors, including lack of knowledge around the vaccines and how to access them. To address this, they *paired educational outreach with every testing or vaccination event*. This allowed for community members to voice their concerns openly to people who spoke their language and had shared cultural knowledge.

Recognizing the diversity within the refugee, immigrant and migrant community, the Community Health Response Team made efforts to implement *culturally and community specific strategies*. These included: partnering with trusted community organizations and cultural and religious leaders, using communication methods preferred by each community (e.g., WhatsApp or Facebook), attending cultural events or holidays, and ensuring materials are linguistically and culturally appropriate for the community. For example, partnering with Imams in working with the Muslim community to address questions around the Halal status of COVID-19 vaccines. From this partnership, the team created videos in seven languages to address this concern.

The team valued *building long-term relationships* with the community. By having familiar faces at most events, they built trust as people saw the same team members conducting education, testing, vaccinations and contact tracing interpretation. Responding to community feedback obtained through the

relationships built by the Community Health Response Team, CORE funded additional staff to support needs beyond COVID-19 testing and vaccination (e.g., providing food for those in quarantine). Also, IRC Atlanta and CORE were able to work as parts of a concerted effort by fostering partnerships with the more than 30 member organizations of the Clarkston Health Equity Coalition as well as other organizations. Having a continued presence and growing these working partnerships with other organizations, IRC and CORE have been able to more effectively work in a concerted effort to address refugee, immigrant and migrant community needs around COVID-19 and beyond.

Cutting across these keys to success is *building trust* with community members. Recognizing that asking community members to trust the team with supporting an aspect of their health, the Community Health Response Team's strategies and approaches were always rooted in listening to community voices and valuing their trust.

4.2 Challenges addressed

The main barriers to vaccination that the refugee, immigrant and migrant community faces are around language, culture, and

transportation. With staff and resources to translate materials, ensure their cultural relevance, and speak with community members in their preferred language, the Community Health Response Team effectively addressed language and cultural barriers to vaccination. The program also held clinics in locations frequented by RIM community and contracted with ride-share services to provide transportation to and from vaccination events for those that could not easily find transportation for themselves.

With public health campaigns and this type of community outreach being new to many refugee, immigrant and migrant community members, Community Health Response Team efforts to do outreach in the community often led to many people questioning why they were there, who was behind their efforts, and questions around vaccines. Being able to speak the same language as those community members and being understanding of their concerns without judgment, opened up a lot of conversations that helped address many community concerns and fears during an ever-changing public health emergency. The team was also able to rely on the positive reputation of IRC Atlanta and CORE while serving as educated experts taking the time to address questions, talking about trusted community leaders' (e.g., religious leaders) stances on vaccination, and sharing personal testimonials. Through these conversations the team was able to successfully recruit participants that would otherwise struggle to navigate mainstream or mass vaccination/testing sites.

4.3 Addressing future public health emergencies

The COVID-19 pandemic highlighted many inequities that DeKalb County's refugee, immigrant and migrant communities had already been experiencing. The creation of the Community Health Response Team and their approach to public health interventions demonstrated how public health responses can be tailored to meet the needs of these and other underserved groups. The process of developing a Community Health Response Team, establishing the Clarkston Health Equity Coalition, and slowly building community trust in public health and health systems, increased community capacity to respond to public health crises.

Since May 2020, when IRC Atlanta and CORE first established the Community Health Response Team, there has been a demonstrated need by community for increased public health presence and services. By 2021, Georgia Department of Public Health and the DeKalb County Board of Health funded and supported the expansion of the team's activities. Now many of CORE's efforts are focused not only on maintaining the network of partners developed during the height of COVID-19, but also on strengthening public health infrastructure beyond emergency funding. Partners in the Clarkston Health Equity Coalition include social services (e.g., Supplemental Nutrition Assistance Program or SNAP), community based organizations, health care services and more. In 2023, the efforts of the Community Health Response Team continue to support these efforts to provide and connect the RIM community to comprehensive health care and social services, in addition to annual vaccinations for COVID-19 and influenza.

Although the focus of the Community Health Response Team was around COVID-19 testing and vaccination, through conversations and relationships built with community members, the team helped patients navigate other health concerns and questions. There is potential in these existing relationships to quickly and effectively address a myriad of current and future public health issues beyond COVID-19. The model of creating tailored intervention strategies through engaging and empowering community members in the response effort should serve as guidance for future public health campaigns and programs.

5 Limitations

The authors acknowledge that content for this case study was primarily based on conversations and listening sessions with key leaders of the Community Health Response Team. Community partners and their perspectives were not included due to limited resources and capacity of the research team. Instead, the authors chose to reflect the nature of the community partnerships through growth of such partnerships and continued collaboration with the Community Health Response Team.

Data availability statement

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

Author contributions

FB: Writing – original draft, Writing – review & editing, Conceptualization, Project administration, Supervision. KY: Writing – original draft, Writing – review & editing, Project administration, Visualization. SA: Data curation, Writing – review & editing. EM: Conceptualization, Supervision, Writing – review & editing. ED-H: Conceptualization, Supervision, Writing – review & editing, Funding acquisition. OA: Supervision, Writing – review & editing.

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Conflict of interest

FB and OA were employed by International Rescue Committee. SA was employed by Community Organized Relief Effort.

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

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Through the eyes of community health workers: what was needed to increase COVID-19 vaccine uptake in the Missouri Southeast region

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Public health emergencies, such as the COVID-19 pandemic, elucidate the strengths, weaknesses, and significant gaps in infrastructure, compatibility and consistency in communication systems, as well as the quality of collaborative relationships, and provider and workforce capacity. They also expose longstanding patterns of mistrust in the government and healthcare systems, and inadequacy in socio-economic infrastructures. These issues resulted in higher COVID-19 infection and mortality rates, and lower vaccination rates in many rural counties across the nation, including Missouri. In response to these challenges, the COVID-19 Response Network was formed in the Southeast corner of the state. The Network was a community-academic partnership that brought together community and faith-based leaders, academicians, healthcare providers and administrators, public health practitioners, and pharmacists to facilitate collaboration on education and outreach efforts aimed at reducing vaccine inequity in the 16-county project area. Importantly, the Network also included Community Health Workers (CHWs) who worked with these different agencies and organizations and were at the heart of implementing Network activities. The intent of this study was to assess their perspectives on the factors that influenced community engagement and communication strategies, and increased vaccine uptake in rural Missouri. Qualitative methods, including in-depth interviews, were used to explore the professional and personal experiences of CHWs working at the grassroots level during an ongoing pandemic. Narrative analysis revealed effective communication and engagement strategies for increasing vaccine uptake in rural communities. For instance, fear-based messaging was perceived as coercive and met with resistance. In contrast, messages that shared personal experiences and catered to the human need to protect their loved ones were more effective. Trust in the source of information was critical. This study highlights the significance of exploring and leveraging the capacities of trusted community members like CHWs to increase the effectiveness of public health interventions in rural communities.

KEYWORDS

community health workers, rural health, COVID-19, vaccine equity, community engagement

Introduction

The Coronavirus Disease 2019 (COVID-19) presented unprecedented challenges to the State of Missouri, the US, and the entire world. Within rural counties of Missouri, including the study site, COVID-19 highlighted what we already knew about deficiencies in clinical, public health, and economic infrastructures, and magnified existing racial and economic inequities and distrust in the government and the healthcare system. COVID-19 safety measures such as wearing masks, testing, social distancing, and vaccination were controversial and politicized across these rural counties (1). Given these circumstances, rural Missouri experienced a higher COVID-19 mortality rate per 100,000 population (94.2) compared to both statewide (87.3) and urban rates (83.2) (2).

It is within the above context that the COVID-19 Response Network was formed to serve a 16-county rural area in the Southeast region of Missouri including Butler, Cape Girardeau, Carter, Dunklin, Howell, Iron, Madison, Mississippi, New Madrid, Oregon, Pemiscot, Ripley, Scott, Shannon, Stoddard, and Wayne counties. These counties have relatively low levels of racial and ethnic diversity. For example, while around 27.5% of Pemiscot County is comprised of African American persons other counties such as Carter, Ripley, Oregon have less than 0.5% of their population self-identifying as African American (3). Similarly, there are few individuals who self-identify as Hispanic/Latinx communities living in this 16-county area (Dunklin County being the highest at 7.2%) (3). Despite this, Black/African American persons living in rural areas were 80% more likely to die from COVID-19 than White persons living in rural areas (1).

With higher rates of poverty (15.9%) compared to the urban areas of the state (10.9%) (4) these rural counties rank very high or high on the Centers for Disease Control and Prevention (CDC)'s Social Vulnerability Index (SVI) (Mean SVI = 0.69 ± 0.26) as well. This measure includes socioeconomic, population, and housing/transportation vulnerability measures with scores ranging from 0 representing lowest vulnerability to 1 representing highest vulnerability (5). These counties have also been designated as health professional shortage areas. For example, the range of primary care providers per 100,000 population in these southeast counties of the state range from 0 providers per 100,000 population in counties like Shannon and Oregon to 90–100 providers per 100,000 population in counties like Cape Girardeau and Butler (6). Having fewer primary care providers *per capita* has been linked to lower life expectancies (7). Furthermore, the county rankings and roadmaps indicate that these rural counties also experience some of the worst health outcomes and behaviors in the state (8).

During the pandemic additional measures of vulnerability were also utilized, for example the COVID-19 Vaccine Coverage Index (CVAC) measured how well a community could handle the repercussions of a COVID-19 outbreak and was based on a community's access to health care, affordable housing, transportation, childcare, and safe and secure employment (9). The CVAC Index values range from 0 (least vulnerable) to 1 (most vulnerable) and it is categorized as follows: Very Low (0.0–0.19), Low (0.20–0.39); Moderate (0.40–0.59); High (0.60–0.79); and Very High (0.80–1.0). Most counties in these rural counties of Missouri were found to have high or very high vulnerability to handle a COVID-19 outbreak (Minimum: Maximum: Mean CVAC = 0.64 ± 0.06) (9).

Establishing a community-academic network

It is within this context that the COVID-19 Response Network was developed. It brought together community and faith-based leaders, primary and mental healthcare providers, pharmacists, academic institutions, and CHWs affiliated with different community-based agencies. The Network met virtually (via Zoom) weekly prior to and throughout the project period (March 2020 through August 2022). During these meetings, community, and academic facilitators shared data on COVID-19 for the region, the state of Missouri, and the US, as well as resources available (financial, material and informational) in and beyond the state to mitigate the challenges raised by the pandemic. The meeting participants contributed by sharing resources available through their organizations and in the community with other participants along with information about COVID-19 related events and locations where education, awareness, and vaccination activities would be performed. These joint efforts also led to a number of diverse COVID-19 Response Network actions including mobile food banks; the creation and distribution of health infographics tailored specifically for the community; and the organization of vaccination events in collaboration with local community pharmacies (8).

Purpose of the study

The intent of this study was to assess community health worker perspectives on the factors that influenced community engagement and communication strategies, and increased vaccine uptake in rural MO. This paper focuses on the experiences and perspectives of CHWs regarding community engagement during the COVID-19 pandemic, specifically documenting the communication strategies that enabled them to be successful at providing education regarding COVID-19 and encouraging vaccine uptake in the rural counties of Missouri. The study aims to further provide insights into the potential of CHWs to contribute to the health-seeking behaviors of individuals living in rural areas of the US.

Methods

Study population

A total of 65 CHWs from three different partner organizations were mobilized to conduct community outreach events in multiple counties within the Southeast region of Missouri. A little over half of the CHWs (55%) were employed by the partnering pharmacies, and the other half were employed by community-based organizations. Most of these CHWs (89.2%) were females and 20% were between the ages of 18–25, while around 77% were over the age of 25. Efforts were made to hire CHWs that represented the most vulnerable populations in our 16-county area. Sixty-nine percent of our CHWs lived in the same community or in one of the communities where they worked. Majority of the CHWs identified themselves as White (77%), while 17% of them identified themselves as Black or African American. This racial breakdown suggests an overrepresentation of African American given the demographic background of our study area. Almost all

(95%) CHWs involved had completed a GED or a high school diploma. Additionally, 43 % of the CHWs reported having worked prior to the pandemic as CHWs in various capacities such as outreach coordinator, community liaison, healthcare and social services navigator, health educator, as well as community health worker.

Of the total sample of 65 CHWs, a sub sample of 11 were recruited through stratified (by organization that employed them) convenience sampling to participate in a semi-structured qualitative interview. Their demographic characteristics mirrored that of the 65 CHWs in general (e.g., 77% white, 90% female). Similarly, among the eleven study participants, eight of them self-identified as white and the remaining as African American.

Study design

This observational study used designed to capture the unique reflections of CHWs while conducting community-based educational outreach events to improve the uptake of COVID-19 vaccines within the 16-county area of Missouri. Hence, it employed a narrative qualitative approach to understand both the personal and professional insights gained through the efforts made to promote vaccination uptake. Quantitative data were used to capture CHW demographics, the number of educational events, and vaccines delivered.

Data collection and analysis

Members of the community and academic members of the research team reached out to CHWs via email, and provided an information statement about the study, requesting their participation. The interview protocol focused on the context within which CHWs conducted their work, community perceptions about COVID-19 and the vaccine, strategies and messages used for educational outreach, and CHW impact on a community as well as systemic level. Interviews were conducted and recorded via zoom after receiving the verbal consent of the participant. Transcription was completed using Zoom application's written transcription option, and these written transcripts were compared to audio recordings by the team's research assistants to ensure accuracy. All 11 transcripts were then analyzed using an inductive approach, beginning with open coding followed by a focused coding technique in which multiple members of the research team independently assigned codes to transcripts based on the interview topics, discussed disagreements, and came to a consensus on the best way to address discrepancies to ensuring intercoder reliability. After initial coding, codes were then arranged into thematic clusters with summary paragraphs synthesizing key elements from each thematic cluster, along with supporting quotations from the interviews.

Through shared online forms (Qualtrics), partner organizations collected quantitative data to identify CHW demographics, the number of educational events, and vaccines delivered.

Results

Through the interviews, CHWs provided an insight into the context within which they worked. They shared experiences related to

the different strategies employed to navigate through that context and reach community people where they are. These experiences and insights have been documented in the CHW's original words and have been presented below in four major thematic clusters: context, content, strategies, and trust. Context within which the CHWs conducted their work

CHWs stated that most of the community members were not initially concerned about the pandemic as they had 'bigger issues' they needed to focus on, and many individuals in the community did not believe that COVID-19 was "real" (1a, 1b). CHWs also noted that initially when the vaccine came out, many people were 'anxious and scared' about getting the vaccine, and some families and community members had their 'mind set against' it (1c, 1d).

According to the CHWs, they experienced some pushback from the community members during community events, which they believed might have been due to misinformation about COVID-19 and the vaccine (1e). Furthermore, they noted that differences in political ideologies influenced community perspectives about the pandemic and the vaccines (1f). They indicated that social media platforms (including Facebook, Instagram, and TikTok) was their 'worst enemy' and the 'biggest backset' exacerbating much of the misinformation and polarization (1g).

CHWs also noted that lack of social support for getting vaccinated, or social norms against vaccination, made it difficult for some community members to get vaccinated (1h, 1i). Moreover, CHWs stated that families often created what could be called a "cultural block" within the communities which made it difficult for families to receive and accept information (1j). Some CHWs also raised similar concerns about the impact of the medical and social service organizations on community members' decisions to get the COVID-19 vaccines. They noted that some medical professionals in these rural communities told their patients that they were against vaccinations (1k).

Content: messaging for rural communities

Given this context, CHWs noted that certain messages were particularly effective in increasing vaccine uptake among community members. For example, CHWs spoke about how sharing their own personal values and experiences with COVID-19 and the vaccines helped to shift community members' mindsets, encouraging them to receive vaccines against COVID-19 (2a, 2b).

CHWs also indicated that family members, peers and people in their lives played a critical role in motivating their decision to vaccinate themselves (2c); the key driver being the desire to protect vulnerable family members. CHWs stated that recounting these personal stories about the process of accepting the vaccines at outreach events as a messaging strategy resonated with community members and helped them to understand the importance of the vaccine and even change their perspectives towards vaccines (2d, 2e). Sharing clear and easy to understand statistics about hospitalization and loss of life due to COVID-19 also played a critical role in motivating community members to obtain vaccines (2f, 2g).

In addition, working in a diverse community setting with differing levels of understanding required CHWs to tailor the information provided in deference to the individuals or groups they interacted

with (2h). For instance, catering to people's beliefs or faith, was helpful in getting through to some groups (2i).

Strategies for engaging rural communities

Using neutral, non-coercive strategies and handing over the power to decide

CHWs indicated that their success was not just due to what they said to community members, but how they said it. They recognized the importance of being mindful of how the information is provided, starting from the moment they approached an individual (3.1a). They emphasized the importance of framing messages in ways that were appropriate for their communities. CHWs also noted that the level of credibility of the individual delivering the information was seen as equally important (3.1b). Apart from credibility, CHWs emphasized that treating people with respect, being polite, and greeting them with a welcoming attitude made community individuals receptive to the information provided (3.1c). Using appropriate, non-coercive words (3.1d, 3.1e) to offer information on COVID-19 and the vaccine against it was effective in creating an open dialog that people could return to. CHWs who sought to provide community members with options and a sense of control over their own decisions (3.1f, 3.1g) were met with less resistance (3.1h). Furthermore, taking a “neutral standpoint” (3.1i) when providing necessary educational information on COVID-19 and vaccines helped CHWs address misinformation (3.1j) and enabled community members to make informed choices.

“Meeting people where they are” (literally and figuratively) and being polite often helped CHWs to develop trust and rapport with community members (3.1k). In their experience, it was equally important to use easy to understand plain language (3.1l) and visually appealing educational aids such as flyers and audiovisual aids (3.1m, 3.1n). Whatever the mix of strategies for engagement, they also highlighted that to be effective they needed to interact with people in ways that left the door open, allowing for follow up conversations (3.1o, 3.1p). Using educational materials to facilitate a two-way conversation as opposed to a one-way narration of information was met with more ‘acceptance’ by the community members (3.1q).

Using insistent, forceful language, fear-based messaging was ineffective

Trying to force families to get vaccinated was seen as ineffective and in certain cases worsened existing doubts and fears people had about vaccinations. One example where insistent language was used, the individual decided not to get vaccinated, and this also had a detrimental ‘domino effect’ resulting in them discouraging vaccinations for their children as well (3.2a).

Instances where fear-based messaging was used or when the CHWs just told people to get vaccinated without providing educational information reportedly created increased resistance (3.2b). While most CHWs found using different forms of Supplementary educational materials helpful (3.2c), some noted that many community members also preferred to engage in conversations rather than reading information from a piece of paper or having someone read information to them but was important to have it available (3.2d).

Strength in partnership

CHWs shared the positive changes brought about through the outreach efforts conducted in collaboration with community pharmacists and other community-based organizations. They noted that along with the efforts to promote preventive strategies against COVID-19 CHWs also responded to any needs or challenges presented during the pandemic as a ‘united front’ (3.3c). Particularly the collaborative relationship established with pharmacists was quoted to be a ‘big change’ which did not exist prior to the formation of the Network (3.3b) and continued to last beyond the completion of the project (3.3a). Apart from this, partnership with other organizations led to increased accessibility to more resources and provided CHWs with the ability to refer community members to relevant resources and services when necessary (3.3d).

Meeting community members where they are

CHWs relied heavily on partnerships with community organizations to increase their capacity to intervene in person. One of the most used approaches was to be a part of existing community events. Conducting outreach events at locations frequented by community members enabled CHWs to reach people “where they are.” CHWs also organized their own social events such as ‘luncheons,’ ‘pageants’ etc. that offered a combination of entertainment, information, and service (opportunity to vaccinate) that not only ‘attracted’ people but was also a successful engagement strategy for encouraging vaccine uptake (3.4a, 3.4b). CHWs also noted that apart from the content and its delivery, it was necessary to be mindful of ‘who’ was present at the event, and who was providing the information at the event. Having pharmacists provide technical information within the context of such events further increased the positive impact of the information provided (3.4c). This was even more profound when CHWs went into communities they were not familiar with, and the trust factor had not yet been established (3.4d). A big part of meeting community members where they are, and the community outreach efforts conducted by the CHWs was the ability to have ‘face-to-face’ conversations which were noted to be a more effective medium of communication compared to phone calls (3.4d, 3.4e).

Trust was the key factor

In addition to having the right message and medium, when asked about how the community received them, CHWs felt that a key to their success was that the community trusted them regarding the information they provided on COVID-19 and the vaccines, which helped community members make their own decision. A major factor contributing to the community's trust in the CHWs was related to them already being known and ‘embedded’ within the community (4c). As a result, community members felt ‘comfortable’ expressing their views to these CHWs (4a, 4b, 4d). Importantly, as noted earlier, the majority (69%) of the CHWs lived in the same community where they were working as a CHW for this project. The trust factor extended beyond CHWs to the broader community, as observing fellow community members getting vaccinated or learning about their vaccination decisions through social media played a significant role in influencing individuals' own decisions regarding vaccination (4e, 4f) (Tables 1–4).

TABLE 1 Community context.

a. “They (community people) were not negative towards me (CHW) or the information, but like they have bigger issues and things that they needed to focus on, so, and they already had their minds made up that they were not going, they were not worried about it (the pandemic) or that they did not need any information”
b. “There were people that did not even believe that COVID was real whenever I (CHW) was first going into their home”
c. “They (community people) were scared at first...”
d. “I’ll (CHW) just think there were people in the community that had their mind set, and no matter how much telling you did to them, they were not going to listen (to get vaccines)”
e. “I’m (community individual) not ‘gonna do it (get the vaccine) because a magnet would stick to my head, we (CHW) heard that stuff like that a lot. And that the government was putting poison in them (vaccines)”
f. “It’s (vaccination) the government’s way of controlling you, and nobody’s gonna make me (community people) get this”
g. “I would say the media was like our worst enemy because everyone goes on Facebook, social media and all of that stuff for their information. And, as you know, not all of that’s 100% factual... And so that was honestly, the biggest backset was social media, and what others were saying about it (vaccines)”
h. “it’s really hard to get them (community people) to open up, because in order for them to open up, they have to also kind of face their family, or their loved ones, that have different opinions. And being so secluded here, whenever you are, you know when you have such a differing opinion with the 5 people that you are close with, that feels really isolating more than they already are. So, it is kind of hard to get them to accept new information”
i. “I (CHW) think that a lot of it (vaccination) was that you know these, the people in the community, even if they are interested in getting vaccinated, or they do want more information, they are hearing so much negative feedback from their family members at home that they might be afraid to reach out and do what they feel is right because of the judgment they would receive from the people that are close to them”
j. “There’s just a little bit of a culture block here (in the community). It was just really hard for the families in this area to receive this information and be very accepting of it”
k. “The craziest thing is the worst people with this (perspective of medical community towards vaccine) is the people that’s in the nursing school. The nursing classes. The nursing class was the worst class of students that was against the vaccination”

TABLE 2 Messaging for rural communities.

a. “Basically, I (CHW) will let them (community people) know that I personally took the vaccination, and I did not have any complications or anything. So really just letting them know what they want to know “how I’m gonna feel afterwards, like we have a sore arm....,” you know what you are gonna be fine.”
b. “A lot of Community, they (community people) already knew me and a lot of people already knew my stance on the vaccine, they know that I wasn’t kind of pro vaccine and then, when I was going back and telling them that I ended up taking the vaccine, they asked me what changed, what made you do that, and that’s when I was able to really inform them or give them more information and give them reasons why I made the change”
c. “My (CHW) God daughter... She’s a travel nurse and she was working in the COVID Ward, and she saw so many deaths out there so many people died... she was adamant that I get vaccinated because of what she saw. The experiences she had, and so that’s what made me have a transitional thought pattern in my mind and then I decided to go and get vaccinated.”
d. “I (CHW) said, ‘well in all honesty, I would do it (take the vaccine), especially if you have grandparents or parents, (older adult) people’. If they have any kind of chronic disease, it’s really worth taking the vaccination... you have diabetes or you have a grandma, grandpa or older (relative)... your mom or dad. You do not want to catch it, and then they have these chronic diseases, and that could coincide with that health issue, it can lead to death”
e. “My (CHW) main reason for getting this shot... it’s not so much about me, even though it scares me to think I could be laying there on a ventilator... it’s for my family, it’s for my grandchildren... I said that I need to protect her, and I need to protect your children, and that’s how I viewed it. It wasn’t about me and who was forcing something on me. It was me helping protect the people I loved. I turned it around (the messaging), and sometimes they are (community individuals) like, oh, okay! they could kind of see it a little differently.”
f. “... and then 1 week three city leaders, 50 years of age and younger died. We had three people die in 1 week, and they were prominent citizens. One was our prosecutor. Another was a highway patrolman and the other worked for the city as a dispatcher. That was really sobering. So, after those unfortunate tragedies we had more of an outpouring of people thinking ‘I think I’ll go ahead and get the vaccination anyway”
g. “We did have some people that would change their mind and come in, say, for example, a couple of people I called, they said, well, I was not going to do it (get vaccinated), but my husband died...”
h. “Everybody is someone different, and so you (CHW) have to change who you are, what you say and how you say it, depending on who they (community people) are”
i. “I (CHW) want them (community people) to feel comfortable when they can talk to me about anything, and like I say, I’m just a Faith believer and that’s strong right there because some people - I’ve had people come up to me, and, say, ‘wow something about you, I do not know what it is. I would say it is only God, I give God all the credit. And he (God) just felt like I will be really good... helping the people and, so far, I mean it (using faith-based strategy) has worked”

TABLE 3 Strategies.

3.1 Outreach strategies for engaging rural communities (Neutral, non-coercive, power to decide)	
a.	"I (CHW) would open it (community events) up and tell them, like you know, 'the extended family is welcome to come too. I'm going to be there tomorrow, I thought maybe we could talk about COVID and the vaccinations. All opinions are welcome, I'm here to answer any questions that you have. So, if your dad or your grandparents, or your brother would like to be there too, if they have questions, I can answer for them too...'"
b.	"Whenever I'm (CHW) giving them (community individual) the information verbally, like we are having a conversation, and I'm starting to say like statistics, you know, even if they receive it all well, I always leave the paper copy with them so that they can trace back trace back the information and say oh, this was actually legitimate, she wasn't just making numbers up"
c.	"Because I (CHW) always walk up to people with a smile and always you know to greet them with a smile, and I tried to do that and not try to push this on them"
d.	"What we (CHW) did not do, we did not get out in the field to try to persuade people, we did not get out to try to force it (vaccine) on them. The only thing that we were doing was getting out, trying to give them the right information, and at the end of the day, it's up to you. What you want to do is kind of like your own decision. You want to go to heaven or hell? (Metaphor representing decision to vaccinate) Everybody has a choice on what they want"
e.	"...the more you (CHW) say it (talk about vaccine), the more you do not want to feel like you (CHW) are just trying to push something down somebody's throat, to make somebody feel guilty for not taking it or trying to force someone to get the vaccination"
f.	"And so, without really, coming on too strong (during community outreach) without really pushing it (vaccine) on, then bring a little education here and there, and just kind of let them know that I (CHW) could answer any questions if they had. They did ask some, and I felt like they did accept the information that I was giving them"
g.	"For people to be able to voice their thoughts, their concerns, their opinions, and to be able to have that freedom. to be able to engage, but you know, give them food for thought, but at the same time, let it be their decision to embrace what's right for them and their family"
h.	"...And so that was my approach with people. I did not really go to them and try to say you need to get your shot; you need to do this. No, I never did that, because I would not want anybody to do it to me, and so I just treated people the way I wanted to be treated and approached them in the same way I will want to be approached, and so I did not really have a lot of kickback..."
i.	"We (CHWs) kind of just tried to take a neutral enough standpoint on it (vaccines) to just let them come to us for information, education, and feel comfortable. We had also offered confidentiality"
j.	"I (CHW) had to help inform them that the vaccination itself - it will not stop me from getting COVID, it'll help save your life...Some will say, 'Well, I know this person got the shot and he still got COVID,' I say 'Well it's not preventing you from getting COVID, it's trying to prevent you (from developing severe disease) if you got COVID it will not be as bad (severe) on you'"
k.	"You (as a CHW) have to remember, you have to meet people where they are. And you have to remember who you are, and not to say anything that's going to be offensive, you know even, no matter how offensive, a person could be coming to you, you have to remember just who you are"
l.	"She (CHW) uses these big words that nobody knows what she is talking about. She stood there for 15 min. And then I'm standing right beside her, basically breaking down everything she just said"
m.	"We had made up flyers and pamphlets, so that way we could say we have done our research. This is what we found, and we want you to look it over at your own time, your own convenience, and I think that worked better because it was giving them the option to look at it or to not look at it"
n.	"We (CHWs) also have videos that we could show them (community members), we have got laptops and tablets, that worked on a couple, they were pretty receptive to that"
o.	"Make a follow up call about a month later, and just say, 'hey, just wanted to check on you to see if you have any more questions about that kind of thing,' and we did have some people that would change their mind"
p.	"Tried to provide follow up and chances to ask or answer more questions"
q.	"I've (CHW) noticed a trend with this area... a lot of these people do not like to feel like they are being taught. They do not mind sitting down and just have a conversation with you, but whenever you bring out papers and you are like giving it to them, or you are reading things off to them, or you are showing them an informational video more often than not... they just seem standoffish, like they are just really not accepting of the information"
3.2 Outreach strategies for engaging rural communities (insistent, forceful language, fear-based messaging)	
a.	"I'm (CHW) trying to work with moms in families for child checkups and regular immunizations, and that (when forcing them to get vaccines) had a domino effect. They went from, 'you are not telling me to get the COVID shot', to suddenly, 'I'm not getting any of my kid's shots.' I was like, you have gotta be kidding me. We just went back like 15 years!"
b.	"You (CHW) cannot make people be afraid, and say, you know if you do not get this, you are gonna be sick. You cannot come at them like that, and so it's about how you are talking"
c.	"Coming out, and just talking about it without any backup like without any pamphlets or anything definitely did not work whatsoever"
d.	"I've (CHW) noticed a trend with this area... a lot of these people do not like to feel like they are being taught. They do not mind sitting down and just have a conversation with you, but whenever you bring out papers and you are like giving it to them, or you are reading things off to them, or you are showing them an informational video more often than not... they just seem standoffish, like they are just really not accepting of the information"

(Continued)

TABLE 3 (Continued)

3.3 Strength in partnership	
a.	"I (CHW) know just looking back on things, I met a lot of different pharmacists, and they are still open to, even though the pharmacy network kind of diminished at the end of last year, I still have pharmacists reaching out saying, "hey, if you still know anybody, send them over here," you know, so I'm thankful for that little bit of change"
b.	"So, I (CHW) think that's for me, that's a big change. Before this project, nobody, no pharmacist would call me and say hey do you have any name, so you have anybody, you know that is still wanting the vaccination, so I think that was a change as far as me personally, reaching out."
c.	"I (CHW) feel like, probably in the whole... community of pharmacies, the Health Center, the Ozark Action Agency – I feel like all of us together, it was like a united front. We all worked together, but we all PULLED together to try to get done what needed (to be) done. So, I felt like there was this...a closeness probably that was formed because we were all in this together that maybe wasn't there... before that hopefully will stay, will continue with anything that comes up as a challenge in a community that we can face now that we have kind of you know..."
d.	"And just being able to also have access to more resources, you know and referrals, we can refer more to other (organizations as a result of the connections we have made through this project)"
3.4 Meeting community members where they are	
a.	"We (CHW) offer door prizes in some of the churches to get the people to come. We had a luncheon, free lunch. Yeah. We gave them pizza, we gave them pretty much whatever you can think of, we gave them. We had big functions, like free big barbecues in the park, interactive with pageants. Anything that we could think of to get the people to come, because once you get them to come, 9 times out of 10 and somebody is gonna walk away with the vaccination"
b.	"Then you got the food, you got the entertainment, you got free food. Then you got us on the side passing out pamphlets. Then you got a pharmacist that would get up and talk, maybe just a good 5 min. You do not want to be up too long boring the people. But just getting the point across, and just letting them know the importance of getting vaccinated"
c.	"Yes. (It was important having the pharmacists in the vaccine education events) It's kind of like going to the doctor's office really. So, you go to the doctor's office, and you have a doctor that comes in – sometimes a doctor does not even come in. You cannot ask them the questions you want, even though the nurse may know the answer. But you feel more comfortable when you have a one-on-one session with the pharmacist. Yeah, and pharmacists, they know medicine"
d.	"I (CHW) went with 2 of the pharmacists, and both of them talked before we started giving the shots and they both did an excellent job, and to me, I think if they had not talked the way they talked, people would not have gotten their shots. I think they really rely on the pharmacists to know what they are doing and what they are saying, even though they did not even know them. Because I'm not talking about here in our town, I'm talking about we went away from our town to Marston, and we went to Haiti Heights. They listened, and they [the pharmacists] got the questions and they did a very good job"
e.	"We had some negatives, but most of the people who came (to the outreach event/clinics) were at least interested... With the people I met (in-person) with at least we could have debates... a lot of the phone calls I made, people were like not interested, do not call me back"

TABLE 4 Trust was the key factor.

a.	"Because I (CHW) already had a relationship with them (community members), and they trusted me, it seemed to be a lot easier for me to go in and talk to them and share education with them. They seem to take it a little bit better than what they were seeing on the news"
b.	"Exactly trust, they (community people) already trusted me (CHW). Like I said already knowing who you are, and just being reliable person, trustworthy, because just because you know a person do not mean you trust, them"
c.	"I (CHW) think we affect change because a lot of people trust us. Because we are so embedded in our communities"
d.	There were still people who were anti vax, and I felt like they were more comfortable having the conversation with us because they knew us"
e.	"It (vaccination) was just like a domino effect. If you can get one person to do it in front of the other one, you got them all lined up. They trust each other. And that's what I'm saying is all about one little word and its trust"
f.	"They (community people) got on Facebook saying, "We've been vaccinated, we have been vaccinated." It (influenced peers to get vaccinated / look up information on vaccines) did, it was like a chain reaction"

Discussion

This paper provides insight into the functioning of CHWs within an initiative implemented in rural Missouri through a community-academic partnership (10). The central role of CHWs in conducting various outreach events facilitated collaboration among local partner organizations, pharmacies, and community leaders. This further allowed their impact to go beyond providing information to the community members and increasing vaccine uptake. The efficacy of face-to-face conversation was a reoccurring theme among the CHWs.

Apart from making people aware of facts about COVID-19 and providing them with authentic sources of information, the CHWs were also able to empower communities to fact-check information for themselves as well as connect people to resources such as transportation.

Our findings also indicate that CHWs have the potential to contribute to the health seeking behavior of their communities. Health seeking behavior includes recognizing that there is a concern significant enough to require seeking an appropriate remedy for it (11). However, evidence suggests that care seeking is a complex

process influenced by many factors preceding the actual act of decision-making (12), and requiring contextual analysis. Social determinants of health often act as barriers and enablers to treatment decision making and health outcomes. CHWs that were a part of this community academic network were more equipped at understanding these contextual barriers as they were a part of the communities they were serving, and more importantly had their trust. This allowed them to address their health-related needs and placed them in a position to create structural and systems changes to begin to address associated social determinants. As noted by the CHWs, when engaging communities, health workers need to be aware of the social and political context within which this decision-making occurs. When governmental entities, public health, clinical and social services have acted in ways that indicate that they have not had the communities' interests in mind, communities lose trust in these institutions and will view any new health requests, mandates, and suggestions through this lens of mistrust (13).

Our study strongly indicated that rural communities viewed COVID-19 messages and data through a contextual lens. CHWs were able to bridge what was often a lack of trust and dismantle the barriers because they were a part of the communities they served, they established relationships with the community, and they developed unique ways to engage with communities using locally appropriate strategies. This suggests that we need to consider the messages we provide, the way we provide them, who is providing the message and the current and historical relationships that the individual and/or community has with providers and the organizations they represent. Study findings strongly recommend that community health actions draw on the capacities of trusted members of the community for planning and implementing future educational interventions.

There is already a substantial body of evidence demonstrating the disparate burden of the adverse impact of COVID-19 on underserved and under-resourced communities (14, 15). In terms of process of engaging with such communities, the CHWs highlighted the need to meet people where they were and provide information in multiple ways and at multiple times; taking time to realize that health education needs to be a *process* of engagement and building trust, recognizing the historical and cultural perspectives of communities, not just telling people what to do. Although, CHWs saw the negative impact of social media on vaccine uptake, quoting it to be their 'worst enemy', in considering what information to provide, the CHWs emphasized the importance of providing community members with reliable and credible sources of information, in person and online, in ways that facilitated dialog and encouraged reflection and questions.

This is consistent with previous work that has noted that individuals who had questions about COVID-19 vaccines and used the internet as their main source of information about vaccines were less likely to obtain the vaccine (16). Some have suggested that this may be associated with the fact that search engines are designed to reflect individuals' patterns of inquiry, thus if one finds one source that is critical of the vaccine, their future searches are likely to bring them to similarly framed sources. In this way the internet may actually be narrowing rather than broadening access to information (17). CHWs found that the best way to counter the negative impacts of these websites was to encourage people to begin to confirm information for themselves, providing them with online news sources and authentic websites that might help expand their views (and their

future searches), rather than just deepen one perspective. As health educators, we need to recognize and encourage the agency of communities in improving their own health and the need to create the conditions within which they can do so. We need to recognize the potential for benefit from technology but temper it with providing it with both strategies for vetting information on the web and interpersonal interactions.

The CHWs also identified that having CHWs working with and across agencies enhanced coordination among agencies and enhanced the ways that agencies were able to listen to community needs, opening the door to addressing social determinants of health, through lasting partnerships, not just providing direct care.

Limitations

Study findings are consistent with previous work in the field that suggests that vaccine uptake is influenced by the degree to which individuals understand the reasons for obtaining a vaccine, agree to getting the vaccine, and are moved toward obtaining a vaccine (awareness, acceptance, and activation) (18). However, within the context of our project, COVID-19 vaccines were brought to community sites, where people were otherwise gathered, and were offered for free. This reduces the generalizability of our findings, given that they do not highlight two other critical determinants of vaccine uptake, affordability and accessibility.

Conclusion

CHWs are a vital health care resource within our communities. Their knowledge, experiences, and pre-established relationships with community members facilitate program implementation and improve health outcomes in the community. Within rural communities, where healthcare systems are often inadequate, our work suggests that CHWs can also contribute to collaboration among community organizations, social service agencies, and health care providers (including pharmacies) and enhance their ability to positively impact health outcomes.

Data availability statement

Aggregate, deidentified data will be made available, without undue reservation. However raw qualitative data cannot be provided without compromising the confidentiality of our participants. Further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Saint Louis University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Given the nature of the study, the IRB determined that written consent was not necessary and instead participants provided verbal informed consent to participate in this study and for the publication of aggregate, deidentified data.

Author contributions

AB: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Project administration. AS: Writing – review & editing, Data curation. CV: Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing. JB: Conceptualization, Funding acquisition, Project administration, Writing – review & editing. RL: Project administration, Resources, Writing – review & editing, Data curation. TL: Project administration, Resources, Writing – review & editing, Data curation. AF: Project administration, Project administration, Data curation. MM: Project administration, Resources, Writing – review & editing. EB: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – original draft, Data curation, Formal analysis.

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Conflict of interest

Authors RL and TL are employed by company L and S Pharmacy. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1286177/full#supplementary-material>

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Implementing a student-centered stroke intervention and prevention education program; evaluating motivation, cognitive load, and performance among middle school students

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Background: In this study, we investigated the association between motivation, cognitive load, difficulty, and performance in a stroke education outreach program implemented for middle school students.

Methods: Various interactive instructional activities were developed to engage students throughout the program to assess cognitive and intrinsic load arising from learner implementation of various tasks in a stroke education program for middle school kids. Performance was measured using a post-test to assess knowledge gained by the 6th, 7th, and 8th-grade middle school students. A short questionnaire was also administered to collect data on students' motivation using the ARCS model to assess attention, relevance, confidence, and satisfaction. In addition, we evaluated difficulty level and cognitive load. The relationship between performance and motivation was assessed using Pearson's correlation.

Results: In our results, there was no significant difference ($p > 0.05$) in performance between the 6th, 7th, and 8th-grade students. The difference in performance, cognitive load (mental effort and difficulty), or motivation between the 6th, 7th, and 8th-grade students was not significant ($p > 0.05$). The correlation between motivation and performance was significant ($r = 0.87$, $p = 0.001$), while the correlation between mental effort and performance was not significant ($r = 0.34$, $p = 0.270$). Also, the correlation between difficulty and performance was not significant ($r = 0.38$, $p = 0.361$). In the ARCS motivation model, attention, and confidence received the lowest mean scores (3.9), while relevance received the highest score (4.3).

Conclusion: Our findings reveal the importance of implementing novel activities to enhance students' motivation to improve performance in the implementation of stroke education outreach programs for middle school students.

KEYWORDS

stroke, education, middle school, performance, cognitive load, motivation or difficulty

1 Introduction

Within the stroke belt, chronic diseases, poor diet, exercise, and lack of education on stroke awareness lead to an increasing stroke incidence (1). The Stroke Belt are regions in the Southeastern United States with higher stroke deaths from all strokes compared with other regions (2). The age-adjusted stroke mortality rate in the Stroke Belt is higher than for the other regions of the United States (3). Educating the younger generation is a way to avoid this cycle of lifestyle choices and will likely lead to fewer strokes in the future (4). It is only through proactive habits, such as healthy diets and exercise or physical activities, that children can learn how to avoid fatal strokes later in life (5). The use of exercise in the primary and secondary prevention of stroke has a growing evidence base and support. The maintenance of healthy habits and prevention of stroke has been linked with regular physical activity and balanced dietary intake (6). Among kids in middle school, sedentary habits such as watching television, lack of sports participation, and computer games are associated with a decline in physical activity throughout childhood (7). Therefore, given the significance of the decline in physical activity among middle school students, several school-based stroke education and physical health intervention programs (8, 9) have adopted different educational health promotion strategies among middle school students. In most of the existing studies (9, 10), how the employed instructional design, motivation, cognitive load, and difficulty, interplay with each other to impact learning and task performance in a stroke education outreach program implemented for middle school students is not known. Educational intervention must be tailored not just to suit the expertise levels, but also to meet learners' motivational needs for the optimization of cognitive load and mental effort.

Most stroke education programs are within the context of cognitive load theory but have not considered the effect of learner affect and motivation on the use of cognitive capacity. Cognitive load level is typically determined by measuring perceived task difficulty (11), and this can also be the measure of learner motivation for the investment of cognitive effort in learning the materials in a stroke education program. Moreover, the perceived task difficulty can be associated with the perceived pleasure of learning the different tasks in the stroke education program (12). For example, middle school kids may perceive a learning task to be unpleasant if they are very difficult to learn, indicating high cognitive load during task performance, but pleasant and easier to learn, with a low cognitive load at the end. In other words, the structure of the learning tasks or activities in the stroke education program may alter the perception of a learning activity, to be high or low cognitive load, according to how middle school students feel about a particular learning activity. Therefore, the effect of perceived pleasure of a learning task needs to be considered in a stroke education program. Complex instructional techniques that interfere with learning may affect performance among early learners such as middle school students (13). A potential solution is to design learning materials that are less tasking, pleasant, and easier to learn especially for middle school learners in a stroke education program.

Cognitive load is about learning skills about solving problems that originate from extraneous cognitive load (instruction-related) (14). Extraneous cognitive load is described as reducing intrinsic cognitive load through instructional techniques that structure information to focus cognition on schema acquisition (15, 16). Cognitive load theory deals with solving academic tasks using innovative pedagogies (16,

17). Therefore, the cognitive load has dimensions that reflect the interface between learners, pedagogies, and evaluation that describes the measurable aspects such as mental load (ML), mental effort (ME), and performance (18). ML is task-related and represents the cognitive ability to process complex tasks (19). In comparison, ME measures the cognitive capability of an individual while the learner is implementing a specific task (19). Sweller et al. (16) suggested that ML and ME are interlinked. De Jong (14) proposed that performance is a component of cognitive load (CL) and sometimes serves as an indicator for CL. Measuring CL is an important factor to measure in an educational program (20–22). For example, CL can be assessed as a control factor to better understand students' test performance in an educational program (23, 24). Therefore, the interaction between cognitive load and motivation as it relates to learning different activities in a stroke education program will depend on whether the different tasks are easy and pleasurable enough to motivate middle students for better task performance in a stroke education program.

Educational instruction, even when designed and based on effective instructional strategies may not necessarily stimulate students' motivation to learn (25). This is because it is possible that students may not be motivated to pursue lifelong learning and use the knowledge and skills learned to implement measures related to the learned materials. The ARCS model is an instructional design model developed by John Keller (26) and focuses on motivation. The four elements; Attention, Relevance, Confidence, and Satisfaction form the acronym ARCS of the model. Attention is the extent to which the student's curiosity is aroused or gained and sustained over time. Relevance indicates the student's perception that the instruction is related to personal needs. Confidence is the student's perceived likelihood of achieving success through personal efforts and control, and Satisfaction implies reinforcing accomplishment with rewards from the instruction, which can include internal and external factors. The ARCS model is well-validated and has been used in several education studies (27, 28) to help identify components of instruction that can increase student motivation to learn with responsive to the interests and needs of students. Using motivational design to create educational strategies and then incorporating these into the instruction materials can result in complementary enhancement of student learning and performance (29) in a stroke education program. In this study, we investigated the association between motivation, cognitive load, difficulty, and performance in a stroke education outreach program implemented for middle school students. This allows us to determine whether the available pleasurable amount of motivational resources in a stroke education program for middle school can promote better learning, cognitive load, and performance for middle school students. Our prospective findings would help better explain the effect of tailoring an instructional design with a pleasurable amount of resources in a stroke education program on the motivation and performance of middle school students in a stroke education program.

1.1 Study rationale

Understanding the relationship between cognitive load and motivation is important in educational learning activities (20, 30–32). This is significant especially since components of the instructional materials can actively manipulate students' cognitive load or motivation (14). An important theory of motivation is the

self-determination theory, which states that instructors should always seek to intrinsically motivate students, as it helps improve their competence (33, 34). Therefore, investigating motivation, cognitive load, and motivation in a stroke education program for middle school kids is important to determine their relationship and the impact on middle school kids during the implementation of interactive active learning activities in a stroke education outreach program. While active learning activities provide measures of cognitive load and motivation associated with small group interactive learning activities (35), it is not clear whether active learning during interactive social activities that facilitate a better understanding of stroke signs and symptoms can differentially improve performance, cognitive load, motivation, or difficulty among 6th, 7th, and 8th-grade students with different age categories who participated in a stroke education outreach program. The following research questions guided our study:

Research question 1: Is there a statistically significant difference in the performance, mental effort, difficulty, or motivation of 6th, 7th, and 8th-grade students?

Hypothesis: There is no significant difference between 6th, 7th, and 8th-grade students indicating that active learning during interactive social activities may not differentially improve performance, mental effort, difficulty, or motivation levels among 6th, 7th, and 8th-grade students with different age categories who participated in the stroke education outreach program.

Research Question 2: Is there a significant correlation between motivation, mental effort, difficulty and performance?

Hypothesis: There is a statistically significant correlation between motivation and performance indicating the association of active learning activities with performance or motivation among 6th, 7th, and 8th-grade students who participated in a stroke education program.

In this study, we determined whether, (1) motivation, mental effort, and difficulty differ between 6th, 7th, and 8th-grade students, (2) motivation, mental effort, and difficulty correlate with students' performance, and (3) ARCS (attention, relevance, confidence, and satisfaction) model of motivation provide insight into improving stroke education for future generations. The present study contributes to the existing literature on how motivation, cognitive load (mental effort and difficulty), and academic performance differ among 6th, 7th, and 8th-grade students in a stroke education program.

2 Methods

2.1 Participants

A total number of 355 middle school students from 6th grade = 145, 7th grade = 137, 8th grade = 73 from two different middle schools participated in the study. Participants were diverse, from various socioeconomic statuses and races, and their ages range from 11 to 14 years. Two hundred and fifty-one middle school students were involved in the program for the first year, while 104 middle students participated in the second year of the program. The program ran for

the full duration of the school day, from 8:00 AM–2:30 PM, and consisted of 6 periods that lasted 50 min each in both years of implementing the program. The approval for this study was obtained from the PRISMA Health institutional committee for ethics (approval number: Pro00074119).

2.2 Stroke education activities

The Stroke Education Day program consists of various learning activities that were implemented by medical students for middle school students in their gym at two different schools. The program started by showing videos, which shares the reflections by stroke survivors. A total of five learning stations were implemented for Stroke Education Day, with 10–15 students per station. Students rotated through each learning station at a time. At these stations, students participated in different interactive activities that were guided by at least three medical students who were present in each station to facilitate the learning process.

The first station was the FAST station with the goal to introduce middle school kids to the FAST signs of stroke (e.g., F=Face drooping, A = Arm weakness, S=Speech difficulty, T = Time to call 911). Middle school students learned the signs and symptoms of stroke with a large visual representation of each letter and activities corresponding to each letter. These activities included attempting to mimic facial droop, holding a weight in one arm to simulate arm weakness, saying a tongue twister to simulate speech difficulty, and imitating calling 911 to emphasize how crucial time is when someone is having a stroke. By associating each letter of FAST with a stroke symptom, middle school students learned the signs and symptoms of stroke interactively.

The second station was “ReThink Your Drink,” in which middle school students were educated about added sugars and taught that limiting sugar intake could help prevent stroke. Specifically, the students were taught the amounts of sugar that can be found in everyday drinks. To facilitate an interactive environment to maximize student engagement, this station included an activity where students were asked to guess the amount of sugar in each drink and match the corresponding drink with bags filled with sugar.

Station three, named “The Salty 6,” aimed to educate middle school students about the salt content in different foods and how maintaining a healthy diet may help prevent stroke. At this station, middle school students learned the implication of high-level sodium, which is a risk factor for stroke. Middle school students were then able to participate in an activity where they learned the six saltiest foods in the American Diet (e.g., breads and rolls, pizza, sandwiches, cold cuts and cured meats, soup, burritos and tacos) and were able to try guessing how much sodium was in each of these foods.

The fourth station was an activity station, in which students could participate in various exercise activities, including racing, jumping, and pushups. The goal of this station was to emphasize the importance of exercise and physical activity in living a healthy lifestyle and preventing stroke. It was also a way to show students that there are a variety of ways that they can stay active and reach the AHA-recommended levels of weekly physical activity.

In the last station, “Life’s Simple 7,” middle students participated in a discussion with their peers and the medical students. At this station, students learned the seven habits of a healthy and unhealthy lifestyle, which include stop smoking, healthy diet, physical activity,

lose weight, manage blood pressure, control cholesterol, and reduce glucose.

2.3 Data collection and analysis

To evaluate the impact of the stroke program on middle school students to learn about measures to prevent stroke, we administered a survey at the completion of the learning activities (Table 1). The survey has been used in previous studies (6, 36) and was modified to reflect data collection for middle school students for our stroke education program. The first 8 items were based on the ARCS model of motivation (26). There are four components of the ARCS model that assesses attention, relevance, confidence, and satisfaction. Questions 9 and 10 correspond to mental effort and difficulty level as a measure of cognitive load. It is important to point out that mental effort and task difficulty are both subjective measures of cognitive load (37). However, they measure different aspects of cognitive load. The task difficulty rating is related to intrinsic load, and the mental effort is related to germane load (38). Individual students' performance was assessed based on their responses to the questions in the Passport to Stroke (Figure 1). This allowed them to identify and recognize the FAST signs, salty foods, healthy drinks, and basic information about stroke and healthy lifestyles. After the data was collected, Cronbach's alpha score was calculated and found to be 0.96 reflecting that the

survey was internally consistent. Next, we determined the percentages of students in the 6th, 7th, and 8th-grades and their responses to the questionnaire. In addition, the means, and standard deviations (SD) for all variables were calculated. To determine the difference in performance, mental effort, motivation, or difficulty between the 6th, 7th, and 8th-grade students, we used a one-way ANOVA. In using ANOVA, we considered the independence of the groups being compared. This allowed us to determine whether there is a statistically significant difference in the performance, mental effort, motivation, or difficulty between 6th, 7th, and 8th-grade students. We tested for the normal distribution of our data using exploratory data analysis (EDA) before the use of the parametric test. Finally, the relationship between performance, mental effort, motivation, and difficulty was determined using Pearson's correlation coefficient. The significance level was established at $p < 0.05$. We analyzed all our data using SPSS version 29 (SPSS; IBM Corporation, Armonk, NY, United States).

3 Results

For two years, 355 middle school students participated in the stroke education outreach program. Of the 355 students, 145 (40.8%) were in the 6th grade, 137 (38.6%) were in the 7th grade, and 73 (20.6%) were in the 8th grade. Table 2 presents the results for performance, mental effort, motivation, and difficulty. The average

TABLE 1 Measures of motivation using ARCS model (attention, Q 1–2; relevance, Q 3–4; confidence, Q 5–6; and satisfaction, Q 7–8) and cognitive load including mental effort and difficulty in middle school students who participated in the stroke education program.

Stroke Education Activities (SEA)	Very true				Not true
1. The SEA session kept me excited to complete the assigned activities	5	4	3	2	1
2. The SEA experience aroused my curiosity	5	4	3	2	1
3. The content I am learning during SEA session will be useful to me	5	4	3	2	1
4. Students actively participated in the SEA assigned activities	5	4	3	2	1
5. The information to be learned during SEA is just too difficult for me	5	4	3	2	1
6. I found the challenge of learning about stroke by SEA to be about right	5	4	3	2	1
7. Completing SEA tasks gave me a satisfying feeling of accomplishment	5	4	3	2	1
8. I enjoyed the SEA experience	5	4	3	2	1
9. Indicate the amount of mental effort you invested during the stroke learning activities					
1 Very low mental effort					
2 Low mental effort					
3 Rather low mental effort					
4 Neither low nor high mental effort					
5 Rather high mental effort					
6 High mental effort					
7 Very high mental effort					
10. Indicate how easy or difficult the stroke teaching activities were					
1 Extremely easy					
2 Easy					
3 Somewhat easy					
4 Neither easy nor difficult					

5 = very true, 4 = mostly true, 3 = moderately true, 2 = slightly true, and 1 = not true.

understanding of FAST signs, salty six, health drinks, and basic information about stroke.

Passport to Stroke Knowledge

FAST stands for:

F _____

A _____

S _____

T _____

Strokes occur when blood flow to the _____ is interrupted

A. Stomach
B. Heart
C. Brain
D. Liver

Someone in the United States has a stroke every _____

A. 40 seconds
B. 30 minutes
C. 5 minutes
D. 3 days

Name three of the Salty Six

1. _____

2. _____

3. _____

Bonus Question
Which one is the saltiest? _____

True or False: Strokes are preventable

A. True
B. False

How much should you exercise every week for overall cardiovascular health?

A. 30 minutes at least 5 days/week
B. 45 minutes at least once a week
C. 3 solid days. Nonstop.

Which two drinks in the Rethink your Drink display had the highest levels of sugar?

1. _____

2. _____

What is the most valuable thing you learned today?

FIGURE 1

Individual students' performances were assessed based on their responses to the questions that tested their understanding of FAST signs, salty six, health drinks, and basic information about stroke.

TABLE 2 Measurements of mental effort, difficulty, motivation, and performance of middle school students who participated in the stroke education program between 2018 and 2019.

	6th grade (N = 145)	7th grade (N = 137)	8th grade (N = 73)	p value
	Mean (SD)	Mean (SD)	Mean (SD)	
Mental effort	4.57 (1.49)	4.57 (1.78)	4.10 (1.56)	0.106
Difficulty	1.96 (1.04)	1.97 (1.18)	2.15 (1.31)	0.491
Motivation	30.9 (7.52)	31.6 (7.20)	31.0 (5.64)	0.722
Performance	76.3 (25.0)	73.6 (29.2)	68.7 (25.8)	0.163

score for students in the 6th grade was 76.3%, 7th grade was 73.6%, and 8th grade was 68.7%. The difference in performance between the 6th, 7th, and 8th-grade students was not significant ($p > 0.05$). Moreover, the difference between the different grade levels in mental effort, motivation, or difficulty was also not significant ($p > 0.05$). Although the correlation between motivation and performance was significant ($r = 0.87$, $p = 0.001$), neither the correlation between mental effort and performance was not significant ($r = 0.34$, $p = 0.270$) nor between difficulty and performance ($r = 0.38$, $p = 0.361$).

Table 3 presents the results of the ARCS model of motivation. The average result for attention ("A"—questions 1&2) was 3.9, relevancy ("R"—questions 3&4) was 4.3, confidence ("C"—questions 5&6) was 3.9, and satisfaction ("S"—questions 7&8) was 4.1. The ratings for all four categories of the ARCS model were above 4/5 indicating a high level of motivation during the learning activities. Relevance received the highest rating. 84.4% of all the students noted that it was either

mostly or very true that the content they learned during the stroke education activities (SEA) would be useful to them.

4 Discussion

This study investigated whether motivation, mental effort, difficulty, and performance differ among 6th, 7th, and 8th-grade students and how this provides insight into improving stroke education among middle school students. Three major findings originated from our study. First, there was no significant difference in performance, cognitive load (e.g., mental effort and difficulty), or motivation between the 6th, 7th, and 8th-grade middle school students. Second, we observed a significant correlation between motivation and performance, but we did not observe a significant correlation between cognitive load and performance. Finally, students' motivation was high at the end of the stroke education outreach program using the ARCS model, and relevance received the highest rating.

In our study, students' motivation was high at the end of the stroke education outreach program using the ARCS model, and relevance received the highest rating, indicating students' perception that the instruction is related to their personal needs in learning different measures to prevent stroke. It is possible to change the learning conditions and environment so that each student can motivate themselves to learn the activities in the stroke education program. Even in the changed environment, it is also possible that the medical students and facilitators of the program can teach, and teach well, without having middle school students learn the materials. In addition, middle school students may reluctantly learn things that do not mean anything to them. They also may choose not to use or apply what they have learned in the stroke education program to improve healthy lifestyles.

TABLE 3 The motivation scores based on the ARCS model for middle school students who participated in the stroke education program between 2018 and 2019.

Survey Items	Not true/slightly true N (%)	Moderately true N (%)	Mostly true/very true N (%)	Mean (SD)
1. The SEA session kept me excited to complete the assigned activities	27 (8.5)	82 (25.9)	207 (65.5)	3.9 (1.1)
2. The SEA experience aroused my curiosity	33 (10.5)	78 (24.8)	203 (64.6)	3.9 (1.2)
3. The content I am learning during SEA session will be useful to me	17 (5.5)	31 (10.1)	260 (84.4)	4.4 (0.9)
4. Students actively participated in the SEA assigned activities	21 (6.9)	45 (14.9)	237 (78.2)	4.2 (1.0)
5. The information to be learned during SEA was not too difficult for me	73 (24.7)	27 (9.2)	195 (66.1)	3.8 (1.6)
6. I found the challenge of learning about stroke by SEA to be about right	43 (14.4)	50 (16.8)	205 (68.8)	3.9 (1.3)
7. Completing SEA tasks gave me a satisfying feeling of accomplishment	38 (12.6)	55 (18.3)	208 (69.1)	4.0 (1.2)
8. I enjoyed the SEA experience	31 (10.1)	48 (15.6)	228 (74.3)	4.1 (1.2)

The motivational strategies used in this study allowed us to positively influence middle school students' motivation to learn materials that can help prevent strokes. Our finding of increased motivation has been reported by other studies that support the validity of the four basic constructs and their positive effects on student motivation and performance (29, 36). In addition, our finding reveals the importance of using the ARCS Model to evaluate the effectiveness of educational strategies in a stroke outreach program for middle school students.

In our program, medical students as facilitators implemented different healthy lifestyle interactive activities. They led the conversations in their small groups and shared their ideas and thoughts on different activities they embarked upon at home including exploring their local parks, biking, hiking, walking on street trails, outdoor tennis or volleyball courts, or baseball and football fields. They shared experiences of how their daily routines help develop life skills, reduce stress, and build healthy habits. They provided specific examples such as assisting with laundry and washing dishes. They worked together, interacted socially, and had fun while implementing the different activities that kept them physically active in the stroke education outreach program. They were motivated to implement physical activities that allow them to live healthy lifestyles and help prevent stroke in the future. In general, when middle school kids are provided with the opportunity to take responsibility for their learning and provided with interactive activities they could perceive the entire learning activities as fun instead of mainly educational.

A major finding of this study is that performance, cognitive load, or motivation between the 6th, 7th, and 8th-grade students were not significantly different. This finding suggests that our learning strategy may provide some innovations in motivating middle school students of a broad age category to be actively involved in their learning by working together during the different stroke learning activities, identifying problems, and paired discussions, with a greater responsibility in solving the problem on their own. This approach allows higher-order thinking, with emphasis on student's ability to solve problems, struggle with complicated issues such as signs and symptoms of stroke, suggest solutions on how to prevent stroke and explain ideas in their own words to their colleagues. Therefore, our approach of using interactive visual learning materials not only improves learning in middle school students across 6th 7th, and 8th-grade classes but also cognitive load level was appropriate for all the three student grades who participated in the program (39).

There was a significant correlation between motivation and performance, and motivation was high at the end of the stroke

education program. For academic success, motivation is known to be an important variable (40). This is because it enhances the willingness of the learner to implement a specific task (41). Motivation can be intrinsic and extrinsic (42). The latter form of motivation focuses on the benefit of a specific reward while the learner is implementing a task (43). An example of extrinsic motivation is when a student is motivated by reviewing materials primarily to perform well in an examination (44). Intrinsic motivation is important in the academic environment (42, 45, 46). An example of intrinsic motivation implemented in this program is students learning healthy lifestyles and stroke prevention activities because the topic is fun and the learning materials are entertaining. This type of intrinsic motivation is proposed to increase performance among learners (47). This finding supports our current result and indicates that intrinsic motivation may be associated with using an excellent instructional strategy for middle schoolers that is entertaining, with unforgettable experiences to help develop healthy lifestyles.

While students' motivation was high at the end of the stroke education program, we observed that relevance received the highest rating. The high rating of relevance in our ARCS model of motivation suggests students' awareness that participation in this program can equip them with the knowledge to save the lives of their friends and family in the future. Therefore, future stroke education outreach programs may consider strategies to increase students' confidence and attention. For example, improving the student's confidence because students with higher confidence levels tend to be more attentive and involved (26). This indicates that attention can be dependent on confidence. Keller suggests various strategies for working on students' confidence, including organizing activities on an increasing difficulty level and linking students' successful performance to their hard work (26).

Furthermore, developing activities that stimulate and sustain the students' attention, rather than simply capturing it initially, may be an effective strategy (48). Some specific examples include presenting the students with various problem-solving situations to increase participation, shifting between instructor-student interaction and student-student interaction to increase variability, and using humorous analogies.

4.1 Limitations

There are some limitations in this study. For example, the lack of control groups and data were collected from only two middle schools.

There was no pre-test given to the students; therefore, there is no way to see if there was a major gain in learning the stroke signs, symptoms, risk factors, and prevention after participating in the stroke education program. Another limitation is that several students did not answer all of the questions on the survey. This may be due to their young age, lack of maturity, or possibly even a lack of time to complete the survey. In addition, single-item assessments used in this study that include student self-assessments are generally less reliable and statistically sound especially in measuring cognitive load and difficulty that likely would have been more appropriate. No test or survey was established to give to students who previously participated in the program. We did not code the different comments made by students during the sessions, to generate qualitative data for the sessions. However, longitudinal data could provide insight into whether students retain the knowledge gained during the program and whether it has proven helpful in their lives. In this study, we used Cronbach's alpha to measure the reliability but not validity. While it helped us to determine whether responses are consistent between items (reliability), it did not determine whether the items measure the correct concept (validity).

5 Conclusion

The current study developed stroke education program that adopt interactive learning strategies that allowed middle school students to initially watch videos made by stroke survivors and then participate in small group interactive learning activities. The interactive social activities were designed to enable active learning activities in the learning of stroke signs and symptoms, prevention, and promoting healthy lifestyle activities. In addition, active learning activities provided measures that reflect changes in cognitive load and motivation originating from the small group interactive learning activities. Our findings indicate that the different activities implemented in the stroke program are sensitive to changes in motivation and optimize the difficulty level to avoid cognitive overload among middle schoolers engaged in the stroke education program.

Data availability statement

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

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Ethics statement

This study was approved by the Institutional Committee for Ethics (approval number: Pro00074119). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

SI-N: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. II: Investigation, Methodology, Writing – review & editing. AS: Investigation, Methodology, Writing – review & editing. KB: Investigation, Methodology, Writing – review & editing. KC: Investigation, Methodology, Writing – review & editing. AB: Methodology, Investigation, Writing – review & editing. MK: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. TN: Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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

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Summer undergraduate biomedical research program for underrepresented minority students in a rural, low-income state

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Introduction: Diversity can enhance the agenda and quality of biomedical research, but a dearth of underrepresented minorities and women serve as biomedical researchers. The study purpose was to examine the impact of the a summer undergraduate research program on self-efficacy in research, scientific communication, and leadership as well as scientific identity, valuing objectives of the scientific community, and intent to pursue a biomedical research career.

Methods: Underrepresented minority and female undergraduate students participated in a mentored research experience in a rural, low-income state.

Results: Students' self-efficacy in research, scientific communication, and leadership as well as scientific identity, valuing objectives of the scientific community, and intent to pursue a biomedical research career increased post-program compared to pre-program.

Conclusion: This study supports implementation of a biomedical summer undergraduate research program for URM and women in a poor, rural, settings.

KEYWORDS

minority groups, female, education, medical, undergraduate, biomedical research, mentors, surveys and questionnaires

Introduction

Diversity in biomedical research can reduce health disparities (1). A diverse biomedical research workforce promotes a more comprehensive research agenda, including research on diseases with a disproportionate impact on underrepresented minorities (URM), primarily because researchers from populations with the greatest burden of disease tend to identify and apply solutions (2). Diversity can also enhance research quality. Ethnically or gender diverse research teams publish manuscripts in journals with higher impact factors and receive more citations, and peer reviewers perceive them as higher quality (3, 4). Yet, in many cases, biomedical researchers lack resemblance to the population they serve, because of a lack of diversity.

Indeed, a dearth of URM and women serve as biomedical researchers. Though URM make up 34.6% of the U.S. population, URM hold <6% of appointments among biomedical research faculty. African Americans constitute <3% of researchers

with NIH research grants (5–7). Similarly, women hold less than one-third of tenured biomedical research faculty positions (8). A large gap exists in the number of URM and female biomedical researchers compared to their white and male counterparts. Reaching population parity may be an ideal goal, but there are many barriers to achieving parity including persistent incidents of discrimination, bias, stereotyping, and exclusion of minority students. These barriers collectively maintain the gap and result in low numbers of URM and women who pursue and attain a degree in science, technology, engineering, mathematics, and medicine (STEMM) (9).

Degree attainment in STEMM by URM and women is not narrowing this gap. Though URM students pursue STEMM majors at nearly the same rate as White and Asian students, unfortunately, the number who persist and graduate is low (10). African American and Hispanic STEMM students graduate at a rate of 34% and 43%, compared to much higher rates in White students (58%) (11). Indeed, African Americans earned only 9% and Hispanics 15% of STEMM bachelor degrees (12). Moreover, women earned 85% of health related degrees but less than one-fourth of the degrees for other sciences (13). A small pool of URM and female students are in a position to pursue graduate degrees in STEMM careers.

Pipeline programs for undergraduate students promote academic achievement and URM entry into STEMM and healthcare fields (14–16). The Survey of Undergraduate Research Experiences indicated most students had a sustained or increased interest in post-graduate studies after a summer research experience and reported an increase in their independence, motivation to learn, and undergraduate course participation (14). Further, pipeline programs for undergraduate students have reported improvement in research skills and increased matriculation into graduate biomedical research programs (15, 16). Still, observed gains are minor compared to the needs of URM and women in the population. A significant need exists for more interventions to improve diversity and inclusion in STEMM education and careers. Summer Undergraduate Research Programs exist throughout the country, including the rural south (17). For example, the University of Mississippi Medical Center offers the Summer Undergraduate Research Experience, which has many attributes similar to those of our Summer undergraduate Research Program (SURP) (18). In contrast, our SURP explicitly seeks to enroll URM and female students. Further, a scarcity of reports exist in the literature that report effective strategies, interventions, and evaluation outcomes in STEMM undergraduate pipeline programs in rural, impoverished southern states such as Arkansas, which account for 20% of Americans and where URM have less access to STEMM careers and chronic health disparities have the largest impact (19).

Arkansas is a rural, low-income southern state. It is the sixth most rural state, with 41% of the population living in rural areas compared to 14% nationally (20). Arkansas has the sixth highest poverty rate, with 17% of the population living below the poverty line compared to 13% nationally (21). Moreover, 37% of the Arkansas population is low-income, and 27% receive Medicaid coverage (22). In rural low-income households, many parents have little formal education. Thus, many of these parents lack expectations for children to pursue a STEMM education and career (23).

At the University of Arkansas for Medical Sciences (UAMS), <7% of the faculty are minorities, which constrains efforts to engage URM communities using URM faculty for direct advocate-to-community engagement. In particular, it constrains biomedical research domains with a focus on cardiovascular and blood disorders, as heart disease is the leading cause of death in the United States, including individuals of most racial and ethnic groups (24, 25). African Americans in Arkansas with reduced cardiovascular function have a significantly higher number of hospitalizations and readmissions than White Americans (26, 27). Further, prevalence of cardiovascular-related chronic conditions, such as congestive heart failure, and mortality risk are nearly twice the national average in many Arkansas counties where poverty persists. Thus, Arkansas is a fitting environment for assessing innovative biomedical training programs to address the complex health needs of its communities. UAMS, the only academic health center in Arkansas, implemented a SURP to increase the volume and quality of URM researchers with interests in cardiovascular, pulmonary, or hematologic research in the biomedical workforce pipeline.

SURP is a nine-week research experience, with the overarching goal to increase the percentage of URM students who pursue STEMM graduate degrees and careers in research or health professions. Specific aims were to: (a) Recruit a diverse group of academically talented and enthusiastic undergraduate students interested in pursuing careers in cardiovascular, pulmonary, or hematologic research, (b) Support and cultivate successful and rewarding mentor-mentee relationships, (c) Develop and promote student leadership and communication skills, (d) Stimulate underrepresented, minority, and disadvantaged students' interest in research and health-related careers, and (e) Evaluate the program and its activities to ensure student satisfaction and program effectiveness.

The purpose of this study was to examine the impact of the SURP on the students' self-efficacy in research, scientific communication, and leadership as well as impact on the extent they identified with science, valued objectives of the scientific community, and their intent to pursue a biomedical research career. We believed other academic health science centers in rural, low-income states could use our findings to help develop or enhance similar mentored research experiences for underrepresented minority undergraduate students.

Materials and methods

Setting

The setting was at UAMS, an academic health science medical center in a rural, low-income southern state.

Participants

The participants were URM, female, and first-generation undergraduate students enrolled in the 2022 and 2023 SURP.

Study design

The study design was a one-group, retrospective pre-post, and qualitative framework analysis.

Procedures

Each year, the SURP recruited and accepted up to 13 URM, female, or first-generation undergraduate students from colleges and universities throughout the U.S. The program has received an average of 70 applications per year. Program directors reviewed each application and selected participants based on several requirements. Participants were U.S. citizens who had completed at least 1 year of undergraduate studies with a minimum of 2.5 GPA. Applicants also answered questions about their research experience and career goals. In addition, applicants provided two letters of recommendation from faculty. Once accepted into the program, UAMS hired SURP participants as temporary student employees for 9-weeks during the summer.

Before the program began, based on the students' interest and background, SURP administrators paired each student with a faculty mentor, who supervised the students' summer research project and worked closely with the student throughout the summer. A SURP administrator had formal mentor training at the Center for the Improvement of Mentored Experiences in Research in Wisconsin and is currently participating in a campus wide effort to facilitate research mentor and mentee training at UAMS. The SURP program provided funding for research supplies. In mid-summer, students introduced their research project to other SURP participants and program staff. The research project culminated with each student delivering a research presentation in an open forum to all faculty mentors, program participants, and SURP administrators as well as invited faculty and family members.

In addition to the research project, students attended weekly research and professional development seminars. The seminars exposed students to various areas of research on the UAMS campus and sought to increase their knowledge about biomedical science and research careers. Students received a comprehensive tour of all of the research areas on the campus and had the opportunity to shadow health professionals who worked in the clinics and main hospital. At the conclusion of the program, students completed an evaluation. This manuscript presents the results of that evaluation.

Theoretical framework

The Tripartite Integration Model of Social Influence served as the theoretical framework for the program and the evaluation (28, 29). This framework helps explain how people socially integrate into a community. It features three social variables that influence the extent someone integrates into a community: (a) self-efficacy, (b) identity, and (c) values. In the context of this study, scientific self-efficacy refers to the extent the students believed in their ability to meet the challenges of planning, conducting and communicating about scientific experiments. Scientific identity was the extent the students had a gratifying definition of themselves as scientists.

Scientific community values reflected how aligned the students were with the objectives of the scientific community. Together, scientific self-efficacy, science identity, and scientific community values can influence biomedical research career intention. Effective mentorship, a key component of our SURP, can promote self-efficacy, identity, and values (30, 31).

Measures

Demographic measures included undergraduate status, first-generation college student, gender, race, and ethnicity. We elicited the students' satisfaction with the program, including relevance, extent the SURP stimulated interest in a biomedical research career, quality, and recommending the SURP to other students.

The Mentoring Competency Assessment examines the competencies and skills of scientists who serve as research mentors (32). The instrument features a seven-point Likert scale (1 = Not at all skilled; 7 = Extremely skilled) to assess 26 skills needed for six competencies, including: (a) Communication, (b) Alignment of expectations, (c) Assessment of understanding, (d) Fostering independence, (e) Addressing diversity, and (f) Promoting professional development. For example, skills for communication included active listening, providing constructive feedback, and developing a trusting relationship. Aligning expectations included setting goals and developing strategies to meet them. Assessing understanding included assessing the mentee's knowledge and ability. Fostering independence included motivating mentees, building their confidence, and stimulating creativity. Addressing diversity included accounting for different backgrounds. Promoting professional development included facilitating networking and setting career goals.

The investigators used a retrospective post then pre survey method for several measures. With this method, students made two separate sets of ratings, both post-SURP and pre-SURP, only after participating in the SURP. First, the students made post-SURP "NOW" or "AFTER" ratings about their knowledge, skills, attitude, or behaviors. Then, we asked the students to reflect back and rate the same knowledge, skills, attitude, or behaviors "BEFORE" the SURP. Previous research on survey methodology demonstrated that compared to conventional pre and post measures, the retrospective post then pre design reduced participants' overestimation of pre measures and, therefore, avoided underestimation of effect size (33, 34). Post then pre measures included self-efficacy in research competencies, scientific communication, and leadership as well as scientific identity, scientific values, and intention to pursue a research career in biomedical science (35–38). To compare post then pre outcomes for these constructs, the investigators totaled the score for each construct and divided each total by the number of possible points, to arrive at a score on a 100-point scale.

Additionally, students provided written reflections to qualitative inquiries about science identity and values as well as intention to pursue a biomedical research career. Seven open-ended questions assessed program strengths and weaknesses as well as how the program influenced career or academic choices.

Analysis

Descriptive statistics summarized data for demographics, satisfaction, mentoring competencies as well as self-efficacy in research competencies, scientific communication, leadership scientific identity, and scientific values. Median (Mdn) with interquartile ranges (IQR) expressed central tendency and the spread of the middle half of the nonparametric data.

The Wilcoxon rank sum test for nonparametric variables compared pre- and post- self-efficacy for research competencies, scientific communication, leadership scientific identity, scientific values, and intention to pursue a research career in biomedical science. The equation $(r) = Z/\text{square root of } N$ estimated effect size. Alpha was $p < 0.05$.

For written responses to qualitative inquiries, the investigators used a conceptual analysis, with top-down deductive themes and inductive sub-themes. MAXQDA (2021) software analyzed qualitative data.

Ethics

The UAMS institutional review board determined this study was not human subject research.

Results

Participants

Twenty-two ($N = 22$) students participated, with 12 in 2022 and 10 in 2023. Ninety-five percent were URM, women, or first-generation college students (see [Table 1](#)).

Satisfaction

Students were satisfied with the SURP. They rated the SURP positively for: (a) Relevance (83%), (b) Extent the SURP stimulated interest in a biomedical research career (83%), (c) Quality (100%), and (d) Recommending the SURP to other students (100%) (see [Figure 1](#)). Similarly, with the exception of shadowing experiences in the clinical setting, most students were satisfied with each educational activity outside of their mentored research experience ([Table 2](#)).

Mentorship

For the mentored research experiences, the students' median rating for all domains of the mentee-mentor relationship was 7, on a seven-point scale (see [Table 3](#)).

Qualitative inquiry

When asked to discuss the most valuable aspect(s) of the SURP, major themes were networking, hands-on lab training

TABLE 1 Characteristics of the students ($N = 22$).

Characteristic	<i>n</i> (%)
Undergraduate status	
Sophomore	6 (27)
Junior	11 (50)
Senior	5 (23)
First generation college student	
Yes	9 (41)
No	13 (59)
Gender	
Male	7 (32)
Female	15 (68)
Gender identity	
Man	7 (32)
Woman	13 (62)
Non-binary	1 (5)
Preferred not to answer	1 (5)
Hispanic, Latin, or Spanish	
Yes	3 (14)
No	19 (86)
Race	
American Indian or Alaska native	1 (5)
Asian	4 (19)
Black or African American	3 (14)
Native Hawaiian or Pacific Islander	2 (10)
White	9 (43)
Other or unknown	2 (10)
Preferred not to answer	1 (5)

and skills, mentee-mentor relationships, and research experience ([Table 4](#)). The participants' suggestions for improving the SURP were: (a) Better pairing of mentees with mentors, (b) Fewer and more interactive seminars, and (c) More clinical and shadowing opportunities. We then asked participants to discuss how the SURP affected their ability to conduct research. Many indicated they had a better understanding of research, learned new lab techniques, and had more interest in research. We also wanted to know if the SURP affected how participants identified with the role of scientists. An overwhelming number of participants indicated they had a "better understanding of research and the role of a scientist." The next question asked participants to discuss how the SURP affected how they value the objectives of the scientific community. Several participants mentioned more value and appreciation for the scientific community, including a better understanding of the importance of science in relation to medicine as well as more appreciation and respect for the scientific community. How the SURP affected the intent to pursue a science related research career received mixed responses. Some participants indicated the

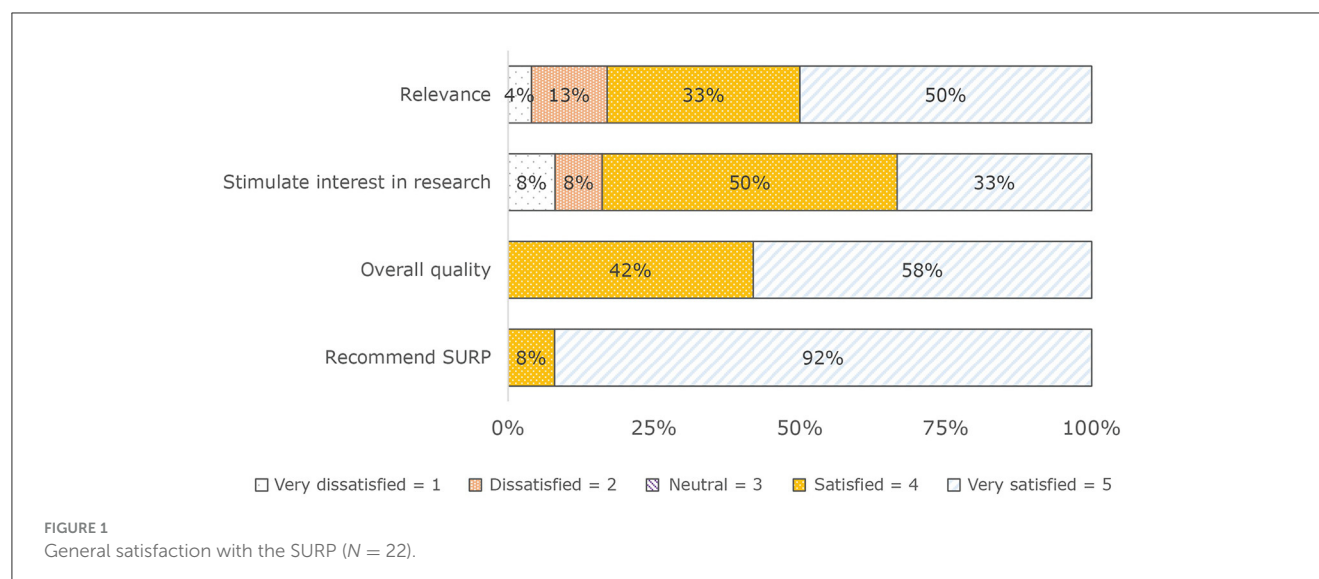


TABLE 2 Satisfaction with specific SURP activities (N = 22).

Activity	1	2	3	4	5	M (SD)	Mnd (IQR)
SURP overview in orientation	0 (0)	0 (0)	2 (9)	6 (27)	14 (64)	4.6 (0.67)	5 (1)
Radiation and lab safety	0 (0)	0 (0)	4 (18)	6 (27)	12 (55)	4.4 (0.79)	5 (1)
Preparing a curriculum vitae	0 (0)	0 (0)	3 (14)	4 (18)	15 (68)	4.6 (0.74)	5 (1)
Writing and talking science	0 (0)	0 (0)	4 (18)	7 (32)	11 (50)	4.3 (0.78)	4.5 (1)
Data acquisition, lab notebooks, management, and ownership	0 (0)	1 (5)	1 (5)	8 (36)	12 (55)	4.4 (0.8)	5 (1)
Careers panel discussion	0 (0)	1 (4)	0 (0)	7 (32)	14 (64)	4.6 (0.74)	5 (1)
Ethics case studies	0 (0)	0 (0)	1 (5)	6 (27)	15 (68)	4.6 (0.58)	5 (1)
Shadowing experience in clinical setting	3 (14)	2 (9)	2 (9)	2 (9)	13 (59)	3.9 (1.5)	5 (2)
Networking seminar	0 (0)	1 (5)	2 (9)	7 (32)	12 (55)	4.4 (0.85)	5 (1)
From discovery to clinical trials	0 (0)	1 (5)	3 (14)	7 (32)	11 (50)	4.3 (0.88)	4.5 (1)
Research presentations	0 (0)	0 (0)	4 (18)	4 (18)	14 (64)	4.5 (0.8)	5 (1)

SURP, Summer Undergraduate Research Program; M, mean; SD, standard deviation; Mnd, median; IQR, interquartile range. Scale: 1 = Poor; 5 = Excellent.

SURP confirmed their intent to pursue a science related research career, while others said it prompted their intent to pursue both an MD/PhD, and a few indicated it stimulated their interest in conducting clinical research as a physician.

(IQR) = 3 (2); Post: M (SD) = 3.6 (0.7); Mnd (IQR) = 4 (1) (see Figure 2).

Self-efficacy in research competencies

Post-SURP, students reported higher self-efficacy score for each research competency: (a) Understand literature Pre: M (SD) = 3.2 (0.9); Mnd (IQR) = 3 (1); Post: M (SD) = 3.7 (0.5); Mnd (IQR) = 4 (1); (b) Explain hypothesis (Pre: M (SD) = 3.4 (0.7); Mnd (IQR) = 3.5 (1); Post: M (SD) = 3.8 (0.5); Mnd (IQR) = 4 (0); (c) Execute experiments: Pre: M (SD) = 3.1 (1); Mnd (IQR) = 3 (1); Post: M (SD) = 3.9 (0.4); Mnd (IQR) = 4 (0); (d) Variable relationship: Pre: M (SD) = 3.1 (0.9); Mnd (IQR) = 3 (1); Post: M (SD) = 3.8 (0.5); Mnd (IQR) = 4 (0); (e) Basic statistics: Pre: M (SD) = 3 (1); Mnd

Self-efficacy in scientific communication and leadership

Post-SURP, students reported higher self-efficacy scores for each facet of scientific communication we measured as well as measures for internal and external leadership (see Tables 5, 6).

Science identity

Post-SURP, students reported higher scores for each facet of science identity: (a) Belonging in science community: Pre: M (SD) = 3.5 (1.2); Mnd (IQR) = 3.5 (2); Post: M (SD) = 4.5 (0.7); Mnd

TABLE 3 Mentoring (N = 22).

Competency	1	2	3	4	5	6	7	M (SD)	Mnd (IQR)
Active listening	0 (0)	0 (0)	1 (4)	2 (9)	1 (5)	4 (18)	14 (64)	6.3 (1.2)	7 (1)
Constructive feedback	0 (0)	0 (0)	1 (5)	1 (5)	0 (0)	4 (18)	16 (73)	6.5 (1.1)	7 (1)
Trust-based relationship	0 (0)	1 (5)	1 (5)	1 (5)	1 (5)	3 (14)	15 (68)	6.2 (1.1)	7 (1)
Accommodate different communication styles	0 (0)	0 (0)	1 (5)	3 (14)	2 (9)	2 (9)	14 (64)	6.2 (1.5)	7 (1)
Communication	0 (0)	0 (0)	1 (5)	4 (18)	0 (0)	1 (5)	16 (73)	6.1 (1.3)	7 (2)
Clear expectations	0 (0)	0 (0)	1 (5)	2 (9)	1 (5)	2 (9)	16 (73)	6.4 (1.2)	7 (1)
Align expectations	0 (0)	0 (0)	2 (9)	1 (5)	3 (14)	3 (14)	13 (59)	6.1 (1.3)	7 (2)
Consider professional & personal differences	0 (0)	0 (0)	0 (0)	2 (9)	2 (9)	2 (9)	16 (73)	6.5 (1)	7 (1)
Help set mentee's research goals	0 (0)	0 (0)	0 (0)	1 (5)	1 (5)	4 (18)	16 (73)	6.6 (0.8)	7 (1)
Develop strategies for mentee to meet goals	0 (0)	0 (0)	0 (0)	1 (5)	2 (9)	3 (14)	16 (73)	6.6 (0.86)	7 (1)
Estimate mentee's scientific knowledge	0 (0)	0 (0)	1 (5)	0 (0)	2 (9)	5 (23)	14 (64)	6.4 (1.1)	7 (1)
Estimate mentee's ability to conduct research	0 (0)	0 (0)	1 (5)	0 (0)	2 (9)	5 (23)	14 (64)	6.4 (1)	7 (1)
Enhance mentee's knowledge and abilities	0 (0)	0 (0)	1 (5)	0 (0)	1 (5)	6 (27)	14 (64)	6.5 (0.96)	7 (1)
Motivate mentee	1 (5)	0 (0)	0 (0)	2 (9)	1 (5)	2 (9)	16 (73)	6.3 (1.5)	7 (1)
Build mentee's confidence	1 (5)	0 (0)	0 (0)	2 (9)	1 (5)	4 (18)	14 (64)	6.2 (1.5)	7 (1)
Stimulate mentee's creativity	1 (5)	0 (0)	0 (0)	2 (9)	2 (9)	3 (14)	14 (64)	6.1 (1.5)	7 (1)

M, mean; SD, standard deviation; Mnd, median; IQR, interquartile range. Scale: 1 = Not at all skilled; 7 = Extremely skilled.

TABLE 4 Qualitative inquiry.

Deductive theme	Inductive sub-themes	Illustrative quotes
Most valuable aspects	• Networking • Hands-on lab skills • Hearing from professionals	The most valuable aspect of the program was my mentor. I also enjoyed the curriculum vitae seminar. I've actually (not) understood how to create one until this summer. Prior to the SURP I had no research experience, and here I got to learn and do real research for the first time.
Suggestions for Improvements	• More guidance and communication from administration • Better clinical opportunities • More interactive seminars	Provide more opportunities for students to shadow (in clinical settings) (Spend) less time on seminars and more time in lab
Biomedical research	• Enhanced ability to conduct research • Enhanced identification with role of scientists • Heightened intention to pursue career scientific research	I can identify a topic, acquire data, assess the evidence, develop conclusions, and share the knowledge I learn thanks to SURP. I believe I exhibit all of the qualities of a scientist. Being able to work directly with (scientists) made me appreciate what they do. It made me see the value in doing research for medicine. It made me affirm my joy for science and understand I can pursue a career in something I'm passionate about. Originally, I was just trying to pursue my MD, but now, since attending SURP, I want to pursue the MD/PhD.

(IQR) = 5 (1); (b) Satisfaction working on science team: Pre: M (SD) = 3.2 (1.2); Mnd (IQR) = 4 (2); Post: M (SD) = 4.7 (0.6); Mnd (IQR) = 5 (1); (c) Identify as a scientist: Pre: M (SD) = 3.5 (1.4); Mnd (IQR) = 4 (3); Post: M (SD) = 4.7 (0.6); Mnd (IQR) = 5 (1); (d) Belonging in science field: Pre: M (SD) = 3.8 (1.2); Mnd (IQR) = 4 (2); Post: M (SD) = 4.5 (0.9); Mnd (IQR) = 5 (1); (e) Scientists' work is appealing: Pre: M (SD) = 3.6 (1.2); Mnd (IQR) = 4 (1); Post: M (SD) = 4.5 (1); Mnd (IQR) = 5 (1) (see [Figure 3](#)).

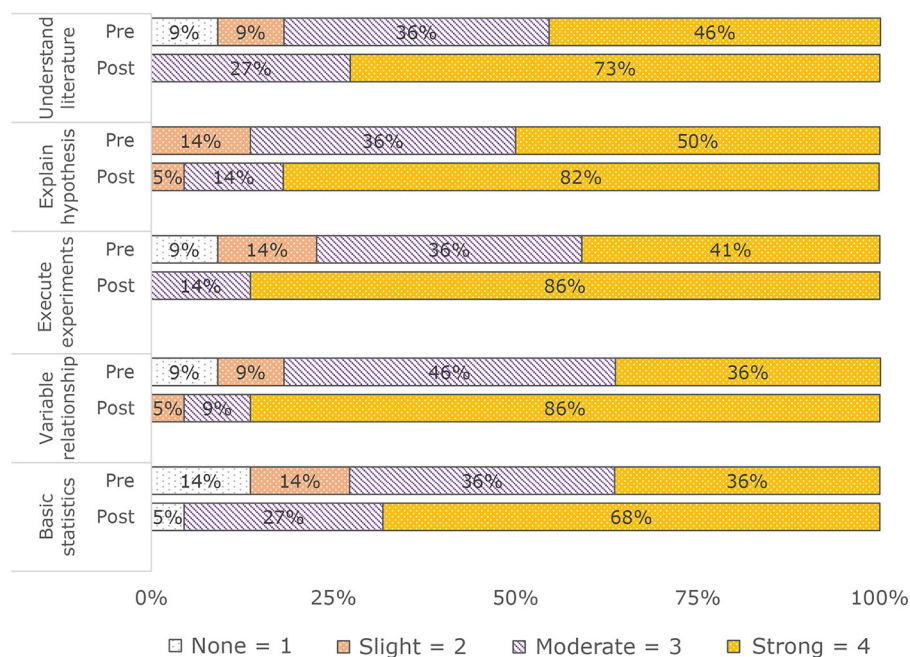


FIGURE 2
Pre/post research competencies (N = 22).

Valuing objectives of the scientific community

Post-SURP, students reported higher scores for each facet of valuing the objectives of the scientific community: (a) Valuable to conduct research: Pre: M (SD) = 3.8 (1); Mnd (IQR) = 4 (2); Post: M (SD) = 4.6 (0.7); Mnd (IQR) = 5 (1); (b) Discovery in science is thrilling: Pre: M (SD) = 4.2 (1); Mnd (IQR) = 4 (1); Post: M (SD) = 4.6 (0.7); Mnd (IQR) = 5 (1); (c) Discussing new theories and ideas is important: Pre: M (SD) = 4.1 (1); Mnd (IQR) = 4 (1); Post: M (SD) = 4.6 (0.7); Mnd (IQR) = 5 (1); (d) Scientific research can solve world challenges: Pre: M (SD) = 4.3 (0.9); Mnd (IQR) = 4 (1); Post: M (SD) = 4.6 (0.7); Mnd (IQR) = 5 (1) (see Figure 4).

Comparison of pre- and post-outcomes for construct totals and intention to pursue biomedical research career

Compared to pre-SURP measures, post-SURP measures were significantly higher with medium or large effect sizes (see Table 7).

Discussion

Summary of the results

Study results demonstrated students were satisfied with the SURP and rated their mentee-mentor relationships highly. Compared to pre-SURP, self-efficacy in research, scientific communication, and leadership as well as increased science

identity and valuing the objectives of the scientific community improved post-SURP. Further, compared to pre-SURP, post-SURP students indicated a stronger intention to pursue a career in biomedical research. Qualitative inquiry revealed the SURP encouraged students' to strongly identify with science, value the scientific community's objectives, and intend to pursue a biomedical research career.

Explanation of the results

The Tripartite Integration Model of Social Influence helps explain our findings (28, 29). The model provides a framework for explaining how a URM student orients to a scientific community/research environments (11). The model posits individuals socialize into a group through three processes: building scientific efficacy (i.e., following rules and norms for rewards, minimizing punishment), building scientific identity (i.e., developing a social identity that includes the environment), and internalizing scientific community values (i.e., embracing and sharing the values of the group/research (31)). Our results suggest: (a) The SURP contributed to the students' increased self-efficacy and (b) Increased self-efficacy generated by the SURP program may have influenced the students' intention to pursue a scientific career. Immersive mentored research projects and hands-on laboratory training help explain students' increased self-efficacy in research, scientific communication, and leadership. In turn, increased self-efficacy likely explains the students' increased science identity and valuing objectives of the scientific community, which may explain their enhanced intention to pursue a biomedical research career.

TABLE 5 Pre/post scientific communication (N = 22).

Communication skill	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	M (SD)	Mnd (IQR)
Write using correct grammar							
Pre	0 (0)	1 (5)	4 (18)	9 (41)	8 (36)	4.1 (0.9)	4 (1)
Post	0 (0)	0 (0)	0 (0)	5 (23)	17 (77)	4.8 (0.4)	5 (0)
Write abstract							
Pre	1 (5)	6 (27)	3 (14)	3 (14)	9 (41)	3.6 (1.4)	4 (3)
Post	0 (0)	1 (5)	2 (9)	5 (23)	14 (64)	4.5 (0.9)	5 (1)
Manage anxiety about writing							
Pre	0 (0)	2 (9)	5 (23)	6 (27)	9 (41)	4.0 (0.1)	4 (2)
Post	0 (0)	0 (0)	0 (0)	7 (32)	15 (68)	4.7 (0.5)	5 (1)
Excel in scientific presentations							
Pre	0 (0)	5 (23)	5 (23)	4 (18)	8 (36)	3.7 (1.2)	4 (2)
Post	0 (0)	0 (0)	3 (14)	4 (18)	15 (68)	4.6 (0.8)	5 (1)
Give an oral presentation							
Pre	0 (0)	0 (0)	8 (36)	5 (23)	9 (41)	4.1 (0.9)	4 (2)
Post	0 (0)	0 (0)	2 (9)	5 (22)	16 (70)	4.6 (0.7)	5 (1)
Require little assistance with speaking and presenting							
Pre	1 (5)	2 (9)	7 (32)	5 (23)	7 (32)	3.7 (1)	4 (2)
Post	0 (0)	0 (0)	2 (9)	4 (18)	16 (73)	4.6 (0.7)	5 (1)
Defend point of view in a scientific discussion							
Pre	0 (0)	1 (5)	9 (41)	4 (18)	8 (36)	3.9 (1)	4 (2)
Post	0 (0)	0 (0)	2 (9)	5 (23)	15 (68)	4.6 (0.7)	5 (1)
Answer questions in scientific discussion							
Pre	0 (0)	2 (9)	7 (32)	5 (23)	8 (36)	3.9 (1)	4 (2)
Post	0 (0)	0 (0)	1 (5)	7 (32)	14 (64)	4.6 (0.6)	5 (1)
Speak using correct grammar							
Pre	0 (0)	0 (0)	2 (9)	9 (41)	11 (50)	4.4 (0.7)	4.5 (1)
Post	0 (0)	0 (0)	0 (0)	6 (27)	16 (73)	4.7 (0.5)	5 (1)
Manage worries about speaking							
Pre	0 (0)	0 (0)	4 (18)	6 (27)	12 (55)	4.4 (0.8)	5 (1)
Post	0 (0)	0 (0)	0 (0)	6 (27)	16 (73)	4.7 (0.5)	5 (1)
Ask question or add comment during discussion in the lab							
Pre	0 (0)	2 (9)	5 (23)	6 (27)	9 (41)	4 (1)	4 (2)
Post	0 (0)	0 (0)	1 (5)	5 (23)	16 (73)	4.7 (0.6)	5 (1)
Ask a question in front of audience after a presentation							
Pre	0 (0)	4 (18)	5 (23)	3 (14)	10 (46)	3.9 (1.2)	4 (2)
Post	0 (0)	1 (4)	2 (9)	5 (22)	14 (64)	4.5 (0.9)	5 (1)
Use scientific speaking style							
Pre	0 (0)	3 (14)	5 (23)	5 (23)	9 (41)	3.9 (1.1)	4 (2)
Post	0 (0)	0 (0)	1 (5)	6 (27)	15 (68)	4.6 (0.6)	5 (1)
Introduce self and research							
Pre	0 (0)	2 (9)	5 (23)	4 (18)	11 (50)	4.1 (1.1)	4.5 (2)
Post	0 (0)	0 (0)	0 (0)	5 (23)	17 (77)	4.8 (0.4)	5 (0)

M, mean; SD, standard deviation; Mnd, median; IQR, interquartile range.

TABLE 6 Pre/post leadership (N = 22).

	1	2	3	4	5	6	7	M (SD)	Mnd (IQR)
Self-awareness and confidence									
I can identify my strengths and weaknesses									
Pre	0 (0)	0 (0)	1 (5)	1 (5)	4 (18)	10 (45)	6 (27)	5.9 (1)	6 (2)
Post	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8 (36)	14 (64)	6.6 (0.49)	7 (1)
I am confident in my ability to get things done									
Pre	0 (0)	1 (5)	0 (0)	3 (14)	1 (5)	7 (32)	10 (46)	6.0 (1.4)	6 (1)
Post	0 (0)	0 (0)	0 (0)	0 (0)	2 (9)	4 (18)	16 (73)	6.6 (0.66)	7 (1)
I always know how to get the best out of situations									
Pre	0 (0)	1 (5)	0 (0)	4 (18)	2 (9)	6 (27)	9 (41)	5.8 (1.4)	6 (2)
Post	0 (0)	0 (0)	0 (0)	0 (0)	4 (18)	5 (23)	13 (59)	6.4 (0.8)	7 (1)
I can help group members to reach the group's target									
Pre	0 (0)	0 (0)	1 (5)	4 (18)	0 (0)	8 (36)	9 (41)	5.9 (1.3)	6 (2)
Post	0 (0)	0 (0)	0 (0)	0 (0)	3 (14)	5 (23)	14 (64)	6.5 (0.74)	7 (1)
I am able to affirm my beliefs and values									
Pre	0 (0)	0 (0)	1 (5)	3 (14)	3 (14)	4 (18)	11 (50)	6.0 (1.3)	6.5 (2)
Post	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	5 (23)	16 (73)	6.7 (0.57)	7 (1)
Interpersonal relations									
I can establish very good relationships with the people I work with									
Pre	0 (0)	0 (0)	0 (0)	0 (0)	5 (23)	6 (27)	11 (50)	6.3 (0.83)	6.5 (1)
Post	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (32)	15 (68)	6.7 (0.48)	7 (1)
I am sure I can communicate with others, going right to the heart of the matter									
Pre	0 (0)	0 (0)	0 (0)	1 (5)	5 (23)	5 (23)	11 (50)	6.2 (0.96)	6.5 (2)
Post	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	6 (27)	15 (68)	6.6 (0.58)	7 (1)
I can successfully manage relationships with all members of a group									
Pre	0 (0)	0 (0)	0 (0)	1 (5)	5 (23)	5 (23)	11 (50)	6.2 (0.96)	6.5 (2)
Post	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (27)	16 (73)	6.7 (0.46)	7 (1)

M, mean; SD, standard deviation; Mnd, median; IQR, interquartile range. Scale: 1 = Absolutely false; 7 = Absolutely true.

Comparison with other studies

Our results were consistent with that of other studies that demonstrated the influence of summer research programs on intention to pursue a career in the biomedical research workforce. A previous report about our SURP demonstrated students had positive and sustained interactions with mentors and the SURP influenced their career goals (39). The current study extends these results. Hernandez et al. (31) found development of science identity and values was associated with intention to pursue a STEMM career in undergraduates in several summer research programs. A qualitative study of the Arkansas IDeA Network of Biomedical Research Excellence Summer Research Fellowship found providing mentored research experiences for undergraduate students enhanced their interest in pursuing a career in the biomedical research workforce (40). A study in Idaho revealed improvements in science identity were associated with transitioning from summer undergraduate research to graduate

school. The study found 91.4% of summer research students entered a scientific or healthcare related career, while 71% pursued graduate training, citing improved awareness of science as a cause of pursuing in the workforce pipeline (41). Similarly, the K-INBRE, a summer undergraduate research program in Kansas, identified career awareness as a critical component of program success, with 37% of students matriculating into graduate programs, 19% into medical school, and 12% into health-related professions (42). Yassa et al. (43) reported improvement in science self-efficacy and identity as well as visualization of a career as a scientist, in students predominantly from a Historically Black Universities after they participated in a mentored summer research program at the University of California. Both the Short-term Research Education Program to Increase Diversity in Health-Related Research Fellowships and the Integrative Organismal Systems Physiology Fellowships enrolled underrepresented students (44). However, none of the programs in these studies specifically targeted URM and female students in a rural, low-income southern state and

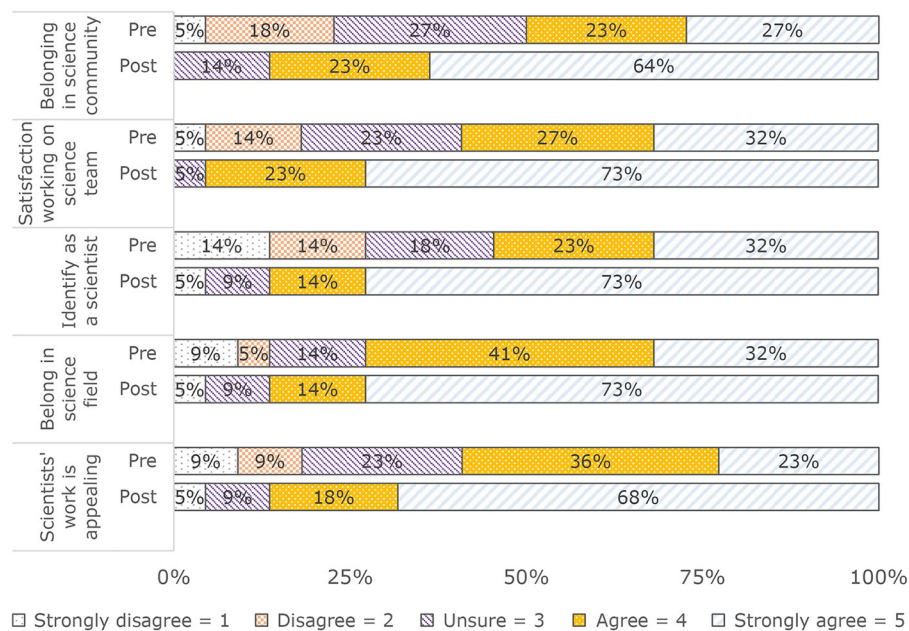


FIGURE 3
Pre/post identify with science (N = 22).

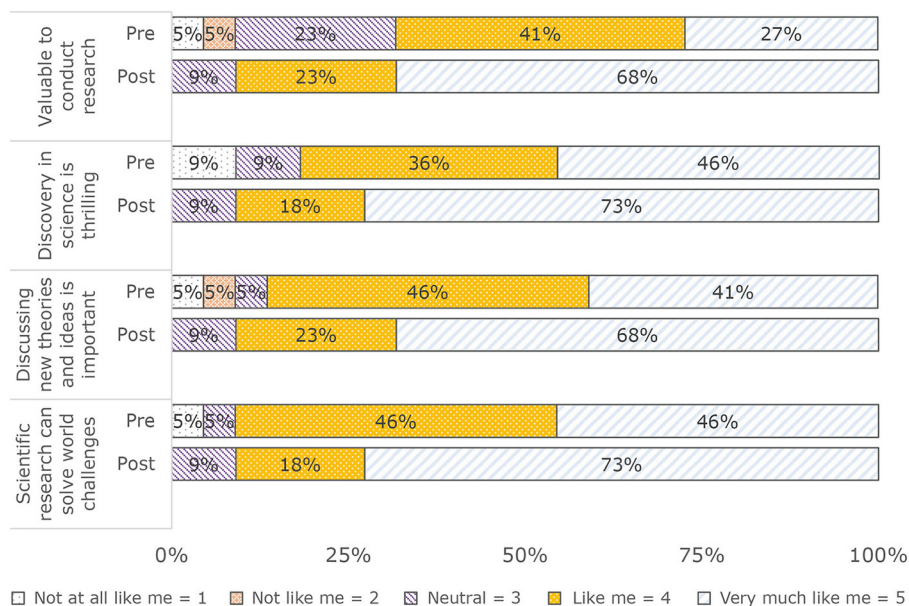


FIGURE 4
Pre/post value scientific community objectives (N = 22).

reported outcomes that included science identity and alignment of values with the scientific community, which are components of the Tripartite Integration Model of Social Influence.

Summer research programs increased the probability of retaining students in the pipeline by expanding career awareness components of the programs beyond their common elements, such as lectures and lab exposure. This expansion could include a

framework for career intention, such as the Tripartite Integration Model of Social Influence. Effective career awareness programs do the following: (a) Engage family, teachers, and friends of the students and (b) Use socialization initiatives to rebrand science, such as mitigating negative gender connotations (45). However, unlike the SURP, previous summer research programs do not universally integrate these strategies for enhancing career intention.

TABLE 7 Pre/post comparisons of construct totals (N = 22).

Variable	M (SD)	Mnd (IQR)	Ranks ^a	Effect size ^b	p-value ^c
Research competencies ^d			Positive 11	0.64	0.003
Pre	0.78 (0.2)	0.78 (0.4)	Negative 1		
Post	0.94 (0.1)	1.0 (0.1)	Ties 10		
Communication ^d			Positive 15	0.73	<0.001
Pre	0.79 (0.2)	0.80 (0.4)	Negative 0		
Post	0.93 (0.1)	1.0 (0.2)	Ties 7		
Leadership: self-awareness and confidence ^d			Positive 15		
Pre	0.84(0.2)	0.87 (0.2)	Negative 1	0.63	0.003
Post	0.94 (0.1)	0.97 (0.1)	Ties 6		
Leadership: interpersonal relations ^d			Positive 9		
Pre	0.89 (0.1)	0.93 (0.2)	Negative 0	0.57	0.007
Post	0.95 (0.1)	1.0 (0.1)	Ties 13		
Identify with science ^d			Positive 16		
Pre	0.72 (0.2)	0.76 (0.4)	Negative 1	0.73	<0.001
Post	0.91 (0.2)	1.0 (0.2)	Ties 5		
Value scientific community objectives ^d			Positive 14		
Pre	0.82 (0.2)	0.80 (0.2)	Negative 0	0.71	<0.001
Post	0.93 (0.1)	1.0 (0.2)	Ties 8		
Intention to pursue a science related research career ^d			Positive 15		
Pre	0.71 (0.3)	0.75 (0.4)	Negative 4	0.43	0.03
Post	0.80 (0.3)	0.93 (0.4)	Ties 3		

M, mean; SD, standard deviation; Mnd, median; IQR, interquartile range. ^aRanks compare each student's pre and post scores. ^bEffect size (r) = $Z/\text{square root of } N$; r 0.10–0.30 = small effect size; r between 0.30 and 0.5 = medium effect size; $r > 0.50$ = large effect size. ^cWilcoxon Rank Sum Test. ^dTotal score of all construct items/Total possible highest score of all construct items.

Limitations

This study had several limitations. Prominent among them was the use of self-reported data. Students could have provided inaccurate responses. However, the questions were anonymous, evidence exists for validity of the outcomes measures, and our findings were consistent with that of other studies. Additionally, the retrospective post then pre design could have introduced a recall bias. However, we used this design to help avoid response-shift bias seen with traditional pre-post measures, that is, students' pre-SURP self-evaluation overestimation of their self-efficacy, values, and intentions, which could result in underestimation of the SURP outcomes (31, 32).

Implications

Our study supports implementation of a biomedical research pipeline for URM and women in a poor, rural, and settings. Future studies should examine long-term academic and career outcomes and, ultimately, the impact on health disparities.

Data availability statement

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

Author contributions

MA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. LP: Data curation, Formal analysis, Funding acquisition, Project administration, Writing – original draft, Writing – review & editing. TW: Data curation, Funding acquisition, Writing – original draft, Writing – review & editing. RM: Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing. BT: Funding acquisition, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. AA: Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Solidifying the minority high school student pathway: evidence from the health professions recruitment and exposure program

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Purpose: The objective of this report is to provide longitudinal insights on the impact of a health professions exposure program for high school students of underrepresented backgrounds in medicine.

Context: Medical students at the University of Chicago reviewed data from their chapter of the Health Profession Recruitment and Exposure Program (HPREP) from 2016–2021 to discover trends in enrollment. This data is documented in the context of the program's mission to increase awareness of health disparities, the success of prominent alumni, and recent community efforts post-COVID-19 pandemic.

Findings: Two hundred and ninety-nine high school students participated in the University of Chicago HPREP program between 2016 and 2021. Participants ranged in age from 12 to 18 years (mean = 16, SD = 1) and 74% ($n = 222$) were female students. Of 252 respondents, 58% ($n = 147$) identified as Black or African American, 31% ($n = 77$) identified as Latinx or of Hispanic origin, and 10% ($n = 24$) identified as another race or as bi-racial. Ten or fewer black male students participated in the program every year, including the 2020–2021 year in which 61 students participated.

Conclusions: HPREP has played an important role in shaping the face of health care, especially in Chicago. The data suggests significant increases in the number of underrepresented minority women becoming physicians and serving Chicago communities in the next decade. Pathway programs for underrepresented students in medicine should be strategic in recruiting and educating future health professionals based on future workforce needs.

KEYWORDS

health care professionals, pipeline program, underrepresented minorities (URM), diversity and inclusion, medical education

1 Introduction

Diverse health care teams are associated with improved patient outcomes (1). There is no better time to address this topic. Currently, black patients are twice as likely as white patients to have negative identifiers in their health records and black maternal mortality rates are three times higher than the rate of their counterparts (2, 3). Achieving this diverse

health care team becomes difficult when <10% of physicians are people of color, even though 25% of the U.S. population represents those demographics (4, 5). Compared to the 47% increase in medical school applicants overall, medical school matriculants from ethnic and racial minority backgrounds have grown by <2% since 1980 (6).

While more medical schools are being built to address the national doctor shortage, addressing representation has been more challenging. Black student representation amongst medical students decreased from 8.1% in 1994 to 7.1% in 2015 (7). A report from the Association of American Medical Colleges of medical school applicants from 1978 to 2014 found that the number of black men decreased, even though every other minority group increased representation during this time (8). Despite increased college graduation rates for black males and efforts to improve diversity in medical school applicants, the number of black male applicants in 1978 to 2014 dropped from 1,410 to 1,337; matriculants dropped from 542 to 515 during that same time interval (8, 9).

Underrepresented women in the medical field - while rising in number - have had difficulty reaching specific medical specialties and positions of power. Even though one study found that women constituted nearly 50% of the graduating medical student class in 2012, only 7 out of 20 of the largest medical specialties had women entering at proportions of 50% or more, with more underrepresentation seen in African American and Hispanic populations in particular (10). In addition, underrepresented in medicine (URM) women are marginalized in nearly all specialties in academic medicine professorship outside of lecturer and instructorship positions (11) (for program definition of URM, see [Supplementary Appendix](#)). Only 14% of United States academic department chairs were women, with non-White women consisting of only 3% of that number (12). Cited reasons for these discrepancies include workplace microaggressions that create a discriminatory environment, a lack of mentorship and opportunities for URM populations and women due to decreased visibility and leadership of minorities, and a culture of exclusion within hospitals' traditions that attack their sense of belonging (10).

Patterns of underrepresentation are present in other health-related fields, which play a role in provider-level decision making and biases. In 2000, over 2,250 veterinary degrees were awarded across the US, with only 74 people of Hispanic descent, 49 African Americans, and 14 Native-American receiving degrees (13). The U.S. Department of Health found that nursing, the nation's largest health care profession, was 4.6% African American, 1.8% Latinx, 0.4% Indigenous or Alaskan Native, and 1.5% from two or more racial backgrounds in a 2004 survey (14). 81% of nurses in 2020 were White/Caucasian (15). While not representative of the US population, the nursing population is becoming more racially diverse. Nursing has historically been a female-dominated practice, with 10% of the nursing workforce being male (16). Perhaps more problematic is that men in nursing have dominated managerial positions (17, 18). Across all health fields, women make up 78.4% of healthcare and social workers in the US, however, representation of women in individual fields like medicine, nursing and physical

therapy is unequally distributed (19). Mirroring the importance of diverse physicians from underrepresented backgrounds in medicine, diversity in these fields may improve patient experience (17, 20).

Efforts to address these growing issues are limited so far, and notably lack long-term outcomes (21). Medical students at the University of Pennsylvania designed a free guide to the medical school admissions process to support underrepresented and/or low-income students (4). Other programs have been administration-led, like the Florida State University School of Medicine "Bridge to Clinical Medicine" program that aims to accept more diverse medical students (16). However, these types of initiatives are not designed to expose medicine to students from underrepresented backgrounds. Early health care exposure is known to have more influence in increasing interest in medicine compared to late intervention (22).

To help improve diversity among health care professionals, the Health Professions Recruitment and Exposure Program (HPREP) brings high school students from URM backgrounds to science-related activities as well as multiple health careers (23). This program also allows students to improve important skills such as working in teams, performing research, and public speaking (see [Supplementary Appendix](#)). The goal of this case study is to present insights from the University of Chicago chapter of HPREP during the 2016–2021 program years within the context of its community and national trends. This report also describes the positive impact similar initiatives can promote and encourages them to build upon the lessons learned from this case experience in the future.

2 Context

The University of Chicago Pritzker School of Medicine has housed a chapter of HPREP that allows Chicago youth to interact with medical students, physicians, nurses, physical therapists, pharmacists, scientists, and other health professionals based on the South Side of Chicago since 2004. This is performed by hosting 6 weekly sessions for roughly 7 h each week. In keeping this program thriving for 20 consecutive years, this chapter hopes to help cultivate the next generation of Black and Brown healthcare professions who will 1 day serve their local communities as providers.

HPREP focuses its recruitment to schools in Chicago's South and West sides. Recruitment consists of emailing, visiting partnered schools, and presenting the HPREP program in person to students. Bus passes are provided to help students transport from their communities to the University of Chicago Pritzker School of Medicine and back every Saturday. The program consists of in-person educational activities like suture practice, "Stop the Bleed" training, and presentations related to decreasing local health care disparities (see [Supplementary Appendix](#)). Post-workshop surveys are distributed to students to understand their thoughts on each activity. Post-program evaluation surveys are sent out during the final Saturday while students are still on campus. Food and drinks are catered through local stores and businesses. All associated costs are paid for through an annual budget allocated by the University of Chicago Office of Civic Engagement.

Abbreviations: HPREP, Health Professions Recruitment and Exposure Program; URM, Underrepresented in Medicine.

During the 2020–2021 “pandemic” season, program leadership reached out to school counselors individually to advertise the program to students (see [Supplementary Appendix](#)). Scheduling and operations that year were significantly altered to continue to engage prospective high school students. The program was virtual with Zoom sessions. Program leadership adapted the normally in-person activities to be suitably completed from home (see [Supplementary Appendix](#)). Project materials were mailed to residences, including diplomas upon completion of the program. Other mailed items included T-shirts and stethoscopes that were donated by the University of Chicago Pritzker School of Medicine Admissions team and the University of Chicago Department of Surgery.

3 Detail to understand key programmatic elements

Between 2016 and 2021, the University of Chicago HPREP chapter attracted 299 students from 61 total schools. Of these schools, ~5% were private and the rest were public, including charter and magnet schools. Twelve (20%) more student participated in the 2021 cohort compared to the 2020 cohort. The median distance of these schools from the UChicago main campus is 10.2 miles. HPREP has also recruited students from more than 20 organizations around Chicago with various missions to enhance research experience, communication skills, and college readiness among minority populations. The median distance of these organizations from the UChicago main campus is 8.3 miles.

Participants ranged in age from 12 to 18 years (mean = 16, SD = 1) with 74% ($n = 222$) being female students ([Figure 1](#)). Of 252 respondents, 58% ($n = 147$) identified as Black or African American, 31% ($n = 77$) identified as being Latinx or of Hispanic origin, and 10% ($n = 24$) identified as another race or as bi-racial ([Figure 2](#)). Ten or fewer black male students participated in the program every year, including the 2020–2021 year in which 61 total students participated ([Figure 3](#)).

The impact of these sessions on students is evaluated through post-program evaluation surveys. After the 2020–2021 program, students felt more comfortable reaching out to an adult for career advice (100%), understanding (97%) and combating (81%) healthcare disparities, and having someone they consider to be a mentor (81%) ([24](#)). During the health professions session that took place in the 2020–2021 year, one student remarked: “The most important thing I learned in this session is that you can have a nice life even with all of the stress from medical school. No one actually said this but just from the smiles on everyone’s face made me happy.” During the college readiness session, another student commented: “The most important thing I learned from this session was advice on how to stay motivated on days you feel unmotivated. You just have to keep striving for those small goals to get to your big goal and it is okay to remind yourself once in a while why you are working hard.” These comments demonstrate how impactful the program is on students directly after the program; however, the exposure to diverse professions, skills, and knowledge remains the primary barometer of program success. Especially given the relatively young age of the UChicago HPREP students, we hope

that their experience will fuel them as they strive to enter the health professions and serve underrepresented populations.

4 Discussion

Estimating the implications of these five cohorts is challenging, but there is an established precedent for success from program alumni. Dr. Abdullah Pratt, an emergency medicine physician at the University of Chicago Medical Center, is a graduate of HPREP and the University of Chicago Pritzker School of Medicine. He has been instrumental in creating and maintaining several health-related programs for Chicago youth and was instrumental in gaining support for the University of Chicago’s Trauma Center ([25](#), [26](#)). Dr. Pratt describes his experience in the program as an integral stepping stone in his desire to become a doctor as it informs his current practice and community engagement efforts. His mentor in HPREP was Dr. Edward McDonald IV, a then Northwestern University Feinberg School of Medicine student and current gastroenterologist at the University of Chicago Medical Center. In addition to his duties as a physician for gastrointestinal disease, Dr. McDonald channels his knowledge and passion for nutrition into the community. After performing a fellowship in clinical nutrition and receiving culinary training, he created a website and children’s book aimed at improving the health through nutrition education ([27](#), [28](#)).

4.1 Lessons learned

Based on the University of Chicago HPREP’s experiences, the team has learned how to better cultivate future healthcare leaders within its community. Programs that aim to replicate this example may benefit from considering the following lessons.

4.1.1 Developing partnerships and involving your community in your vision

Prior to the COVID pandemic, this chapter of HPREP focused primarily on its students. The post-pandemic era has been a time to recognize those who have been constant supporters and may not know it. Program leadership are building partnerships with businesses that consistently support the program. Showcasing their dedication to increasing underrepresented youth in healthcare to the community may also encourage other businesses to follow their lead.

Developing partnerships with other pathway programs is another potential avenue to create a larger and more unified community. After reaching out to many chapters, program leadership connected with and learned from the chapter at Harvard University, and shared successful practices. DNA extraction experiments that could be performed at home were acquired after learning from their chapter. There has also been increased interest in expanding and hosting events in collaboration with other Chicago chapters. Given the shared passion to support underrepresented youth in healthcare, teamwork will be paramount in taking HPREP beyond individual institutions and toward the city and state levels.

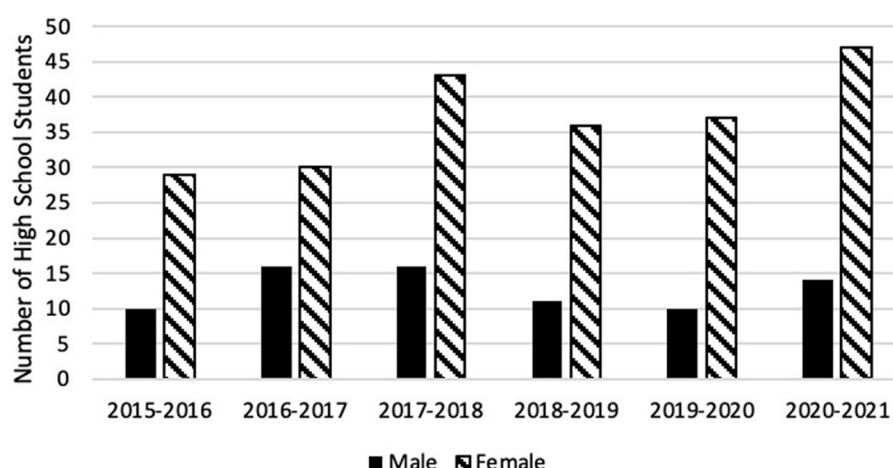


FIGURE 1
HPREP participant gender by cohort year.

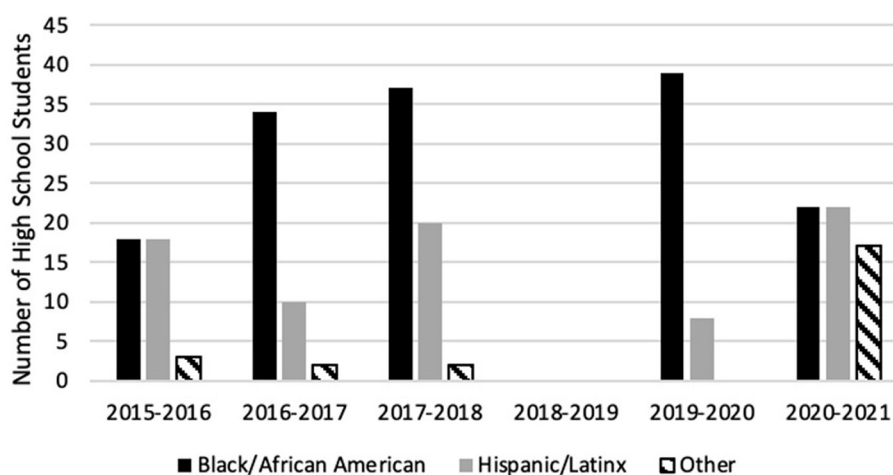


FIGURE 2
HPREP participant racial/ethnic breakdown by cohort year. Racial and ethnic demographic data from 2018 to 2019 cohort year is missing.

4.1.2 Setbacks to successes, and the importance of reflection

While COVID-19 hampered traditional HPREP activities, it was also the catalyst for positive change. Virtual recruitment allowed efforts to expand to the greater Chicagoland area and some nearby underserved areas in Illinois and Indiana. The 20% increase in participation seen in the 2021 cohort compared to the 2020 cohort was likely due to increased funding and reduced need for transportation.

Beyond acute programming changes, the pandemic provided ample time to be reflective about progress. Given revolving leadership within the program, it is difficult to identify success beyond annual program completion and participant satisfaction. The post-pandemic leadership has facilitated a shift toward addressing trends discovered over multiple cohorts instead of reacting to feedback from only the previous year. Currently, the University of Chicago HPREP chapter is more equipped

to identify specific goals and foster targeted solutions to achieve them.

4.2 Strengths, limitations, and recommendations

This is the first published longitudinal data aimed at understanding enrollment from a pipeline program for URM students. We found a striking and near-consistent 3:1 enrollment ratio of underrepresented women in medicine compared to male counterparts in our Chicago-based program. Given the program geography and recruitment strategy, the relative lack of black male enrollment is concerning. This work reiterates that pathway programs may be a root cause of national trends in medicine and underscores their importance going forward (7, 8).

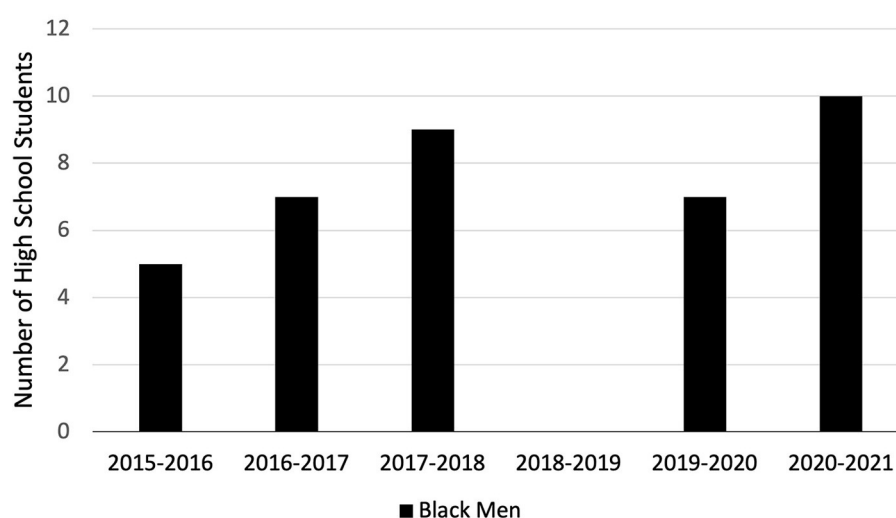


FIGURE 3

HPREP black male participants by year. Racial and ethnic demographic data from the 2018–2019 cohort year is missing.

The practical implications that stem from this include enacting intentional and strategic efforts addressing the disparities present within local and global communities, and promoting the people and institutions that are dedicated to them. The University of Chicago HPREP is strengthened by the examples set by its clinicians, primarily the physician alumni. These physicians have helped their communities in unique ways, from advocating for a level 1 trauma center on the south side of Chicago to teaching the community about healthy eating habits through children's books and other media. Seeing people who were born and raised in similar neighborhoods and understand local experience can be impactful for students and help promote sustainability and continuous innovation of the pathway.

This report has several limitations. While we are the first group to provide published longitudinal data from our pathway program, this data does not provide college or graduate school admissions outcomes. Large time periods between program participation and eventual enrollment, lost institutional memory within program leadership, and low survey response rates by cohort members post-program make this data difficult to collect. Program leadership and mentors are primarily physicians and surgeons, so other careers in healthcare are underrepresented and likely undertaught to cohort members each year. Guests from other careers are present, but typically for only one of the six workshops. Enrollment may be a result of the methods used to promote the program, even though the choice to apply is based on individual capacity and decisions (see [Supplementary Appendix](#)).

Given the experience and lessons learned from this case study, other pathway programs should consider the following actionable recommendations:

1. Consider the program's evolving goals, reflect on how the program structure reflects them, and make changes accordingly. This includes asking participants why they chose to apply to the program, how they heard about it and implementing recommendations from their feedback. This would have been especially useful in this program to target

recruitment efforts toward black men. Pathway programs should at least have pre and post-program evaluations to understand changes in perspectives, skills, and knowledge by the end of the program.

2. Promote longitudinal evaluations by preserving core aspects of the program. This is key to interpret program trends and determine where more progress can be made. For instance, keep qualitative questions about which healthcare fields participants like at the end of the program and maintain those question for years.

3. Programs should build systems made with the goal of sustainability and progress in mind, especially if they have revolving leadership. Descriptive information about admissions, budgets, resources, contacts, schedules, outcomes are important for most programs, but others may be useful too. While it is difficult to obtain outcomes data that “proves” the utility of these programs, one suggestion is to create a “mentor and alumni network” such that alumni can expect to be contacted on a frequent basis, whether for mentorship or career outcome purposes.

4. Programs should maintain individual initiatives, but also establish connections between programs in the same city or region. These collaborations will broaden each team's perspectives, and ultimately enrich participants' experiences.

5 Conclusions

HPREP continues to have a large influence in shaping the face of healthcare, especially in Chicago, IL. This report aimed to present insights from the University of Chicago HPREP chapter and describe its impact on the local community. The data suggests significant increases in the number of underrepresented minority women becoming physicians and serving Chicago communities in the next decade. The strengths (and pitfalls) of pathway programs may be root causes of national trends in medicine and

special attention should be paid to improve involvement of other groups like black men in medicine. By sharing progress metrics, solutions, lessons learned, and recommendations, this case study helps underscore the potentially vital role of pathway programs in improving the future of health care and provides actionable details encouraging improved pathway programs. Given the importance of diverse medical teams and the impact that programs like HPREP have, pathway programs for underrepresented students in medicine should strategically engage with their local communities to help recruit and educate future health professionals.

Data availability statement

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

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

MA: Conceptualization, Formal analysis, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing. AD: Conceptualization, Data curation, Investigation, Methodology, Resources, Supervision, Visualization, Writing – original draft. DD: Data curation, Methodology, Project administration, Visualization, Writing – original draft. SF: Data curation, Formal analysis, Validation, Writing – original draft. IH: Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft. IS: Conceptualization, Funding

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Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1408859/full#supplementary-material>

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Promoting health and productivity management in small companies through outreach-based public-private partnership: the Yokohama Linkworker Project

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Introduction: With health promotion initiatives in small companies lagging behind those in larger corporations, strengthening health and productivity management in small companies through innovative strategies is an urgent priority. We hypothesized that an outreach strategy involving a public-private partnership would be beneficial for this purpose. The present study examines the implementation of a public-private partnership strategy in Yokohama City, Japan, assessing its impact on health and productivity management in small enterprises, focusing on implementation outcomes.

Methods: As part of the Yokohama Linkworker Project (Y-Link Project), this study describes and examines a public-private partnership program in Yokohama City, Japan, involving the city's government and a private life insurance company. Trained insurance sales representatives served as "Linkworkers" for the program, reaching out to small enterprises in the city. These Linkworkers provided tailored support to these companies, assisting them with obtaining the "Yokohama Health and Productivity Management Certification" issued by the City of Yokohama authorities and collaborating with external entities to offer health promotion programs for employees. Program interventions took place from August to September 2020. The RE-AIM framework was utilized to evaluate the Project. Data were extracted from Linkworkers' activity records, certification records, the Linkworker survey, and follow-up surveys with participating companies at 6- and 18- months post-interventions.

Results: Within 2 months, 71 Linkworkers visited 500 companies (50% were small firms, <50 employees). Among them, 224 (45%) enterprises received certifications, contributing to an increased regional certification rate. Linkworker-assisted companies tended to be significantly smaller in size. The odds ratios of implementing workplace health promotion programs in certified firms, compared to non-certified firms, were 4.09 (95% CI: 1.79–9.35) at 6 months and

2.31 (95% CI: 1.04–5.11) at 18 months. For small firms, the odds ratios were 6.87 (95% CI: 1.74–27.06) at 6 months and 3.42 (95% CI: 1.17–10.03) at 18 months. The certification retention rate at 24 months was 60%, irrespective of company size. Linkworkers perceived the outreach strategy as having a positive impact on their primary operations.

Conclusion: The Y-Link Project's outreach strategy enhanced health and productivity management in small enterprises in Yokohama City, enabling long-term health promotion programs addressing program availability disparities related to company size.

KEYWORDS

occupational health, health disparity, small companies, workplace health promotion, health and productivity management, public-private partnership

1 Introduction

The workplace is an important setting for health promotion; however, efforts are inequitable based on company size. Workplace health promotion programs that promote employee health and productivity (1) are not implemented as often in small companies as in larger ones (2–5). Employees in small companies experience socioeconomic disadvantages, leading to poorer health (6) and a higher mortality risk in old age (7). Health promotion should be adopted in small-scale companies to correct company size-related health disparities in employee health and productivity.

Employee health promotion also benefits employers by reducing healthcare costs and boosting stock prices (8, 9). The employer's investment in employee health promotion is called health and productivity management (HPM) (10). HPM is important in a society with a declining birthrate and an aging population (11). The national award systems in the United States (12), Wales (13), and elsewhere support HPM promotion. Japan has followed suit, recognizing that securing a productive labor force while reducing medical costs are important goals for a nation that is experiencing a rapid decline in birthrate and a population that is aging (14, 15).

Overall, companies implementing HPM have reported better employee health status (16) and higher stock prices (17). However, the uptake of HPM has varied by company size. For example, even though the number of large companies implementing HPM has increased, similar program interventions in smaller companies have not, due primarily to these small businesses' limited capacity to invest in these types of workplace interventions (11). HPM in small companies could enable a reduction in health disparities caused by company size. Yet, to the best of our knowledge, no specific methods or program strategy have been established to promote HPM in these small companies.

Public institutions seeking to promote HPM can create certification programs (15) and award outreach efforts (13); they can also conduct media campaigns about HPM interventions. However, only large companies typically respond to such campaigns, as these public sector actions alone are insufficient to promote and facilitate implementation of HPM in small companies. With cooperation from private sector, public institutions like a city government may be able to do much more, especially when it comes to delivering messaging and information for small companies to consume and trust (18).

In recent years, cooperation between public institutions and private companies in the health sector has become common and is regarded as a public-private partnership (PPP) strategy that could effectively engage private/commercial sector entities (19, 20). Many PPPs in primary healthcare, for example, have increased access to prevention and health services (21). Insurance brokers with small business clients often have greater capacity to work with them and represents a potential bridge between small business owners/companies and outside wellness programs (18). As such, an outreach strategy based on a PPP involving a local government and a private insurance company could be a novel and impactful approach to promoting HPM in small companies—this is the primary hypothesis of the present program evaluation.

The present program evaluation sought to assess the implementation and impact of a novel PPP strategy used to promote HPM in Yokohama, City Japan. This particular strategy and its program interventions targeted micro-and small companies with 49 or fewer employees. Under Japanese law, such small companies are legally exempted from appointing industrial physicians and holding health committee meetings. We evaluated this innovative strategy using the RE-AIM framework—domains include reach, effectiveness, adoption, implementation, and maintenance—(22) to systematically assess the feasibility and implementation progress of these HPM interventions in the small company setting in the real-world.

2 Materials and methods

2.1 Study design and setting

Conducted as part of the Yokohama Linkworker Project (Y-Link Project), this study describes and examines a PPP strategy in Yokohama City, Japan; the program involves the city's government (the City of Yokohama) and a private life insurance company (Company M). Yokohama City, a large commercial city with a population of approximately 3.76 million, actively promotes the HPM certification program. Company M, a mutual life insurance company with around 47,000 employees and branch offices nationwide, including 41 sales offices in Yokohama City with around 2,000 employees, participated in the project. The primary aim of the Y-Link Project is to promote HPM in Yokohama City

		2020					2021												2022												2023		
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Intervention period																																	
Linkworker training sessions		○	○	○			○		○																								
Follow-up survey									○												○												
Yokohama HPM Certification ¹	Application			○																								○					
	Publication of Certification								○																								○

¹ Yokohama Health and Productivity Management Certification

FIGURE 1
Schedule of the study.

companies and encourage health promotion among the city’s citizens. The project commenced in August 2020 and is still ongoing, following a partnership agreement signed by the City of Yokohama and Company M in March 2020. During the intervention period (from August to September 2020; Figure 1), the sales staff from Company M were selected as “Linkworkers” and trained to provide interventions on a company-by-company basis. These trained Linkworkers visited client companies to recommend HPM. Data collection on intervention companies continued until February 2023. Although the Linkworker activities were systematically implemented during the intervention period, the necessity of engaging in post-intervention follow-up activities was decided by each Linkworker.

2.2 Intervention strategy

Linkworkers recommended client companies to pursue the “Yokohama Health and Productivity Management Certification (Y-HPM Certification),” a system certified by the City of Yokohama, as an intervention method for promoting HPM. The certification system, launched in 2017, recognizes companies in Yokohama City that engage in health management. Companies seeking certification must apply to the City of Yokohama in September of the previous year, and the results of the examination are announced in February. The examination criteria include a declaration of systematic HPM implementation, establishment of a promotion system, understanding employee health issues, and implementation and evaluation of WHPPs. The Y-HPM Certification has three levels, with the easiest level available to companies that declare their commitment to the implementation of HPM. Once certified, a company becomes eligible to use the certification mark, publicize it on the city’s website, and receive support and subsidies for its HPM efforts. Financial benefits include favorable loan terms and guarantee fee subsidies. Additionally, certified companies receive preferential treatment in public procurement by the City of Yokohama. Essentially, certified companies receive social recognition, support for health promotion, and economic benefits through Y-HPM Certification. Certification is valid for 2 years; therefore, companies must reapply and undergo an examination every 2 years to maintain their certification.

The companies visited were primarily selected by the Linkworkers from among their existing client companies. Some visits involved follow-up activities, such as reviewing insurance policies, whereas others were simply seasonal greetings. Additionally, there were visits to companies where appointments were made spontaneously with company representatives. During client visits, Linkworkers began by providing explanations about health management and the Y-HPM Certification. They then offered to assist interested companies with their certification applications. Additionally, Linkworkers introduced external public institutions that support WHPPs for companies wishing to implement specific WHPPs for their employees, and helped with applications as needed. These interventions were tailored to meet the specific needs of each client. Linkworker activities were conducted within Company M’s working hours, and no additional salary was provided. To ensure the proper use of Linkworker activities and prevent their use in sales activities, the City of Yokohama and Company M established the “Linkworker Activity Guideline.”

2.3 Linkworker training program

The City of Yokohama and Company M collaborated to train Linkworkers. The group training session was held three times: once before the intervention and twice during the intervention. Additionally, two online follow-up sessions were conducted after the intervention period. A total of 71 corporate sales representatives and sales office managers from 41 Company M offices in Yokohama City participated in the program. The training session included a discussion on the importance of HPM, information on the Y-HPM Certification application process, different external organizations supporting WHPPs, and an opinion exchange workshop. During the follow-up sessions, successful cases were reported, and the results of the Y-HPM Certification were announced. The first session lasted for 180 min, while the subsequent sessions were 90 min each.

2.4 Evaluation methods

In this study, we conducted an assessment using the RE-AIM framework, which has been widely applied in public health and

implementation science for 20 years. The framework bridges the research-to-practice gap and addresses health inequities. Recognized for its transparent reporting, it serves as a valuable tool for strategic planning in disseminating evidence-based interventions (22). The RE-AIM framework comprises five dimensions: reach, effectiveness, adoption, implementation, and maintenance. In this intervention, it was elucidated through the following methods.

“Reach” was examined by analyzing the number and characteristics of client companies visited by Linkworkers during the intervention period. “Effectiveness” was evaluated at two levels: intervention and community. At the intervention level, we assessed the proportion of companies successfully obtaining Y-HPM Certification among those where Linkworkers intervened. At the community level, changes in the number of companies receiving Y-HPM Certification throughout Yokohama City served as indicators of intervention impact. “Adoption” was measured by evaluating the project’s participation rate among Company M’s sales offices in Yokohama City. Additionally, feedback regarding Linkworkers from intervention companies was collected from Yokohama City officials. “Implementation” was assessed by examining the proportion of companies visited by Linkworkers that implemented the intervention. Furthermore, we investigated the specific content of the interventions provided. “Maintenance” was determined by evaluating the implementation status of the WHPPs for employees at 6- and 18-months post-intervention. To gauge the maintenance of Y-HPM Certification, we examined the companies’ re-certification statuses 24 months after their initial certification. Additionally, we investigated the perceptions of Linkworkers regarding the impact on primary operations, to verify whether this innovative strategy can be sustained by private enterprises.

2.5 Key constructs and definitions

Company sizes were categorized by number of employees into “micro” (<5 employees), “small” (5–49 employees), “medium” (50–299 employees), and “large” (≥ 300 employees) (23). In Japan, companies with 50 or more employees are legally obligated to appoint an industrial physician and hold health committee meetings, but companies with 49 or fewer employees are exempted from this rule; hence, the health management in the latter companies tends to be inadequate. Therefore, we focused on evaluating micro-and small companies.

2.6 Data sources and collection

We extracted details from the activity records of Linkworkers, which detailed information about the companies they had visited. This included data on company size, industry type, certification status, and the specifics of the interventions. Data on the number of companies that obtained Y-HPM Certification at the community level and their scale was obtained from the City of Yokohama.

Additionally, we conducted follow-up mail surveys of the companies where interventions had occurred at two time points after the initial intervention—6 months (March 2021) and 18 months (March 2022). The surveys delved into the implementation status of WHPPs related to lifestyle improvement

(“implementing,” “considering implementation,” or “not implemented”), the level of awareness of the HPM at the time of the Linkworker intervention, and impact of the coronavirus disease 2019 (COVID-19) pandemic on business performance. Each of these variables was identified using the following questions: “Does your company plan to implement initiatives to improve the physical activity and dietary habits of your employees (e.g., walking and eating campaigns, lifestyle improvement seminars, introduction of apps, etc.)?”, “Did you know the term ‘health and productivity management’?”, and “Has the COVID-19 epidemic affected your company’s performance?” This follow-up survey aimed to include all visited companies, with responses ideally provided by company presidents or individuals responsible for health management. However, survey questionnaires were not sent to those companies that had previously declined the survey through Linkworkers. The follow-up survey response rates were 56% at 6 months and 51% at 18 months post-intervention. The differences in the characteristics of responded and non-responded companies are detailed in [Supplementary Tables S1, S2](#).

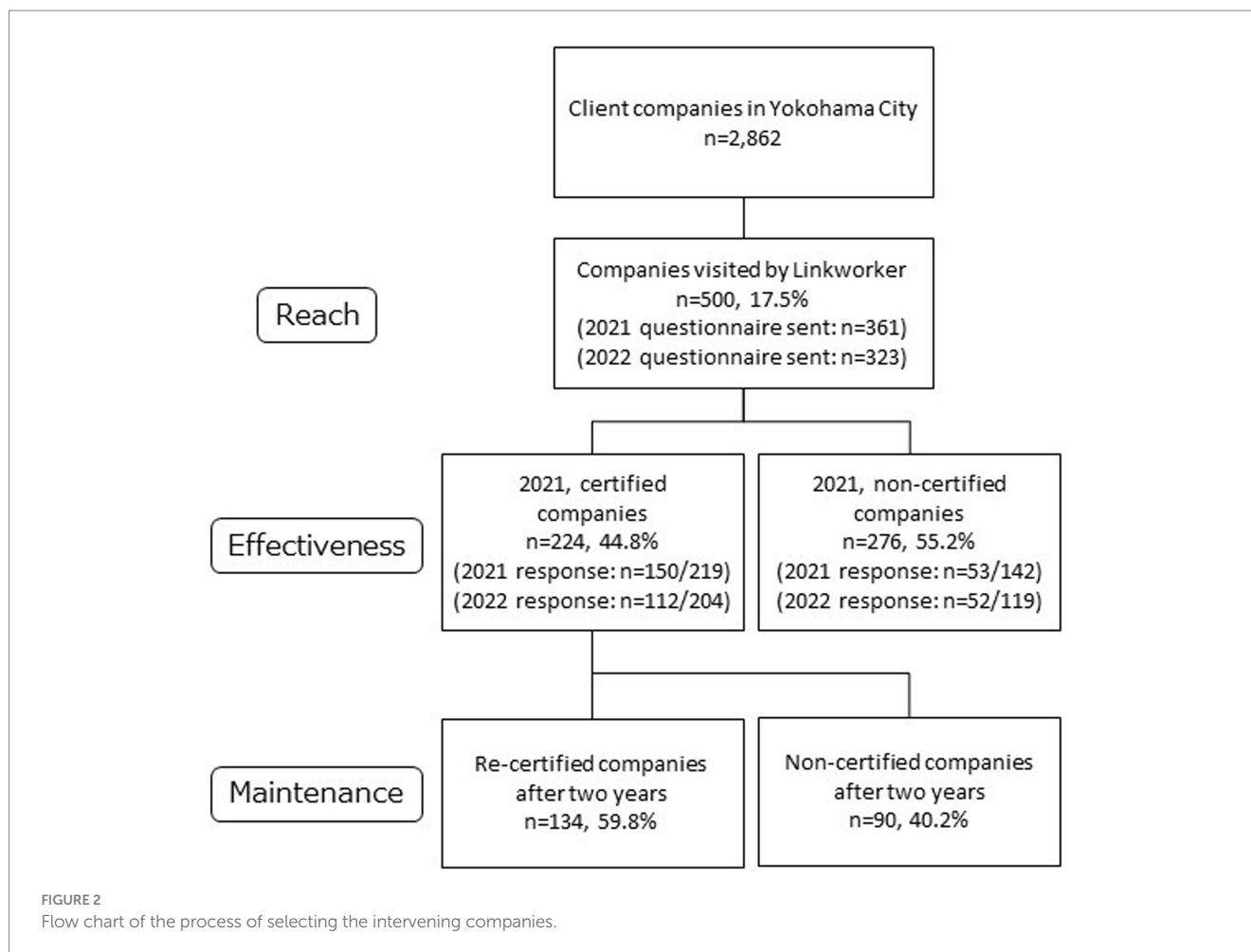
In all sessions of the Linkworker training program except for the first session, an anonymous survey was conducted among the Linkworkers to assess the impact of their activities on primary operations. The question posed was, “What impact do Linkworker activities have on primary operations?” with the response options including “positive impact,” “somewhat positive impact,” “neutral impact,” “somewhat negative impact,” and “negative impact.” Moreover, in the surveys conducted during the third and fourth sessions, the Linkworkers were asked to provide reasons for their selected choice in free-text format. The response rate for the Linkworker survey ranged from 48 to 87%, with an average of 70%.

2.7 Data analysis

The χ^2 test and residual analysis were used to assess the differences in characteristics between certified and non-certified companies, size differences among companies with Y-HPM Certification and the responses from the Linkworker survey. The “implementing” and “considering implementation” responses to the follow-up survey evaluating the impact of Y-HPM Certification on WHPP adoption were re-classified as “WHPPs implemented.” A multiple logistic regression analysis was conducted, with “WHPPs implemented” as the dependent variable and company size, industry type, employment status, and impact of COVID-19 as moderator variables. Sub-analyses were only conducted in micro-and small companies as the sample size from medium and large companies was insufficient. The statistical significance level was set to <5%, and SPSS Statistics version 26 (IBM) was used to perform all analyses. Content analysis was employed to extract categories from the free-text responses in the Linkworker survey.

2.8 Ethics statement

This study was approved by the ethics committee of the Physical Fitness Research Institute, Meiji Yasuda Life Foundation of Health and Welfare (approval number: 2020–0002). The research collaboration between the City of Yokohama and the Physical Fitness Research Institute is governed by a memorandum of understanding, ensuring



that the Institute offers academic support and scientific evaluation for the Y-Link Project.

3 Results

3.1 Reach

Of the 2,862 client companies of Company M in Yokohama City, Linkworkers visited 500 during the intervention period, achieving a 2-month reach rate of 18% (Figure 2). Of these, 50% were micro-and small companies. When companies of an unknown size are excluded from the 500 companies visited the proportion of micro-and small companies increases to 69% of the total (Table 1). The type of industry each company operated in was not controlled for in this study; nevertheless, the visited companies included a diverse range of industries without notable bias. The majority of the companies had full-time regular employees. Many companies were unaware of the HPM at the time of Linkworker intervention.

3.2 Effectiveness: intervention level

Of the 500 companies reached by Linkworkers, 224 obtained Y-HPM Certification, resulting in a success rate of 45% for the

Linkworker interventions. Certified companies were significantly smaller than non-certified companies (Table 1). No significant differences were observed in the industry type, employment type, and awareness of HPM.

3.3 Effectiveness: community level

Figure 3 illustrates the evolution of companies awarded the Y-HPM Certification over a 5-year period, starting from its initiation in 2017. The impact of this project's intervention is solely observed in 2021, as Linkworker support to companies was implemented in the preceding year, 2020. In 2021, the number of certified companies reached a record high of 308, compared to previous years (Figure 3A). A significant difference was observed in the trend of company size proportions. Residual analysis indicated that there were significantly fewer large and medium-sized companies and significantly more small and micro-sized companies in 2021 compared with other years. The proportion of micro-and small-sized companies increased by 18.2 percentage points (from 57 to 75%). Among the 224 companies supported by Linkworkers, there was a significant size difference compared with the 84 unsupported companies (Figure 3B). Residual analysis for Linkworker-supported enterprises revealed a significantly lower proportion of large and medium businesses and a significantly higher proportion of small and micro businesses compared with the

TABLE 1 Characteristics of the intervening companies.

	all		Certified companies		Non-certified companies		<i>p</i> value ^a
	<i>n</i> = 500		<i>n</i> = 224		<i>n</i> = 276		
Company size							0.02
Micro (<5 employees)	62	(12.4)	40	(17.9)	22	(8.0)	
Small (5–49 employees)	187	(37.4)	119	(53.1)	68	(24.6)	
Medium (50–299 employees)	95	(19.0)	46	(20.5)	49	(17.8)	
Large (≥300 employees)	16	(3.2)	6	(2.7)	10	(3.6)	
Unknown	140	(28.0)	13	(5.8)	127	(46.0)	
Industry type							0.41
Manufacturing	58	(11.6)	29	(12.9)	29	(10.5)	
Service	55	(11.0)	38	(17.0)	17	(6.2)	
Construction	54	(10.8)	33	(14.7)	21	(7.6)	
Transportation/postal business	38	(7.6)	22	(9.8)	16	(5.8)	
Other	149	(29.8)	88	(39.3)	61	(22.1)	
Unknown	146	(29.2)	14	(6.3)	132	(47.8)	
Employment type							0.35
Mainly full-time employees	306	(61.2)	173	(77.2)	133	(48.2)	
Half are non-regular	46	(9.2)	29	(12.9)	17	(6.2)	
Mainly non-regular employees	9	(1.8)	7	(3.1)	2	(0.7)	
Unknown	139	(27.8)	15	(6.7)	124	(44.9)	
Awareness of HPM ^b							0.62
Content known	51	(10.2)	38	(17.0)	13	(4.7)	
Had heard of it but did not know content	55	(11.0)	38	(17.0)	17	(6.2)	
Did not know	97	(19.4)	74	(33.0)	23	(8.3)	
Unknown	297	(59.4)	74	(33.0)	223	(80.8)	

^aComparison of certified and non-certified companies using the chi-square test (excluding unknown companies).

^bHPM, Health and productivity management.

unsupported group. The percentage of micro-and small-sized companies was 30.1 points higher than the unsupported group (52% vs. 84%).

3.4 Adoption

Company M's 41 sales offices in Yokohama City completely adopted the Linkworker program (adoption rate: 100%). The intervention companies had no complaints regarding the Linkworkers.

3.5 Implementation

Linkworkers implemented the prescribed HPM support activities in 317 of the 500 visited companies (implementation rate: 63%). Activities included HPM explanation (100%), information/advice

certification acquisition (51%), application form support (42%), and application submission (42%).

3.6 Maintenance

We assessed the Y-HPM Certification's impact on the implementation of WHPPs for improvements of employees' lifestyles. Certified companies showed a significantly higher odds ratio (2.31–4.09) of implementing WHPPs compared with non-certified ones (Table 2). The odds ratio (3.24–6.87) was higher in the sub-analysis of micro-and small companies (<49 employees). Out of the 224 certified companies in 2021, 134 were re-certified after 24 months (maintenance rate: 60%; Figure 2). No significant differences (*p* = 0.51) were observed in the maintenance rate by company size (<49 employees: 61%, ≥50 employees: 54%).

In Table 3, we present the impact of Linkworker activities on primary operations as self-evaluated by Linkworkers. The majority of

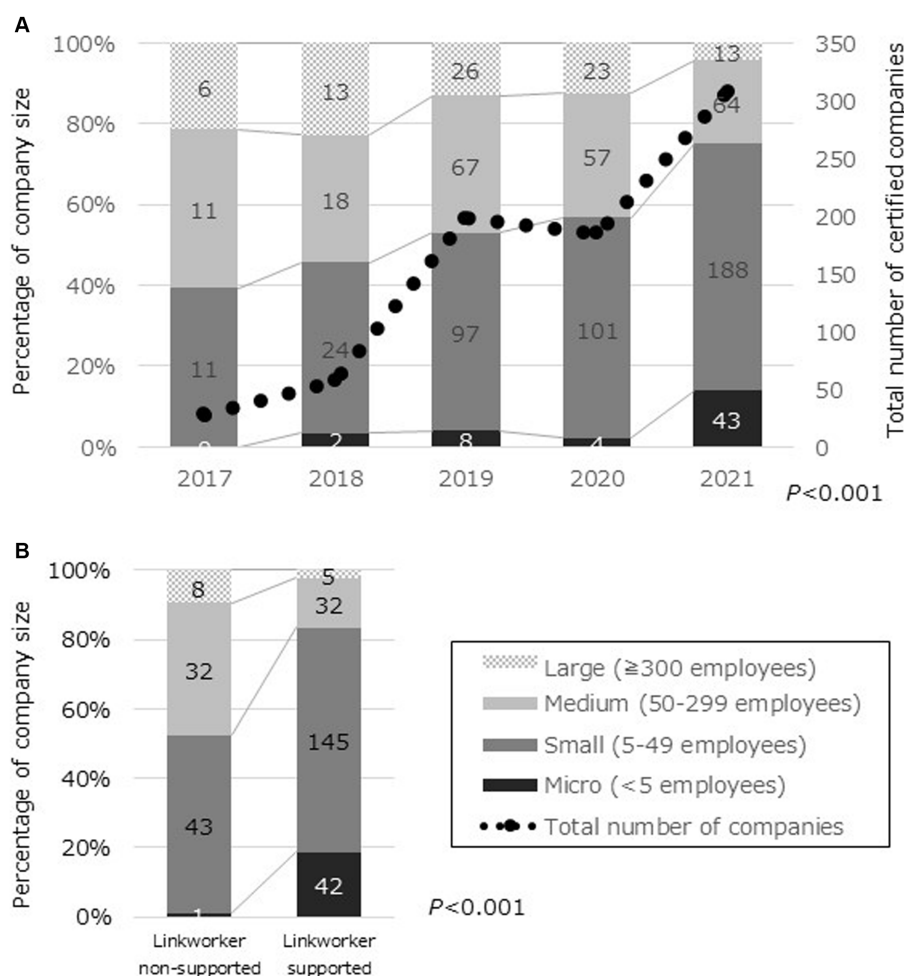


FIGURE 3

Changes in the number of certified companies at community level. (A) Total number and size of certified companies in Y-HPM Certification¹ from 2017 to 2021. (B) Comparison of company size with and without Linkworker support among Y-HPM Certification¹ companies in 2021. ¹Y-HPM, Yokohama Health and Productivity Management Certification.

Linkworkers reported (somewhat) positive impacts on primary operations, with no Linkworkers selecting negative impacts in any of the surveys. The main reasons cited for selecting (somewhat) positive impacts, as extracted through content analysis, included “contribution to clients,” “promotion of business activities,” “strengthening relationships with clients,” “improvement in the quality of customer service,” “enhancement of the company’s social reputation,” and “increase in customer satisfaction.” Reasons for selecting somewhat negative impacts included “burden on primary operations,” “insufficient customer demand,” and “lack of time due to the Covid-19 pandemic.”

4 Discussion

To promote HPM in small companies, we developed an outreach-based support strategy through the PPP and assessed its impact, focusing on several implementation outcomes in real-world settings. The Linkworkers achieved successful outreach to small-scale companies; the rate of HPM certification has significantly increased in small companies compared with large companies at both the

intervention and community level. Companies that obtained HPM certification implemented WHPPs 2–4 times more frequently when compared with non-certified companies, with a particularly pronounced effect observed in small companies. The retention rate of HPM certification for small companies after 24 months was comparable to that for large companies. Additionally, the Linkworkers themselves, being employees of private enterprises, evaluated this strategy as having a positive impact on their own businesses. Therefore, the Y-Link Project’s outreach strategy successfully enhanced the HPM in small enterprises in Yokohama City, enabling long-term health promotion programs to be implemented. In addition, this strategy aligned with business interests, garnering company support for the interventions.

To our knowledge, this is the first study to demonstrate that the social implementation of the PPP framework can promote HPM and improve the long-term implementation of WHPPs in small companies. Of particular note is that the intervention effectiveness of Linkworkers was more pronounced in small enterprises than in large ones. If implemented on a broader scale and for an extended duration, this strategy could contribute to the reduction of health inequalities based on company size and have a significant impact on public health.

TABLE 2 Multiple logistic regression analysis: impact of the Y-Link Project on implementation of workplace health promotion programs.

	n	case	%	OR	95%CI	p value ^a
6 months						
All companies						
Non-certified companies	53	16	30.2	1.00		
Certified companies	148	89	60.1	4.09	(1.79 – 9.35)	<0.01
Companies with 49 or fewer employees						
Non-certified companies	23	5	21.7	1.00		
Certified companies	102	56	54.9	6.87	(1.74 – 27.06)	<0.01
18 months						
All companies						
Non-certified companies	51	23	45.1	1.00		
Certified companies	111	65	58.6	2.31	(1.04 – 5.11)	0.04
Companies with 49 or fewer employees						
Non-certified companies	30	11	36.7	1.00		
Certified companies	81	42	51.9	3.42	(1.17 – 10.03)	0.03

^aAdjusted for company size, industry type, employment type, and impact of the coronavirus disease 2019 pandemic. CI, confidence interval; OR, odds ratio. Bold indicates statistical significance.

TABLE 3 Impact of Linkworker activities self-evaluated by Linkworkers on primary operations.

	2nd session		3rd session		4th session		5th session		p ^a
	n = 51		n = 62		n = 52		n = 34		
Positive impact	12	(23.5)	13	(21.0)	14	(26.9)	7	(20.6)	0.34
Somewhat positive impact	14	(27.5)	30	(48.4)	26	(50.0)	21	(61.8)	
Neutral impact	9	(17.6)	7	(11.3)	8	(15.4)	4	(11.8)	
Somewhat negative impact	6	(11.8)	5	(8.1)	2	(3.8)	1	(2.9)	
Negative impact	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	
Unknown	10	(19.6)	7	(11.3)	2	(3.8)	1	(2.9)	

^aUsing the chi-square test (excluding unknown).

Prior studies have explored practical interventions meant to promote occupational health services in small and medium-sized enterprises (SMEs), albeit to a limited extent. For instance, Al-Khudairy L et al. revealed through a cluster-randomized controlled trial that providing organizational-level financial incentives was associated with increased engagement in health and well-being activities among SMEs (24). However, while employer awareness and behaviors changed, employee behaviors did not shift as expected, suggesting the necessity of organizational support alongside financial incentives. Moreover, financial incentives require substantial funding, raising concerns about the sustainability of such interventions.

Ahonen G et al. reported that positioning multiple SMEs as virtual joint companies could provide access to occupational health services akin to those available to large enterprises (25). However, access to occupational health services for Japanese SMEs is facilitated through the Japan Health Insurance Association to which most SMEs are already enrolled. Nevertheless, disparities in health access based on company size persist.

Saito J et al. emphasized, through meticulous interview research, the pivotal role of employer leadership and motivation in promoting health promotion activities in SMEs (26). Hence, beyond preparing occupational health services, there arises a necessity for establishing a

social framework to facilitate “links” between these services and SMEs, particularly with employers.

In our study, interventions by Linkworkers had a more pronounced impact on small-scale enterprises compared to medium-sized or large enterprises. Their effectiveness in advancing health promotion in small-scale companies may be explained by their existing relationships with small business owners, which they cultivated through regular engagement in insurance sales and counseling.

To ensure the successful implementation and sustainability of the new framework, it is essential that stakeholders can reap benefits from it. Given that this study is based on a PPP, it is imperative that the framework offers benefits to the public and private sectors. In this PPP framework, the potential for contributing to cost reduction in healthcare expenditures for the public sector and insurance payout costs for insurance companies was identified through improvements in the health status of community residents and clients. Thus, this strategy managed to avoid the often-problematic issue of conflicting interests in PPPs, allowing for the sharing of benefits derived from the framework. Additionally, Linkworkers themselves recognized the benefits of their activities for their work. This realization likely contributed to their proactive engagement, evidenced by an average reach of seven companies per Linkworker within 2 months, intervention implementation in 4.5

companies, and successful certification acquisition in 3.2 cases. Recently, the “Creating Shared Value” management concept, aiming to achieve economic and social values, has been attracting the attention of health promotion sectors (27). It is speculated that the mutual understanding of this management concept by public and private entities in the future could lead to the development of sustainable PPP frameworks.

Nonetheless, this study revealed some challenges associated with the devised strategy. First, the sustainability of the effectiveness of Linkworkers’ support was identified as a concern. At 6 months after the intervention, certified companies showed a fourfold higher workplace health promotion program implementation rate compared with non-certified companies, but this increase had declined after 18 months. The lack of systematic enforcement of post-intervention follow-up support for intervention companies raised concerns regarding the longevity of the project’s positive impacts. Relying solely on the conduct of training sessions among Linkworkers was insufficient for sustaining long-term effectiveness, emphasizing the need for management policies at the organizational level.

Second, the perceived burden at the operational level emerged as another challenge. Linkworkers cited “burden on primary operations,” “lack of time,” and “insufficient understanding of customer needs” as key issues. It is therefore necessary to implement improvement measures to alleviate the burden at the operational level, such as streamlining the electronic application process and developing user-friendly tools for clients to enhance their comprehension.

This study has several limitations. First, we were unable to conduct a pre-intervention survey because the intervention companies could not be set up in advance. Consequently, the possibility that certified companies were already actively implementing health promotion before the intervention cannot be ruled out. However, considering the lack of difference in the level of awareness of HPM, any disparities in health promotion status prior to the intervention may have been minimal. Second, both follow-up surveys had low response rates. Although no significant differences were found in the characteristics between responding and non-responding companies, the non-responding group included a considerable number of non-certified companies (Supplementary Tables S1, S2). Therefore, the non-responding companies were less receptive to worksite health promotion, potentially leading to an underestimation of the apparent difference in WHPP implementation rates between certified and non-certified companies. In other words, the intervention’s impact may have been underestimated. Finally, because we focused on the characteristics of the companies in this study, we did not address factors related to the employees. However, employee characteristics are important confounding factors that ideally should be adjusted for. Additionally, the impact on employee health status is an important outcome. Therefore, future research should evaluate the effects of this intervention on individual health status, adjusting for factors related to employees such as employee demographics, job types, and working conditions.

In conclusion, our findings showed that the Y-Link Project’s outreach strategy successfully enhanced health and productivity management in small enterprises in Yokohama City, enabling long-term health promotion programs to be implemented. In addition, this strategy aligned with business interests, garnering company support for the interventions, addressing disparities in program availability related to company size.

Data availability statement

The datasets presented in this article are not readily available because the dataset for the Y-Link Project is not available due to obligations related to the protection of participant data. Requests to access the datasets should be directed to y-kai@my-zaidan.or.jp.

Ethics statement

The studies involving humans were approved by the ethics committee of the Physical Fitness Research Institute, Meiji Yasuda Life Foundation of Health and Welfare. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants in accordance with the national legislation and the institutional requirements.

Author contributions

YK: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. YF: Writing – review & editing, Data curation, Investigation, Methodology. NT: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. KY: Conceptualization, Investigation, Methodology, Project administration, Visualization, Writing – review & editing. YM-N: Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – review & editing. TN: Conceptualization, Data curation, Investigation, Project administration, Supervision, Writing – review & editing. TJ: Conceptualization, Data curation, Investigation, Methodology, Project administration, Writing – review & editing. TK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. YY: Data curation, Methodology, Project administration, Supervision, Writing – review & editing. JK: Conceptualization, Data curation, Investigation, Project administration, Supervision, Writing – review & editing. TA: Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

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Conflict of interest

The Meiji Yasuda Life Foundation of Health and Welfare, where YK, YF, KY, YM-N, TN, and TA work, receives donations from Company M. However, this organization is a public interest incorporated foundation under the jurisdiction of the Cabinet Office of the Japanese government and is obligated to conduct research activities for the public interest.

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

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Bodies and Bites: a medical school program that teaches anatomy, physiology, and nutrition to elementary school kids

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Undergraduate medical students who participate in community outreach programs gain a multitude of benefits that impact not only their professional development but also the well-being of the communities they serve. At the Virginia Tech Carilion School of Medicine (VTC SOM), students have the opportunity to volunteer in the “Bodies and Bites” program at the West End Center for Youth, an after-school educational center that serves K-12 children in Roanoke, Virginia. The purpose of Bodies and Bites is to teach elementary school children in 2nd to 5th grade how their bodies work and how to keep them healthy through good nutrition and exercise. All sessions are led by VTC SOM medical students and graduate students from our partnering academic institution, the Fralin Biomedical Research Institute (FBRI). Each week, the children and Health Professions students explore a different topic related to human anatomy and physiology using anatomical models, small group discussions, and hands-on activities. At the end of each session, the participants create a healthy snack related to the day’s topic. The overall goal of the present study was to assess the perception of the Bodies and Bites program from the view of our student volunteers, and the 4th and 5th graders who attend the West End Center. Now in its 6th year, Bodies and Bites continues to be popular as a voluntary program among our Health Professions students, and is well received by the West End Center and the elementary school children they serve. Our students and community mutually benefit from this program, with the former having an opportunity to briefly disengage from the rigors of their studies while gaining valuable skills in science communication and inspiring children to pursue fields in Science, Technology, Engineering, Math, and Medicine (STEMM), and the latter having fun while learning about their bodies and discovering ways to improve their health.

KEYWORDS

community engagement, community outreach, service-learning, medical education, STEMM education

1 Introduction and context

A student's record of consistency and depth of involvement in volunteerism is often among the pillars of successful medical school applications. However, the continuation of such activities has shown to truly benefit these same students as they progress through their Undergraduate Medical Education (UME) (1–5). Since patient contact is often limited for students during their pre-clerkship years, having these experiences is particularly valuable in helping build empathy and compassion, alleviating burn-out, and reminding students of why they wanted to become doctors in the first place (1, 6). One of the most important features of these experiences is establishing that human connection between the Health Professions student and the community members they strive to serve. These community engagements can take a number of different forms, from volunteering time in free clinics, to serving in shelters for individuals experiencing homelessness, to helping out in soup kitchens, and others.

An additional effort to broaden engagement between Health Professions students and their communities has focused on developing programs for children in primary [usually grades K–6 in the United States; e.g., (7, 8)] and secondary education [grades 7–12; e.g., (9–14)]. These programs are typically tailored to the educational level of the children, and often focus on populations that are underserved or underrepresented in medicine. One such opportunity for our local Health Professions students was developed through a unique partnership between the Virginia Cooperative Extension Office,¹ Virginia Tech-Carilion School of Medicine (VTC SOM),² Radford University-Carilion (RUC),³ the Fralin Biomedical Research Institute at Virginia Tech-Carilion (FBRI),⁴ and the West End Center for Youth,⁵ in Roanoke, Virginia. As the on-site location for this partnership, the West End Center for Youth is a non-profit after-school educational program that serves K–12 children who live in one of Roanoke's most disadvantaged and under-served neighborhoods. The mission of their center is to “strengthen the future of youth by offering holistic programming focused on academics, health and wellness, and cultural arts in a safe and nurturing environment.” The facility contains multiple small classrooms, a large area for dining and working on homework, and a fully equipped kitchen. The West End Center staff, committed to helping children develop the ability to make choices that support their long-term future, rely heavily on visits from external partners and content experts to the center.

To positively impact our community by contributing to the well-being of the children at the West End Center, in 2018, our partnering organizations collaborated on developing the “Bodies and Bites” program. Held during four sessions in the Spring and four in the Fall, this program teaches children in 2nd to 5th grade how their bodies work and how to keep them healthy through good nutrition and exercise. Originally, the Bodies and Bites program served as a primary component of the VTC SOM and RUC Interprofessionalism curriculum, during which Health Professions students (including medical students, student nurses, physician assistants, and allied health

providers) were tasked with developing interactive educational programs that promote health to members of our community. The program has since evolved into a purely extracurricular opportunity for medical students at VTC SOM and graduate students at the FBRI to volunteer their time and serve their community in a meaningful way. Program sessions are entirely led by these Health Professions students.

The Bodies and Bites lesson plans focus on different topics for each session, such that the elementary school participants are never exposed to the same lesson plan during each of the 4 years that the Health Professions students work with them. The themes always relate to human anatomy and physiology, as well as nutrition and exercise. Each week, the participants and Health Professions students explore a different theme using anatomical models, small group discussion and hands-on activities. At the end of each session, the children make a healthy snack that is related to the day's theme.

The overarching goals of the Bodies and Bites program are different for each of the participating groups. For Health Professions students, the program is intended to: (1) Improve and expand the dynamic classroom; (2) Increase student science outreach and engagement with members of the community; and (3) Improve public engagement capabilities to effectively communicate complex science concepts to the public; and (4) Demonstrate positive role modeling and mentorship to promote healthy lifestyles and encourage more students to pursue future careers in STEMM-related fields. For the West End Center children, the program is intended to teach the children to: (1) Have fun while working together as a team; (2) Expand knowledge in science through hands-on activities that demonstrate anatomy and physiology; (3) Identify ways they can keep their bodies healthy and active throughout their lives; and (4) Follow a simple recipe to make a healthy snack.

The relationship that has been established between the Health Professions students, children, West End Center, and other partnering organizations has mutually benefited all invested parties. Evaluation and constructive feedback are regularly requested from everyone involved, including the West End Center staff and administration, which helps ensure that the children, in particular, are given the best possible experience while also benefiting our Health Professions students. We plan to expand and improve the Bodies and Bites program by strengthening collaborative partnerships that are mutually beneficial for academic institutions and the communities they serve.

As the Bodies and Bites program has evolved since it transitioned to a purely voluntary activity outside of the VTC SOM curriculum 3 years ago (e.g., expanded sets of STEMM concepts that are now covered, new hands-on activities, and new recipes), there has not been a regular assessment of the program. Furthermore, this assessment was originally only from the perspective of the Health Professions students. Therefore, the goal of the present study was to assess the Bodies and Bites program from the perspectives of both the Health Professions Student volunteers, as well as 4th and 5th grade children of the West End Center who participated in the program during the Fall 2023 session.

2 Key programmatic elements

2.1 Overall structure

Prior to their visit to the West End Center, Health Professions students are provided with the lesson plans and have an opportunity

1 <https://www.virginia.gov/agencies/virginia-cooperative-extension/>

2 <https://medicine.vtc.vt.edu/>

3 <https://www.radford.edu/content/ruc/home.html>

4 <https://fbri.vtc.vt.edu/>

5 <https://www.westendcenter.org/>

to practice the activities that they will be leading. A VTCSOM faculty member designs the lesson plans, purchases and delivers supplies, and remains on-site at the West End Center to provide guidance when necessary; however, the actual sessions are entirely run by the Health Professions students. During the Fall semester, the students work with the combined group of 4th and 5th graders, and during the Spring semester the students work with the combined group of 2nd and 3rd graders. There are typically 8–12 Health Professions students who volunteer per session, and depending on the enrollment at the center, there can be a range of 12–20 participants in each of these groups. This high ratio of Health Professions students to children permits a more conversational and highly engaged interaction among participants.

The program runs for four consecutive Thursday afternoons, each lasting 1.5 h in duration. The children are further split into four smaller groups which are maintained throughout the duration of the program (i.e., the same 3–5 participants per group each week, facilitated by 2–3 Health Professions students). Each group focuses on a different topic each week. All topics are offered concurrently, and groups rotate topics from 1 week to the next. Since there are four total sessions spread across 4 weeks, all of the children have the opportunity to learn about each of the topics.

2.2 Lesson plans

Each individual group session begins with a 10-min interactive discussion introducing the day's topic, why the topic is important in the context of the overall body's function, and how to maintain health. For the subsequent 40-min, multiple hands-on activities keep the children engaged while demonstrating specific functions. These activities typically include games, crafts, simple experiments, or other high energy activities that get the children moving. For the next 30-min, the Health Professions students assist the children in following a simple recipe to make a healthy snack. Prior to the snack, the children are asked about allergies, since we are doing food prep, we practice good hygiene by having everyone wash hands with soap and warm water, wear gloves, and rinse off any fruits and vegetables required in the recipe. All of the recipes that we use are kid-friendly in simplicity, can be completed within 30 min, and do not require the use of the stove or oven at the facility. The final 10-min are used to answer any final questions and clean up. A full description of the most recent lesson plans that are tailored to 4th and 5th graders are provided as [Supplementary material](#).

Over the 4 years the Health Professions students engage, the West End Center participants progress through four series of topics, each with an age-appropriate, increasing level of challenging concepts and activities that are covered. Set one (tailored to participants in grades 2 and 3) focuses on the senses of sight, hearing, balance, smell, taste, and touch. Set two (grades 2 and 3) focuses on the cardiovascular, digestive, musculoskeletal, and nervous systems. Set three (grades 4 and 5) focuses on cell biology, engineering, genetics, and physiology. Set four (grades 4 and 5) focuses on neuroscience, neurorobotics, neuroprosthetic devices, and artificial intelligence.

2.3 Study participants

For the current study, 30 Health Professions student volunteers included VTCSOM medical students from the Classes of 2027

(M1 year of study; $n = 15$), 2026 (M2; $n = 5$), and 2025 (M3; $n = 1$), as well as FBRI graduate students ($n = 9$). Our group worked with all of the 4th and 5th grade children ($n = 16$) who were attending the West End Center in Fall 2023. Not all of these participants were able to attend all four sessions of Bodies and Bites due to occasional absences.

FY2023 total enrollment at VTCSOM is 196 students (49 students per year, four-year curriculum), and for the FBRI is 78 graduate students (~15 students per year; average time to graduation = 5 years), which means for this particular study, 10.7% of VTCSOM students and 11.5% of FBRI students participated in the Fall 2023 Bodies and Bites program. Although it is not a formal component of the curriculum, at VTCSOM there is a service requirement of 30-h for graduation through the VTCSOM Engage service-learning program.⁶ Most Tuesday and Thursday afternoons are free in the curriculum for medical students to study, perform research, or pursue volunteer opportunities. While not required for graduation at the FBRI, volunteer service is highly encouraged for all students. Throughout the year, there are multiple collaborative service opportunities for VTCSOM and FBRI students.

3 Assessment and impact metrics

3.1 Ethics statement

The requirement of ethical approval was waived by the Institutional Review Board at Virginia Tech for the studies involving humans because the study was considered exempt, as no sensitive or protected data were collected from either the Health Professions students or children. The studies were conducted in accordance with local legislation and institutional requirements.

3.2 Health professions student recruitment

Approximately 1 month prior to the first session of Bodies and Bites, an invitation is sent out via email to all VTCSOM medical students and FBRI graduate students. The email contains a description of the program and dates of the sessions. Notices are also posted on bulletin boards with QR codes to sign up online. All students who respond are accepted as volunteers, and no students are turned away. A small proportion of students (approximately 10%) volunteer for multiple sessions during the semester. Approximately 80% of the students will volunteer for multiple semesters. Most of the medical student participation comes from the pre-clerkship years (M1 and M2), although there are typically 2–3 returning students each semester who volunteer during their clerkship years (M3 and M4). Students may add their participation to their CV and receive credit for reporting their volunteer hours (at VTCSOM there is a requirement of 30 h across their 4 our years of UME); however, nothing is formally added to their transcript for participating.

⁶ <https://medicine.vtc.vt.edu/community/vtc-engage.html>

3.3 Assessment

For the past several years, Health Professions students have been sent surveys to identify strengths and opportunities for improvement in the Bodies and Bites program. This feedback has helped optimize the activities and recipes that we currently utilize for each of our sessions. Assessment of the program has only recently become much more intentional. During the most recent program (Fall 2023), an anonymous online questionnaire generated in Google Forms was emailed to participating Health Professions students. The survey included open-ended and Likert-style questions after each session to assess their views of the program. The former identified positives and opportunities for improvement:

- 1 What topic did you lead?
- 2 What positive(s) did you take away from your experience as a Bodies and Bites facilitator?
- 3 What challenges did you experience during the Bodies and Bites program related to your group's lesson plans?
- 4 What suggestions do you have for ways to improve the Bodies and Bites program?

Likert-style questions were also used to assess overall attitudes toward the program and outreach in general (1–5 scale, where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree; 4 = agree; and 5 = strongly agree):

- 1 It is important for me to participate in community outreach.
- 2 After having participated in the Bodies and Bites program, I will definitely participate again in the future.
- 3 I highly recommend that my classmates participate in the Bodies and Bites program.

We have also started to assess the in-the-moment impact on the children at the West End Center using pre- and post-activity surveys that utilize a colorful 5-face emoticon scale (similar to the Faces Pain Scale used in pediatrics; see [Supplementary material](#)). The emoticon scale was then converted into a five-point scale for analysis, ranging from the “very frowny” emoticon = 1, to “very happy” emoticon = 5. To de-identify the children and their assessments, no names were utilized, but rather they were asked to pick a unique color pencil to use for both the pre- and post-activity surveys. The pre-activity survey was given prior to starting the science component, and included the following questions:

- 1 How do you feel today?
- 2 Are you interested in this topic?
- 3 Are you good at science?
- 4 How much do you like cooking?

The post-activity survey was given prior to cooking, due to Health Professions students sometimes forgetting to distribute these surveys, and the children sometimes having to leave early when their parents or caretakers picked them up. The post-activity survey included the following questions:

- 1 Was this activity fun?
- 2 Are you interested in this topic?

- 3 Are you good at science?
- 4 Did you learn anything new from the activity?

The only components that were comparable in these surveys were questions #2 (Are you interested in this topic?) and #3 (Are you good at science?). Other questions in the pre-activity survey were intended to (1) assess the general mood of the participants going into the session to determine if their emotional disposition had any effect on answers to subsequent questions (question #1), and (2) qualitatively assess if the participants were interested in cooking in the first place, and whether the broad distribution of these answers changed over the course of the four-week session (question #4). Other questions in the post-activity survey were intended to (1) identify whether the activities were enjoyable or should be modified (question #1), and (2) determine if anything new about the topic was learned from the experience (question #4).

The operations staff at the West End Center is also routinely engaged prior, during, and after each month's session to determine effectiveness of the program and identify opportunities for improvement.

3.4 Statistical measures

The GraphPad online statistical calculator for paired t-tests was used to calculate significance in comparisons between pre- and post-test groups. A two-tailed *p*-value of <0.05 was taken as indicative of significance. Effect size was calculated by dividing the difference between the mean post-test score and the mean pre-test score by the standard deviation of the post-test scores. Data is reported as means (M) and standard deviation (SD) for each group, and when paired t-tests were used, the t test statistic (t), its *p* value (p), and its effect size (d) are listed.

4 Results

4.1 Assessment from health professions students

Overall, the Bodies and Bites program has consistently received positive feedback from the Health Professions students, West End Center children, and participating organizations. After each session, the Health Professions students were sent links to an anonymous survey. During the previous session, 30 Health Professions students participated in the program, and we received 16 responses to the survey. Two of the 30 students volunteered for two sessions, but were only sent a survey link after their first session, and not their second.

The language used in the open questions by the Health Professions students was assessed for overall conceptual themes. Regarding positives of the program, students expressed enjoyment in interacting with the children (*n* = 14), having the opportunity to teach (*n* = 4), seeing children get excited about STEM (*n* = 5), seeing children's attitudes improve during the session (*n* = 2), and flexibility of the lesson plans (*n* = 2). For challenges that were experienced, students identified behavior of some of the children (*n* = 6), time limitations to get through all of the activities (*n* = 4), and difficulty in teaching challenging concepts to children (*n* = 5). Students also suggested ways

TABLE 1 Attitudes of Health Professions students (*n* = 16) toward community outreach and the Bodies and Bites program.

Likert prompt	<i>n</i>	1	2	3	4	5
It is important for me to participate in community outreach.	16	0% (0)	0% (0)	6.25% (1)	12.5% (2)	81.25% (13)
After having participated in the Bodies and Bites program, I will definitely participate again in the future.	16	0% (0)	0% (0)	6.25% (1)	31.25% (5)	62.5% (10)
I highly recommend that my classmates participate in the Bodies and Bites program.	16	0% (0)	0% (0)	0% (0)	25% (4)	75% (12)

All entries are reported as a percentage of the total with number of respondents in parentheses. The assessment was based on a 1–5 scale, where 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; and 5 = strongly agree.

to improve the program, primarily focusing on ways to improve activities (*n* = 10), recipes (*n* = 2), and classroom arrangement (*n* = 3).

Some sample comments from the session include:

“I really liked how the lesson plan was flexible in terms of instruction and timing so that we can spend more time working with each student or explaining things in detail.”

“I love this experience! The kids are fun, funny, inquisitive, eager, engaged, and wide open! Each time I volunteer, I’m excited about the next time I’m able to volunteer again.”

“One of our kids had previously marked “no interest or experience in science” before the session and marked “full interest” (green happy face) afterwards!”

“It was great to see the kids become so passionate about the topics! One student said she wasn’t very good at science at all, but by the end she said she loved science after all.”

“I gained a lot of respect for the center workers! I was also touched by how excited the kids were by the end, even though several of them started with pretty bad attitudes. It was nice to see their interest grow in such a short time.”

Students were also sent Likert-style questions to assess their overall views of the Bodies and Bites program. During the previous session, most responders selected “Agree” or “Strongly Agree” for each question (Table 1).

4.2 Assessment from children who attend the West End Center

During the Fall 2023 session, the 4th and 5th grade participants were asked a series of questions to assess their mood and their view of components of the Bodies and Bites program (*n* = 10–13 children per topic and per session; Tables 2–4; see Supplementary material for survey). The averages for each of the survey questions is shown by topic and sequence of session in Tables 2, 3, respectively. For the question concerning “Are you interested in this topic?” paired *t*-tests did not indicate significant changes in outcome between pre- and

post-activity surveys for cell biology (*p* = 0.72, *t* = 0.37, *d* = 0.10), engineering (*p* = 0.28, *t* = 1.15, *d* = 0.44), genetics (*p* = 0.17, *t* = 1.50, *d* = 0.61), or physiology (*p* = 0.64, *t* = 0.48, *d* = 0.25). For the question concerning “Are you good at science?” paired *t*-tests indicated significant changes in outcome between pre- and post-activity surveys for engineering (*p* = 0.03, *t* = 2.42, *d* = 1.24), but not for cell biology (*p* = 0.64, *t* = 0.49, *d* = 0.19), genetics (*p* = 0.06, *t* = 2.12, *d* = 0.79), or physiology (*p* = 0.47, *t* = 0.74, *d* = 0.29). The percent of children whose ratings between the pre- to post-activity survey decreased, stayed the same, or increased are indicated in Table 4. Sorting data by attitude (“How do you feel today?”) did not change significance (data not shown).

4.3 Assessment from staff and administration at the West End Center

Although no official surveys are sent to our partners at the West End Center, they regularly provide timely feedback regarding their needs, the organization of the event, and suggestions for improvement. Their staff assists with corrective behavior to the children when necessary, and guides our Health Professions students to improve their interactions with the children. Input from the administration has always been positive and they express their appreciation of the program.

5 Discussion

5.1 Discussion of results

Based on feedback from the Health Professions students, outreach was viewed as a worthwhile endeavor and in particular, students valued their involvement with the Bodies and Bites program. This is in accordance with other studies that examined the perception of Health Professions students who engaged in community service while in school [e.g., (2, 15, 16)]. Participation in programs that focus specifically on elementary school age children has also been viewed as a positive experience that produces valuable outcomes in these students [e.g., (3, 17, 18)]. The topics that the Health Professions students taught to the West End Center kids focused on the fields of cell biology, engineering, genetics, and physiology.

Children from the West End Center were given a pre-activity survey to assessed their attitudes each day, their interest in the topic, whether they felt they were good at science, and how much they liked cooking. A post-activity survey was also administered to assess

TABLE 2 Self-assessment of participants at the West End Center, prior to and following the hands-on activities, organized by topic.

Topic	Pre-activity survey			
	How do you feel today?	Are you interested in this topic?	Are you good at science?	How much do you like cooking?
Cell biology (<i>n</i> = 13)	4.2 ± 1.3	3.8 ± 1.1	4.2 ± 1.2	3.9 ± 1.7
Engineering (<i>n</i> = 12)	3.7 ± 1.2	3.3 ± 1.7	3.8 ± 1.5	4.3 ± 1.1
Genetics (<i>n</i> = 10)	4.3 ± 1.1	3.4 ± 1.6	3.5 ± 1.6	4.0 ± 1.4
Physiology (<i>n</i> = 12)	4.5 ± 0.9	4.2 ± 1.3	4.1 ± 1.3	3.8 ± 1.6

Topic	Post-activity survey			
	Was this activity fun?	Are you interested in this topic?	Are you good at science?	Did you learn anything new from the activity?
Cell biology (<i>n</i> = 13)	4.5 ± 1.3	4.0 ± 1.5	4.3 ± 0.9	4.1 ± 1.3
Engineering (<i>n</i> = 12)	4.4 ± 1.0	3.9 ± 1.5	4.6 ± 0.7	4.0 ± 1.5
Genetics (<i>n</i> = 10)	4.8 ± 0.4	4.2 ± 1.3	4.5 ± 1.3	4.2 ± 1.3
Physiology (<i>n</i> = 12)	4.6 ± 1.0	4.4 ± 1.0	4.4 ± 1.2	4.4 ± 1.2

Number of participants (*n*) who participated and completed the pre- and post-test survey is listed next to each topic. Data is reported as mean ± standard deviation on a 5-point scale, from least (1) to most (5) favorable.

TABLE 3 Self-assessment of participants at the West End Center, prior to and following the hands-on activities, organized by sequence of sessions.

Session	Pre-activity survey			
	How do you feel today?	Are you interested in this topic?	Are you good at science?	How much do you like cooking?
1 (<i>n</i> = 9)	4.1 ± 1.4	2.4 ± 1.6	4.0 ± 1.6	3.7 ± 1.4
2 (<i>n</i> = 11)	4.0 ± 1.3	4.3 ± 1.3	3.5 ± 1.5	3.9 ± 1.5
3 (<i>n</i> = 13)	4.2 ± 0.9	4.0 ± 1.2	3.8 ± 1.4	4.4 ± 1.3
4 (<i>n</i> = 14)	4.2 ± 1.1	3.7 ± 1.3	4.2 ± 1.2	3.9 ± 1.6

Session	Post-activity survey			
	Was this activity fun?	Are you interested in this topic?	Are you good at science?	Did you learn anything new from the activity?
1 (<i>n</i> = 9)	5.0 ± 0.0	4.4 ± 1.1	4.4 ± 1.1	4.8 ± 0.4
2 (<i>n</i> = 11)	4.5 ± 1.2	4.7 ± 0.5	4.2 ± 1.3	4.3 ± 1.3
3 (<i>n</i> = 13)	4.6 ± 0.9	3.9 ± 1.6	4.6 ± 0.9	4.2 ± 1.4
4 (<i>n</i> = 14)	4.2 ± 1.2	3.6 ± 1.5	4.5 ± 0.8	3.6 ± 1.4

Number of participants (*n*) who participated and completed the pre- and post-test survey is listed next to each topic. Data is reported as mean ± standard deviation on a 5-point scale, from least (1) to most (5) favorable.

whether the children felt the activity was fun, if their interest in the topic had changed, if their self-assessment of being good at science had changed, and if they learned anything new from the activity. When sorting by topic or sequence of session, most of the means of these assessments (63 out of 64) were above 3 on a 5-point scale. The exception was initial interest in the topics during the first session. Although this value increased in the remaining sessions, it did not reach the threshold of significance. Initial interest in the topics of engineering and genetics were also relatively low, whereas cell biology and physiology were viewed more favorably. Statistical analysis was performed on the children's change in interest in each topic and a self-assessment of whether they were good at science. While the means for these values increased for each topic between the pre- and post-activity survey, only the increase in interest in the topic of engineering was significant. Although perhaps challenging in conceptual content,

other higher education centers have similarly tailored outreach programs to the fields covered in this study, pairing their graduate and medical students with local elementary schools [e.g., (19–22)].

5.2 Impact

In this study, Health Professions students shared positive views on community engagement, and especially valued their involvement in the Bodies and Bites program. Their feedback has already led to improvements in lesson plans and recipes, making them more engaging and manageable for the children. Children at the West End Center generally had positive attitudes toward the sessions, enjoyed the activities, and maintained or increased their interest in science. Not captured in the surveys was the genuine enthusiasm of the West

TABLE 4 Change between pre- and post-activity self-assessment of participants at the West End Center, for interest in topic and view of being good at science.

	Are you interested in this topic?			Are you good at science?		
	Decrease	Same	Increase	Decrease	Same	Increase
Overall (<i>n</i> = 47)	21.3% (10)	38.3% (18)	40.4% (19)	10.6% (5)	53.2% (25)	36.2% (17)
Cell biology (<i>n</i> = 13)	23.1% (3)	38.5% (5)	38.5% (5)	15.4% (2)	61.5% (8)	23.1% (3)
Engineering (<i>n</i> = 12)	16.7% (2)	30.0% (3)	70.0% (7)	8.3% (1)	41.7% (5)	50.0% (6)
Genetics (<i>n</i> = 10)	20.0% (2)	40.0% (4)	40.0% (4)	0.0% (0)	60.0% (6)	40.0% (4)
Physiology (<i>n</i> = 12)	25.0% (3)	50.0% (6)	25.0% (3)	16.7% (2)	50.0% (6)	33.3% (4)

All entries are reported as a percentage of the total with number of respondents in parentheses.

End Center kids when they saw the Health Professions students arriving at the center each day. They frequently expressed their excitement for “Bodies and Bites” day each week.

Overall, there are multiple benefits to all participants in programs like Bodies and Bites. Through interactions with young children in small groups, professional students hone the necessary skills to communicate complex science concepts to the public and promote healthy lifestyles (23–25). Children in elementary school similarly benefit from such experiences. They are naturally curious about their bodies and can easily relate to activities involving anatomy and physiology, so beginning to teach these topics at an early age fosters numerous positive outcomes, including improved perception to learn, reduced propagation of health misinformation, better awareness of the dangerous effects of drugs and alcohol, increased interest in STEMM-related fields, and others (26, 27). Furthermore, studies have also demonstrated the positive impact of programs in which Health Professions students teach elementary school children about nutrition, culinary skills, and hygiene (28). Such programs not only teach children about ways to maintain a healthy lifestyle, but also increase student confidence in providing nutrition and obesity counseling for their future patients.

5.3 Challenges, limitations, and future directions

Challenges associated with the program include keeping energetic children focused and dealing with tiredness and hunger. This was the impetus for developing lesson plan activities that piqued curiosity and involved movement. During cooking, limited supplies at times made taking turns difficult. Nonetheless, everyone who participated seemed to enjoy the experience, and students learned that working with the kids required creativity, adaptability, and communication, which are all useful skills for future careers in medicine and research.

Although the Bodies and Bites program continues to be successful, other significant challenges exist. As this program has transitioned from being embedded within the curriculum to voluntary, one of the primary challenges is establishing a reliable funding mechanism to support the costs of materials and food, which is approximately \$500 USD per semester. Currently, funding is acquired through small internal grants at Virginia Tech, as well as support from

VTCSOM. Another challenge relates to recruiting student volunteers in sufficient numbers to staff each of the stations. With in-class requirements and out-of-class studying, demands on the time of Health Professions students are often quite high. Furthermore, to maximize effectiveness, long-lasting impact, and mutually benefit all invested partners, it is vital that outreach programs such as Bodies and Bites are not only designed in partnership with community stakeholders, but that there are additional opportunities to reflect on these experiences (29). A service-learning reflection is not currently associated with the Bodies and Bites program.

It is acknowledged that Health Professions students have numerous opportunities for community outreach in the local area. Some students participate in Bodies and Bites a single time whereas others regularly volunteer one or more times per session. Also, the children of the West End Center undoubtedly have other exposures to similar topics in STEMM and activities that are used in the Bodies and Bites program. The surveys used in this study were designed to gauge in-the-moment satisfaction with the program for the Health Professions students and the children. This is not sufficient to assess overall attitudes toward community service or science, knowledge gained, or impact. Therefore, any direct effects of the program are difficult to determine at this juncture. A more longitudinal, repeated measures design could be used to better track how knowledge and attitudes evolve over time. We are currently not permitted to track individual kids at the West End Center as they progress from grade to grade.

As it pertains to this study, the biggest limitation is the very small sample size. While we worked with all of the 4th and 5th graders who currently attend the West End Center (*n* = 16), not all of the kids were able to complete all four sessions due to absences or being picked up early by their guardians. The structure of the Bodies and Bites program is such that the 2nd-5th grade kids that we work with will have different experiences in terms of topics, activities, and recipes in each grade (i.e., the Fall 2023 program will not be run again until Fall 2025). Regarding the participation of Health Professions students, we similarly had a small sample size, although considering the relatively small population of VTCSOM medical students and FBRI graduate students, as well as other opportunities for community engagement, participation by approximately 10% of students was judged to be successful. Due to limitations of space at the West End

Center, it would also be challenging to accommodate more students for each session.

Future directions of the Bodies and Bites program will aim to expand upon the content and engage with children in the middle school age. We are also in the process of developing relationships with other after-school programs in the area. Although we have begun to assess the program more robustly, we are also curious as to whether the learning extends beyond our time in the West End Center. For that reason, we intend to survey parents regarding what the kids discuss about their experience in the program at home.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Virginia Tech Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

KB: Conceptualization, Methodology, Writing – review & editing. MW: Project administration, Supervision, Writing – review & editing. HC: Project administration, Supervision, Writing – review & editing. EH: Project administration, Supervision, Writing – review & editing. ST: Formal analysis, Writing – review & editing. CP: Project administration, Resources, Supervision, Writing – review & editing. DT: Conceptualization, Writing – review & editing. KR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1398124/full#supplementary-material>

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Examining the relationship between attitudes toward science and socioeconomic status among middle-class, midwestern middle school students

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Background: Previous research has uncovered disparities in children's attitudes toward science based on gender, income, parenting, geographical location, and school resources, among other factors. However, less is known about socioeconomic influences on science attitudes within the evolving rural middle class. The present study investigated the relationship between indicators of socioeconomic status on middle schoolers' attitudes toward science in a predominantly middle class, white, rural sample within the midwestern United States of America.

Methods: Parents were asked for demographic information and consent for their child participating in the study. Middle school children were invited to complete a short survey quantifying their attitudes toward science.

Results: Science attitudes did not vary based on gender. However, students with at least one parent that earned at least a bachelor's degree or from a household income exceeding \$90,000 had more positive attitudes toward science than those whose parents did not obtain a college degree or whose household income was less than \$90,000, respectively. Regression revealed that household income and parent's assessment of their child's interest in a scientific career significantly predicted a child's attitudes toward science, but gender and highest degree earned by a parent did not.

Conclusion: This study found differences in children's science attitudes within a rural, predominantly middle-class population. This finding contributes to the literature by revealing differences in science attitudes relating to higher levels of parental education (bachelor's degree) and income (\$90,000) than previously identified. This highlights additional opportunities to support children's science growth and promote equitable science opportunities for everyone.

KEYWORDS

science attitudes, socioeconomic status, rural, parental education, middle class income, science career, middle school

1 Introduction

Science is foundational to modern medicine, technological advances, and tackling many of the world's problems including disease, famine, and climate change. Therefore, many scientists and educators seek to share their science knowledge and an enthusiasm for science with the general public through outreach activities and to inspire the next generation of science, technology, engineering, math, and medicine (STEMM) professionals. However, to do so effectively, one needs to know their audience.

For decades, research has shown that children's interest in science varies, and their attitudes toward science can be impacted by gender, their parents' careers, geographical location (urban versus rural), socioeconomic status (SES), and inequitable educational opportunities, among other factors (Gorard and See, 2009; Peterson et al., 2015; Betancur et al., 2018; Grimes et al., 2019; Archer et al., 2020; Gall et al., 2020; Liu and Schunn, 2020; Guo et al., 2022). Prior research has revealed that students from families of lower SES are more likely to have lower interest in science, science careers, and summer science experiences than students from higher SES families (Gorard and See, 2009; Liu and Schunn, 2020). Studying disparities in science opportunities and how to eliminate them for lower SES students remains an active and important research topic. However, there is a paucity of scholarship examining science attitudes within the evolving middle class in the United States. Indeed, parameters characterizing the middle class have changed. From 1970 to 2020, while middle class household incomes have increased, the middle class's share of aggregate income in the United States decreased from 62 to 42%, respectively (Kochhar and Sechopoulos, 2022). According to the Pew Research Center, the median household income of American middle-class families in 2020 rose to \$90,131 (Kochhar and Sechopoulos, 2022). This number is substantially above the poverty line and threshold for free school lunches, which is often used as an indicator for studying students of lower SES in educational research. Although middle-class income has risen 50% over the past 50 years (Kochhar and Sechopoulos, 2022), inflation has resulted in higher expenses for many households. Indeed, many families earning a middle-income salary do not live a middle-class lifestyle due to increased spending on housing, healthcare, education, and other necessities (Haller et al., 2022). We hypothesized that socioeconomic variability within the middle class may correspond to differences in middle school children's attitudes toward science.

This study was envisioned through a socioeconomic theoretical framework, which posits that SES includes "not just income but also educational attainment" (APA, 2010). These factors can influence many areas of life, including students' education and career goals. A combination of current economic trends impacting the middle class, increased median middle-class income, variability in parental educational attainment, and a rural midwestern setting formed the conceptual framework. Specifically, the present study investigated the relationship between two indicators of socioeconomic status (household income and parent's education) and middle schoolers' attitudes toward science in a midwestern rural area that was predominantly middle class.

2 Materials and methods

2.1 Ethics and setting

This study was reviewed by the Institutional Review Board at Western Michigan University Homer Stryker M.D. School of Medicine, which determined that the study met the criteria for exempt status. The study was conducted in accordance with their guidelines. We partnered with the seventh and eighth grade classrooms at a middle school in a rural setting within Southwest Michigan in the United States. The school leadership agreed to the study being conducted within their school. The school district is in a small village that was surrounded by farmland. According to the United States Department of Agriculture Rural Development, the school is in a rural area.

Information about our science outreach program, a study consent form, and a demographics survey were sent home to the students' parents. When students were invited to complete an online survey, it began with an assent process. Only data from students who assented and whose parents consented were included in the study. All students in the seventh and eighth grade classes were welcomed to participate in science outreach sessions, regardless of whether or not they participated in the study. Surveys were collected in early 2020.

2.2 Surveys

Parents completed a survey that included demographic questions such as their educational attainment, household income bracket, and their student's gender, race, and ethnicity. Additionally, the survey asked whether or not their middle schooler was interested in a career in science. All questions were optional, and parents could skip any question that they did not want to answer. The categories for highest degree earned by a parent included: less than high school diploma, high school/GED, associate's degree, bachelor's degree, master's degree, doctorate, and prefer not to answer. The categories for annual household income included: less than \$30,000, \$30,000–\$59,999, \$60,000–\$89,999, and \$90,000 or greater.

Teachers distributed the student survey during class when the researchers were not present to reduce the possibility of their presence influencing student responses. After assenting to participating in the study, the middle schoolers completed an abbreviated Student Attitudes Toward STEM Survey–Middle and High School Students (Faber et al., 2013) survey that focused on science questions as previously described (Gall et al., 2020). A 5-point Likert-style scale was used ranging from strongly disagree to strongly agree for each question (Supplementary Table S1).

2.3 Data analysis

Parent and student forms were matched and de-identified by an honest broker. Participants' attitudes toward science scores were calculated by summing their responses to the survey questions (with one question that was phrased in the negative being reverse scored). The highest score that a student could receive on this scale was 45, and the lowest possible score was 9. To assess the internal consistency of

the abbreviated Student Attitudes Toward STEM Survey–Middle and High School Students used in this study (Supplementary Table S1), we conducted a Reliability Analysis in SPSS on our dataset; the Cronbach’s alpha was 0.88. Planned contrasts (between-subjects *t*-tests) were used to compare attitudes toward science based on gender, interest in scientific career, household income, and parents’ educational level. Based on the socioeconomic demographics of this participant pool and the median income of the middle class at the time (Kochhar and Sechopoulos, 2022), we placed the line for comparing attitudes toward science relative to income and education at \$90,000 and a bachelor’s degree, respectively. To test for normality, we ran Shapiro–Wilk tests and generated Q-Q plots. The data were normally distributed, so we used parametric *t*-tests.

To disentangle the contributions of income, education, gender, and science interest on students’ attitudes toward science score, a linear regression was conducted. On both tail ends of parents’ education, the sample size was low. Therefore, both to preserve participants’ anonymity and to minimize the influence of a few participants on the analysis, the “less than high school diploma” and “high school diploma/GED” categories were combined, and the “master’s degree” and “doctorate degree” categories were combined. For the same reasons, “less than \$30,000” and “\$30,000–\$59,999” were combined.

The threshold for statistical significance was 0.05. Data were analyzed in GraphPad Prism and SPSS. Bar graphs were created using GraphPad Prism, and the area-proportional Venn diagram was created using BioVenn (Hulsen et al., 2008).

3 Results

We received 118 parental consent forms that included demographic information. Of the children granted permission by a parent to participate in the study, 105 middle schoolers completed the attitudes toward science scale. The combined enrollment of the seventh and eighth grade cohorts was approximately 150 students, indicating approximately 70% participation. The students ranged from 12 to 14 years old. Table 1 details the demographic information of the participants.

Attitudes toward science did not significantly differ between male and female students [Figure 1A; $t_{(102)} = 0.498$, $p = 0.620$]. However, students from households with incomes greater than \$90,000 had significantly more positive attitudes toward science than students from households earning less than that amount annually [Figure 1B; $t_{(90)} = 2.318$, $p = 0.023$]. Similarly, middle schoolers who had a parent with a bachelor’s degree or higher had higher attitudes toward science than those whose parents earned less than a bachelor’s degree [Figure 1C; $t_{(101)} = 2.094$, $p = 0.039$].

Students whose parents indicated they thought that their student was interested in a science career had significantly higher attitudes toward science than students whose parents thought that their child was not interested in a science career [Figure 2A; $t_{(101)} = 4.927$, $p < 0.0001$]. Of the students whose parents provided socioeconomic demographic data and noted that they thought that their middle schooler was interested in a career in science, 44.4% were from households of less than \$90,000 and/or whose parents did not earn a bachelor’s degree (Figure 2B). Therefore, despite the role of socioeconomic factors on attitudes toward science, there was a

TABLE 1 Demographics of study participants.

Category	Percent (number of participants)
Gender	
Female	50% (53)
Male	49% (51)
Transgender/Other	0% (0)
Prefer not to answer	1% (1)
Ethnicity	
Non-Hispanic	94.3% (99)
Hispanic	1.0% (1)
Prefer not to answer	4.8% (5)
Race	
White	94.3% (99)
Black or African American	1.0% (1)
Asian	1.9% (2)
Native Hawaiian or Other Pacific Islander	1.0% (1)
More than 1 race	2.9% (3)
Annual household income	
Less than \$90,000	31.4% (33)
\$90,000 or more	56.2% (59)
Prefer not to answer	12.4% (13)
Highest degree earned by a parent	
Less than a bachelor’s degree	33.3% (35)
Bachelor’s degree or higher	64.8% (68)
Prefer not to answer	1.9% (2)
Parental assessment of child’s science career interest	
Yes	29.5% (31)
No	33.3% (35)
Prefer not to answer/unsure	36.2% (38)

Parents’ self-reported demographic information of their middle schooler (gender, age, ethnicity, and race), socioeconomic factors (parental education and household income), and whether or not the parent thought that their middle schooler was interested in a career in science.

meaningful proportion of students from households of less income or educational attainment who could be interested in pursuing a career in science.

To further probe how the aforementioned factors predict science attitudes, we ran a multiple regression including the primary variables of interest: household income, highest degree earned by a parent, science career interest, and gender. In contrast to the bivariate analyses above, this test included more income and educational categories as ordinal variables (Table 2). Due to the nature of linear regression, this model only includes participants for whom we had data on all four variables as well as a science attitudes score ($n = 57$). The regression model was statistically significant [$F_{(4,52)} = 5.694$, $p < 0.001$, $R^2 = 0.305$] with household income and interest in a career in science, but not parent’s education or gender, positively predicting a student’s attitudes toward science score (Table 2).

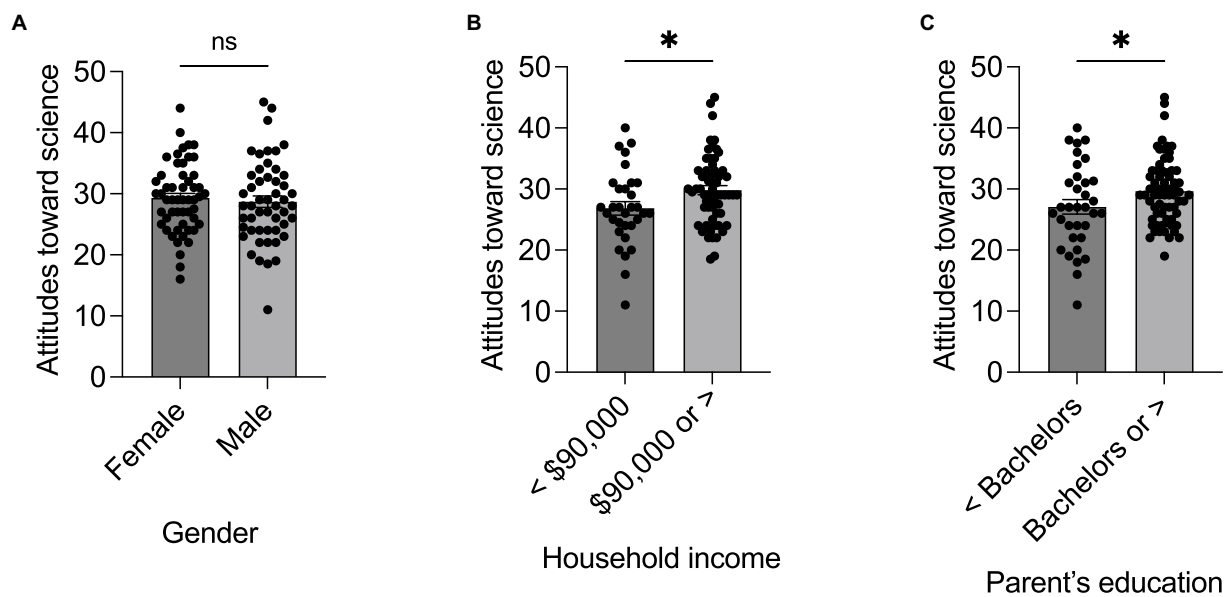


FIGURE 1

Middle schoolers' attitudes toward science. (A) No difference was detected between male and female middle school children. (B,C) Attitudes toward science were significantly higher for students from families earning more than \$90,000 (B) and who had a parent with at least a bachelor's degree (C). ns, not statistically different; * $p < 0.05$; bars = mean; error bar = SEM; $n = 92$ –104.

4 Discussion

The present study examined the relationships among SES, gender, science career interest, and middle school students' attitudes toward science within a middle-class, rural, midwestern community. Consistent with our hypothesis, the present study found differences in these middle schoolers' attitudes toward science based on surveyed metrics of SES and parental assessment of their child's interest in a science career.

In contrast to prior research showing more positive attitudes and interest in science among boys (Mattern and Schau, 2002; Desy et al., 2011; Riegle-Crumb et al., 2011), we did not detect a statistical difference in science attitudes between girls and boys in this population (Figure 1A; Table 2). The lack of gender differences in science attitudes is encouraging for increasing the representation of girls in STEMM and might be attributed to female science teachers that can reduce stereotype threat or an increase in women role models in STEMM (Master et al., 2014; González-Pérez et al., 2020). Despite the lack of gender differences in this study's results, future research should continue to investigate potential sex or gender differences in science attitudes, because science attitudes can be multifaceted. For example, a prior study found that females have more positive attitudes toward the teacher and science's value to society, whereas males have more positive attitudes toward their own self-concept, enjoyment, and motivation in science (Weinburgh, 2000). Finally, there remains a gap in the literature examining transgender and non-binary students' attitudes toward science that future work could address.

SES can include multiple factors; we focused on family income and the highest level of education attained by a parent. Based on socioeconomic demographics of this participant pool and the median income of the middle class at the time (Kochhar and Sechopoulos,

2022), we first compared attitudes toward science relative to income and education at \$90,000 and a bachelor's degree, respectively.

In our sample of rural, midwestern, primarily white, middle class middle schoolers, the children from families of higher income and education had more positive attitudes toward science than those of lower household income or parental education (Figures 1B,C). These results are consistent with the literature. Children of higher socioeconomic backgrounds often have parents with higher levels of education and resources. These parents may place a greater emphasis on their children's science education and have the resources to invest more in extracurricular activities and resources that support their children's exploration and development of scientific interests (Guo et al., 2022).

Although income and education are often correlated, previous work has shown that they can independently impact children's science achievement (Betancur et al., 2018). Therefore, we next ran a multiple regression to tease apart the specific contributions of the variables of interest on science attitudes. Similarly to the results of the *t*-tests (Figures 1, 2), household income and parental assessment of their child's interest in a science career had positive, statistically significant linear relationships with middle schoolers' science attitudes scores (Table 2). However, whereas children with a parent who earned a bachelor's degree had more positive attitudes toward science than children without a parent who earned at least a bachelor's degree (Figure 1C), the effect of education was not significant in the regression which included more educational brackets (Table 2). Indeed, descriptive statistics within these educational brackets show that science attitudes are highest within children who have a parent with a bachelor's degree, but scores for children whose parents earned a master's degree or higher are similar to those whose parents did not earn a bachelor's degree. This may indicate a non-linear relationship between parental education and a child's attitudes toward science, at least in this sample. However, we caution over-interpretation of this result for a few reasons. First, as previously mentioned, the sample sizes for categories on both ends of the

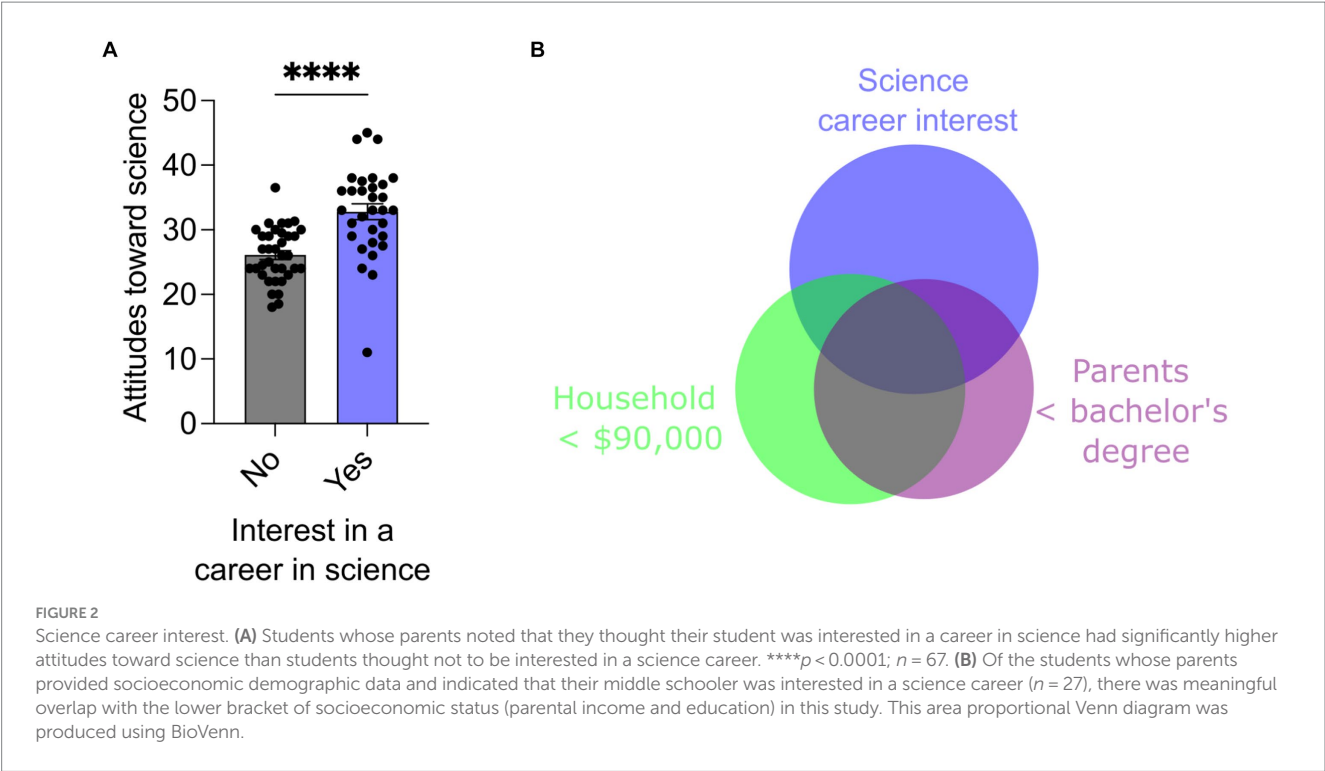


TABLE 2 Linear regression results and attitudes toward science scores by demographic brackets.

Category	Percent (number of participants)	Average science attitudes score (SD)	Beta estimate (95% CI)	p-value
Annual household income			2.623 (0.245–5.000)	0.031*
Less than \$60,000	10.5% (6)	22.1 (6.8)		
\$60,000–\$89,999	26.3% (15)	28.6 (5.1)		
\$90,000 or more	63.2% (36)	30.1 (6.1)		
Highest degree earned by a parent			0.028 (–0.850–0.795)	0.946
High school diploma/GED or less	17.5% (10)	27.0 (8.7)		
Associate's degree	17.5% (10)	26.1 (5.2)		
Bachelor's degree	45.6% (26)	30.9 (5.7)		
Master's degree or higher (including doctorate)	19.2% (11)	27.5 (5.2)		
Parental assessment of child's science career interest			2.625 (1.132–4.119)	<0.001*
Yes	43.9% (25)	32.2 (7.1)		
No	56.1% (32)	26.3 (4.1)		
Gender			0.442 (–1.075–1.959)	0.562
Female	59.6% (34)	29.6 (5.4)		
Male	40.4% (23)	27.8 (7.4)		

This analysis includes the participants for which no data points were missing ($n = 57$). SD, standard deviation; CI, confidence interval. * $p < 0.05$.

educational spectrum were small, prompting combining neighboring categories (less than high school and high school/GED; master's and doctorate) to preserve participants' anonymity and minimize undue influence of a couple data points on the linear regression. Second, we do not know the fields of study for the parents who had earned advanced degrees; they might not be related to science.

Consistent with the present finding on the significant relationship between household income and children's science attitudes (Figure 1B; Table 2), previous scholarship has shown that income can directly influence the learning resources available for families and students; those from wealthier households may be able to purchase more learning resources to use at home, hire tutors to help their

children succeed, or pay for after school or summer activities (Liu and Schunn, 2020). Additionally, economic effects on students' science outcomes may begin at a more basic level: previous research found that the effects of parents' income on students' science achievement was mediated significantly through reading and math abilities (Betancur et al., 2018). Although the aforementioned study examined science achievements rather than attitudes, it is possible that foundational skills such as mathematics and reading may also mediate science learning experiences and thus science attitudes.

Although the present study did not observe a stepwise linear relationship between a parent's educational attainment and their child's attitudes toward science (Table 2), it did find that students with a parent who earned a bachelor's degree had generally more positive science attitudes than children whose parents had not earned a bachelor's degree (Figure 1C). Previous work has shown that parents' level of education can influence children's achievements even more so than income (Erola et al., 2016). Higher levels of parental education can yield increased human, cultural, and social capital; these resources and influences on parenting in turn can impact their child's science learning experiences (Betancur et al., 2018). Parents with higher education may be more aware of the career options available in the sciences. Also, due to their own educational experiences, these parents can converse with their children about science and provide in-home educational experiences relating to STEMM (Betancur et al., 2018). Finally, parents with greater formal education might set higher academic and science expectations for their children. Research suggests that parental expectations can influence a child's self-evaluation and goal-setting in science learning, ultimately affecting their attitude toward the subject (Bandura et al., 1996; Guo et al., 2022).

The present study also found more positive attitudes toward science in students whose parents indicated that they thought their middle schooler was interested in a science career. This result held true in both analyses (Figure 2A; Table 2). This finding demonstrates alignment between parents' perceptions of their children's science interest and their children's science attitudes and is consistent with previous literature showing that more positive attitudes toward science are closely related to persistence in school science and interest in pursuing science as a future career (Iwuanyanwu, 2022). Many factors influence career decisions, and middle schoolers have time for career interests to change; however, children's career aspirations are more stable than expected (Archer et al., 2020). Previous work has shown that SES correlates to students' motivation for science, with children as young as kindergarten reporting less motivation to learn science compared to their higher SES peers (Liu and Schunn, 2020). Interestingly, previous research also has found that parents' education was the largest predictor of children's eventual occupational achievement, more so than income (Erola et al., 2016). Although students in the present study interested in a science career tended to come from families of higher parental education and/or household income, there was a meaningful proportion of children interested in a science career from families of lower middle-class income and parental educational attainment (Figure 2B). This finding highlights an opportunity for educators and STEMM professionals to teach and mentor children interested in science that may not have as much science support from home. It also adds to the literature by extending previous SES differences to a middle class, rural, midwestern community. Additionally, interventions may benefit from encouraging children to think of science as action, instead of identity defining; for

example, the wording of who can "do science" versus who can "be a scientist" can be a powerful shift to encourage children to think of a broader range of people involved with science (Lei et al., 2019). Indeed, many children value science and are interested in doing science but do not strive to become a scientist (Archer et al., 2020).

The present study has several caveats. First, like most studies in this domain, the findings are correlational; we cannot randomly assign participants to families of specific educational or income levels. Second, the sample size was modest. We included as many participants as possible in each analysis; however, because parents could choose not to answer any demographic question, the missing data points (especially for annual household income and parental assessment of their child's science career interest) further shrunk the sample size for certain analyses. To promote transparency, sample size for each group is reported in the tables and figure legends. The participant population was predominantly white, non-Hispanic, and with parents of higher educational attainment and income than average within the United States (Bureau, 2022). Because we did not ask about the highest degree from each parent (only the highest degree achieved by either parent), it is possible that the average is more similar to the national average if one parent had earned a bachelor's degree but the other did not. Regardless, even though the present sample does not represent the entire United States, there are many other rural and suburban communities with analogous demographics. Furthermore, the focus on a rural, midwestern, middle class community adds to the literature. While previous research has observed disparities in science attitudes and career aspirations among racial and ethnic minorities and those of low SES (Weinburgh, 2000; Riegle-Crumb et al., 2011; Lei et al., 2019; Gall et al., 2020; Kaya, 2022), the present study reveals differences in science attitudes within the middle class relating to parents' level of education and income at higher levels than previously reported. Of course, the need to support students in families of lower SES and to create pathways to support their education and STEMM opportunities remains. The present study reveals additional opportunities for supporting another segment of students that may be interested in science but do not come from upper middle-class families of higher educational attainment or income (Figure 2B). Additionally, it highlights the value of STEMM outreach in all communities.

To further understand the impact of socioeconomic status on attitudes toward science, future studies should expand to other regions of the country and seek broader diversity of participants. To begin elucidating the impact of specific socioeconomic descriptors on middle schoolers' attitudes toward science, we ran a multivariate regression in addition to the *t*-tests. Overall, the results were very similar except for the effect of parental education on students' science attitude scores. Sharing the results of both types of analyses provides a more complete picture on the relationships among these factors and allows for the inclusion of more participants rather than reducing the reported analyses only to participants without any missing demographic data points. Future work should continue to compare and contrast the impacts of multiple socioeconomic indicators and mediators on science attitudes. Although the present study was not powered for more complex analyses, the study being conducted within one school minimizes otherwise confounding variables such as school resources and geographical location. Finally, although the SES data are now a few years old, they were not influenced by the significant income and

occupational changes that impacted many families during COVID-19, as surveys were serendipitously collected right before COVID-19-related restrictions began. Future studies should continue to investigate science attitudes and STEMM career aspirations in these communities, especially because recent research reveals an increasing urban–rural divide, with rural residents having less positive attitudes toward scientists than urban residents, even when controlling for income and education (Okada and Shen, 2023). Even when STEMM attitudes are positive (Japashov et al., 2022), barriers persist for many children in rural communities to pursue STEMM careers. For example, colleges may be geographically distant, students may have knowledge gaps and resource limitations impacting their ability to pursue a STEMM career, or they may face pressure to stay within their community or financially assist their family members through work (Peterson et al., 2015; Grimes et al., 2019). Increased political polarization between urban and rural areas, with rural areas less trusting of scientists, can also be a barrier for rural students to pursue STEMM careers (Okada and Shen, 2023). Science outreach in schools can be an effective way to reach rural students (Hendrickson et al., 2020; Lewis et al., 2020), and mentoring can support rural students seeking to pursue STEMM careers (Oshiro et al., 2023).

In conclusion, the present study expands upon the literature of SES impacts on science attitudes by revealing differences corresponding to parental education and household income in science attitudes among predominantly white, middle class, rural, midwestern middle schoolers. The gap in science performance between high and low SES students is narrowing (Broer et al., 2019), demonstrating progress. However, much work remains to fully close this gap and increase STEMM opportunities for all students.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Western Michigan University Homer Stryker M.D. School of Medicine Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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Author contributions

KP-S: Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. WY: Writing – original draft. PV: Writing – review & editing, Formal analysis, Data curation, Conceptualization.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1403039/full#supplementary-material>

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Inspiring rural youth to consider healthcare careers through an interprofessional healthcare traveling roadshow

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There are well-documented shortages of healthcare providers in rural and remote communities worldwide, and these shortages correlate with inequitable health outcomes for rural peoples. Despite a wide array of efforts to remedy the issue, these shortages persist to this day. The Healthcare Traveling Roadshow (HCTRS) is a grassroots initiative that began in 2010 to help address the shortage of healthcare providers in rural communities throughout British Columbia. Since its inception, the HCTRS has been predicated on three evidence-based guiding principles which have been shown to markedly increase the rate at which healthcare students choose to practice rurally. These principles are: (1) to showcase healthcare careers as viable and realistic options for rural youth (high school students) using interactive stations and near-peer teaching; (2) to expose healthcare students to rural communities and showcase them as a potential opportunity for their future practice; and (3) to provide a unique interprofessional experience to healthcare students from diverse healthcare careers and backgrounds. Through the synergy of these three principles the HCTRS aims to increase the longitudinal recruitment and retention of healthcare workers in underserved rural communities. This paper will share our experience from 15 years of running this initiative, for those hoping to implement similar programs in other areas of the world.

KEYWORDS

rural, health workforce, interprofessional, healthcare, university-high school outreach, community engagement, youth

Introduction

Providing access to adequate and equitable healthcare services for rural and Indigenous communities is a long-standing and well documented issue (1–4). Healthcare provider shortages in rural regions correlate with increased morbidity and mortality suffered by rural and Indigenous peoples, the world over (3–5). While approximately 17.8% of Canadians live in rural and/or remote locations (6), only 8.2% of practicing physicians are located within these areas (7). This disparity becomes even more staggering when looking specifically at specialist physicians, only 2.2% of whom practice in a rural setting (7). This shortage is not isolated to physicians either; many other healthcare professions are significantly underrepresented such as occupational therapists and physical therapists, with 5.3 and 7.2% practicing rurally, respectively, (8, 9). This maldistribution of healthcare providers and disparity in the provision of healthcare services, specifically in highly remote locations, generally leads to worse health outcomes due to delayed care, the need for lengthy transport, a higher financial/logistical burden, and longer recovery time (10).

In many ways rural youth are the best candidates for a career as a rural healthcare provider, as they are familiar with the culture and context of rural living (11, 12). However, rural youth face greater barriers than their urban counterparts in studying to be a healthcare provider, including needing to travel long distances, and typically needing to adapt to the urban environment, without nearby family support (13–15). Additionally rural youth, have greater hesitancy about their abilities to succeed in healthcare training (15–17).

Rural youth are less likely to have connections to people who work in healthcare and thus have less ‘social capital’ (17). Yet when youth have greater health-related self-efficacy, this contributes to social capital, and helps individuals and their peers consider the possibility of something that previously felt out of reach (17). Healthcare student facilitators, particularly those with a rural background and/or experience, are uniquely capable of engaging high school students through their relatability and role modeling (18). Thus, providing support and encouragement for rural youth to consider healthcare careers is an important aspect of building and sustaining the rural health workforce.

The Canadian public believe in the importance of universally accessible healthcare, but recognize that our health system is struggling significantly (19). People recognize the importance of growing the primary care workforce, and ensuring that this workforce is representative of the people it serves; which includes increasing training opportunities for northern, rural, remote, and Indigenous peoples (19). The Canadian Collaborative Taskforce for Advancing Rural Family Medicine has acknowledged that initiatives need to be developed, whose central goal is the longitudinal recruitment and retention of healthcare workers to rural and remote locations (1). The Canadian accrediting body for medical schools has recently added an accreditation element on social accountability that requires a medical school to address the priority health concerns of the populations it has a responsibility to serve (20). Given the established maldistribution of healthcare providers and the impact it has on the health of rural and Indigenous peoples, medical schools thus have an obligation to deliver outreach to rural, remote and Indigenous, youth (high school students).

This paper will describe and elucidate the logistics of delivering one such initiative, the Healthcare Traveling Roadshow (21, 22).

The healthcare traveling roadshow

The Healthcare Traveling Roadshow (HCTRS) was conceived in 2009 as a grassroots initiative with the intent of lessening healthcare provider disparities in rural communities throughout the province of British Columbia, Canada (21, 22). In order to achieve this goal, the HCTRS recruits healthcare students from various training programs across a variety of healthcare career training programs, to take part in a 1 week activity visiting several communities within a specific, underserved region of British Columbia, Canada.¹ These students are

tasked with being part of a unique presentation and learning experience wherein they share their story with youth at local schools and engage them in interactive education stations focusing on diverse healthcare careers, having low stakes conversation and stimulating interest. This program serves to correct misconceptions about the possibility of pursuing a career in healthcare as well as providing youth with insight into various options potentially available to them and the scope of practice of specific healthcare professions. In addition to this, the healthcare student facilitators are exposed to rural communities, both in formal educational tours and recreational activities which showcase the natural beauty these areas contain and the potential benefits of practicing in such a setting. By touring facilities and speaking to local healthcare professionals, students are exposed to the reality of the available services and what’s possible in a resource limited setting. This increases the general understanding of rural healthcare service delivery, along with its challenges and opportunities, as well as showcases the opportunities and lifestyle inherent to practicing in these communities.

Over the past 15 years, 23 Roadshows have taken place which have visited more than 13,500 youth in 79 different community visits. These communities are vastly separated in their geographic location, but all share some measure of rural health service disparity. By promoting healthcare careers to rural youth, the HCTRS is designed to alleviate these service shortages by increasing the number of local youth choosing to pursue careers in healthcare, promoting rural practice to students in training, and providing an interprofessional experience for the healthcare students. Through the synergy of its three principles, the HCTRS provides a multifaceted approach to the longitudinal recruitment and retention of rural healthcare providers.

Three guiding principles

From its inception, the HCTRS has been predicated on three guiding principles. While each could be perceived as an isolated, achievable goal; it is the unison of these principles which best serves to promote a change in the rural workforce (21). These principles are to:

1. Showcase healthcare careers as options for rural students.
2. Showcase the rural community as a career option for healthcare students.
3. Provide an interprofessional experience for the healthcare students.

Through ensuring that these core principles are met, the HCTRS is able to achieve consistent positive impact despite changing student facilitators and communities each year. In addition, as the HCTRS has gained a positive reputation, more communities have expressed a desire to have this program come to their region. This has prompted the creation of two additional annual roadshows. Currently, two annual trips are based out of Prince George, B.C. and explore communities within the north. The third is based out of Kelowna, B.C. and provides exposure to rural communities within the Southern Interior region. Given this distributed model, having these well-articulated principles assures communities that they will receive the same program regardless of their location. All three principles should be clearly understood as each provides an evidence-based approach

¹ Jobs in healthcare outside of medicine are often collectively referred to as Allied Health Professions; however, some jobs in healthcare require college training for a certificate or diploma, not a university degree, and people in these positions may feel excluded by the term “profession,” thus we have chosen to refer to jobs in healthcare as “Healthcare Careers,” and the people doing these jobs as “Healthcare Providers,” to be inclusive.

that individually has been shown to improve rates of recruitment and retention of rural healthcare professionals (23).

Showcase healthcare careers as options for rural students

Evidence shows that healthcare students with rural backgrounds are, on average, approximately twice as likely to return to and practice in a rural setting following the completion of their training (24). Evidence also suggests that obtaining secondary, post-secondary or post-graduate education in a rural setting likewise predisposes healthcare providers to practice rurally (1, 23, 24). Thus, showcasing healthcare careers to rural youth should eventually increase the number of rural healthcare practitioners. However, rural youth often experience numerous barriers in pursuing a path in healthcare, compared to students in more urban environments (13–15). Such obstacles include a lack of exposure to the healthcare system, consequent lack of familiarity with the multitude of diverse career options available, and far fewer role models within the healthcare field amongst many others. Through their interactions with rural youth, the healthcare student facilitators provide rural youth with exposure to numerous professions within the healthcare field and highlight these professions as realistic options for their future careers. The HCTRS uses a “near-peer” model, that may be more effective than having individuals who are more established in their careers’ talk to youth (25–28). In addition to benefitting the learners, near-peer teaching approaches have benefits for the personal and professional development of the peer teachers (28). This is the beginning of what has been described as the rural healthcare “pipeline” or “pathways,” concepts which seek to address the many barriers faced by underrepresented populations into healthcare training (1, 29).

Showcase the rural community as a career option for healthcare students

Rural exposure is an important factor in a future healthcare practitioner’s decision to work and live in such a setting. It has been shown that having positive experiences in rural communities significantly increases the rates at which students choose to practice rurally (30). Unfortunately, many healthcare training programs within British Columbia have historically only been made available in metropolitan areas and offer little, if any, rural exposure during the course of training. Compounding this problem, the urbanization of healthcare training often leaves students without the experiences, skills, and training necessary to practice in rural setting should they choose to explore such an option later-on (31). As such it is vital that all healthcare students gain a measure of rural competence during their education even if they choose to practice in an urban environment. The rural exposure students are given during the HCTRS serves the dual purpose of improving students’ ability to practice in a rural setting, and increasing their likelihood of choosing to practice rurally. Should they ultimately choose to practice in a larger metropolitan area, their experiences will have better informed them concerning the challenges of rural healthcare delivery and their competence will better serve them in their future practice when engaging patients from a rural background.

Provide an interprofessional experience for the healthcare students

Interprofessional experiences during the pre-clinical education of healthcare students helps them synergize as part of a larger healthcare team (31). While some programs require interprofessional activities as part of their training, others do not. Interprofessional collaboration is important for successful clinical practice, and even more important in rural contexts (32). Rural practice requires interprofessional collaboration, as healthcare providers must work closely with one another to mitigate gaps in service availability and provide the best possible care with limited infrastructure, staff, and resources.

Healthcare student facilitators are given an in-depth interprofessional experience during the HCTRS with fellow students from a diverse selection of healthcare training programs, and may also have the chance to meet rural healthcare providers within the visited communities. The healthcare students learn with, from, and about each other and must collaborate to carry-out the presentations and modify their approaches as needed (if seeing a different age group, if the initial presentation wasn’t working well). Throughout this process, the students gain a greater understanding of their professional role, gain experience describing their career and scope of practice to the public, and learn about the scope of practice of other healthcare careers, at a stage of training when it is perhaps easier to ask questions that might sound naïve (“what do you do?”). Ensuring healthcare students gain greater experience in this area while in training through projects like the HCTRS may lead to graduates being better prepared for work in a rural setting. Furthermore, some may find they naturally gravitate to a work environment containing a more prevalent component of interprofessional collaboration causing them to more seriously consider work in a rural setting.

Impact

To date, our program evaluation has indicated that the program is largely successful in reaching its goals. Youth, healthcare students, and community members alike, agreed that the program was largely successful and succeeded in encouraging rural youth to consider a career in healthcare, while showcasing the rural community as an appealing option for healthcare students to consider (Table 1) (22). Respondents emphasized that the sincerity of the presenters and interactive design of the initiative made it impactful; community engagement is important; the interprofessional design is important for the youth to see as well as for the healthcare students to experience; and healthcare students can learn much through participating in such an initiative (Table 2) (22).

We are also aware of a number of stories of students who on admission to medical school, told us that the HCTRS was what planted the seed that led to their decision to pursue a career in medicine. We also know of at least one student who chose a career in medical laboratory technology science after seeing the HCTRS as a high school student and has since returned to their hometown and has remained there in practice. Many times on the HCTRS, healthcare students have had conversations about job opportunities with local medical staff. Much anecdotal evidence also indicates that the HCTRS has a dramatic impact on the number of conversations about healthcare careers at schools, for months after our visits.

TABLE 1 Quantitative evaluation of the healthcare traveling roadshow.

		Youth (95% CI)	Community members (95% CI)	Healthcare students (95% CI)	Total (95% CI)
Q1.	How successful do you think this project was in general? 1 = Not very, 5 = Very	4.68	4.68	4.75	4.71
		(4.44–4.92)	(4.55–4.81)	(4.64–4.86)	(4.63–4.79)
Q2.	Do you think this project will encourage healthcare students to consider settling in a rural community after graduation? 1 = Not likely, 5 = Very likely	4.14	3.66	4.58	4.12
		(3.84–4.44)	(3.46–3.86)	(4.43–4.73)	(3.98–4.26)
Q3.	Do you think this project has encouraged local youth to consider careers in healthcare? 1 = Not much, 5 = Very much	4.55	4.31	4.54	4.45
		(4.30–4.80)	(4.15–4.47)	(4.39–4.69)	(4.35–4.55)
Q4.	Please rate your overall experience of the project. (Healthcare students only) 1 = Poor, 5 = Excellent			4.82	4.82
				(4.71–4.93)	(4.71–4.93)

Average of responses to program evaluation questions, with 95% confidence intervals (CI), presented by population: youth ($n=22$), community members ($n=62$), healthcare students ($n=57$), and total ($n=141$ or $n=57$ total for Question 4). Reproduced with permission under Creative Commons CC-BY license (22).

Funding

Funding for the HCTRS has grown as the initiative has grown, from a humble grassroots initiative, to a much larger initiative that still retains its grassroots approach. We have been very fortunate to benefit from stable funding from the provincial Rural Education Action Plan (33) and a local community trust, the Northern Medical Programs Trust (34) along with other partners as outlined on the HCTRS webpage (22). It is worth noting, that this initiative was not developed as a research project and has not been supported by research funds. There is a paucity of literature on theory and best practices for this type of initiative and more research should be done, but this initiative was developed with guidance from the literature that clearly indicates this type of work needs to be done. We feel it's been as successful as it has, because we have focused on making the project successful, not on running it as a research project and needing to continuously seek out new sources of funding. This initiative fits well within the scholarship of application as described by Boyer (35, 36).

As the initiative has grown, the budget has grown accordingly. Early trips relied on healthcare students from the small university and college in the northern region of the province where the HCTRS was born. However, we consistently had trouble getting 12 students to volunteer for a trip, and we were not able to showcase a great diversity of healthcare careers. In 2015, we requested additional funds to support students traveling from the large metropolitan regions in the south (i.e., Vancouver, Victoria) and this has allowed us to get a consistent pool of applicants representing more diverse healthcare careers and more diverse life experiences.

Community selection

When running the HCTRS, it is important to have community buy-in. When we first started the HCTRS, we had a model that relied on a community champion in addition to an academic champion (i.e., staff or faculty lead). The community champion would help to coordinate with the school, the hospital, and local leaders, to provide a well-rounded experience for the healthcare student team. If a

community champion volunteered because they knew about the HCTRS, the process was likely to be relatively easy. If a community champion did not volunteer or was not aware of the initiative, it tended to be harder to explain what it was about and required more effort from the academic champion. More recently, medical students have been organizing the trips, and we are largely a known entity in our region, but still, when speaking with someone new, who does not know what the initiative is, it can take substantial time and effort to explain what it is about, and to move them from seeing this as a chore to seeing it as a gift.

Logistics

Each trip is different. In our rural region, trips can be over 2000 kms in a week, and we now charter a bus as a safer way (than personal vehicles) to carry the team and the equipment. The target audience is grade 10 students (mid-upper secondary education, ISCED level 3) (37), since they are expected to be in the early stages of considering future education and career opportunities, when “career-life interests and possibilities start to become meaningful considerations” for many (38). Depending on the size of the community and school population, we may see only grade 10 students or we may see the whole high school: i.e., if there are 240 youth from grade 8–12, we will likely plan 3 presentations and see the whole school; whereas, in a larger small town, if there 400 grade 10 students, we will only see grade 10 (in 5 different presentations).

We will occasionally visit an elementary school, though this is outside our target grade: if they are particularly remote, if we are invited, or if it otherwise seems like the right thing to do. It can be a fun way to get ‘warmed up’ for the high schools, as elementary school students tend to be easy to engage, and high school students aren’t necessarily. Also, if there is a very small rural high school near to a larger rural center, it can be fun for our students to see the small school, but there’s a tradeoff, as it takes time to get there, and get set up, do the presentation, and take down the equipment. If the school is very small (<30 students) we generally invite them to bus in to the

TABLE 2 Highlights of program evaluation.

Sincerity and Interactivity Sparking Enthusiasm
“Everything was pretty great. I liked that everything was hands on, and that we got to learn a bit about everyone.” – Youth
“I think the range of backgrounds/life experiences/career choices each student had was great for kids to see.” – Community member
“Inspiring and educating the high school students... Seeing their “aha” moments and enthusiasm.” – Healthcare student
“All the hands-on work that we were able to see. I liked how all the medical students personalized their work.” – Youth
“The interactive tables were great for kids to actually see what might be involved, as many of these kids have probably never been exposed to most of the professions incorporated in the roadshow.” – Community member
“I liked the connection obtained by talking to the people who had come for my sake.” – Youth
Learning Through Rural Exposure and Community Engagement
“Having healthcare students from all over BC ... allows us to showcase our community and what we have to offer professionals coming to the [region].” – Community member
“It is inevitable that students will all encounter patients at some point in their career who have come from a smaller community and have faced some of the health care challenges that comes along with that. Having at least some idea of what those challenges are will allow students to be better equipped to care for these patients.” – Healthcare Student
“I can genuinely say that because of this opportunity, I would consider working in a more rural area as a healthcare professional.” – Healthcare Student
“The Roadshow gave me incredibly valuable insight into what this sort of medical path would be like and I feel like firsthand exposure is really the only way to obtain this sort of insight.” – Healthcare Student
Healthcare Student Personal Growth
“It’s great to learn what brought people to their career of choice and it’s inspiring to know there are lots of options to be shared with not only youth but anyone looking for a rewarding career.” – Healthcare Student
“Learned about how to effectively describe my own profession to others, learned about the role/scope of other fields.” – Healthcare Student
“Talking to the students from other training programs helps me to communicate with other health professionals better in my future work.” – Healthcare Student
“That personal sense of brining this important cause to a region that requires this work so acutely and desperately was satisfying.” – Healthcare Student
Interprofessional Collaboration and Development
“...I realized while traveling to these small towns that teamwork is key. It can be daunting and overwhelming to manage the health of an entire community, which is why support networks and interprofessional cooperation among different health professionals is vital for long-term sustainability.” – Healthcare Student
“I learned a little more about what is involved in the different professions as well, which makes it easier for me to understand how I can incorporate partnerships later on when I am in practice.” – Healthcare Student
“I was impressed with the depth of knowledge across all different disciplines and how much we can learn from each other and how our work with patients connects.” – Healthcare Student
“[I] learned that everyone brought a lot to the table and was able to gain more insight into how other peoples’ programs worked and it broadened my own understanding of a healthcare team” – Healthcare Student
“... the most enjoyable part of the roadshow has been learning from the other students that have been alongside me on the tour. I have found it incredibly informative to learn about the professions that influence healthcare in the clinical setting.” – Healthcare Student

Representative quotes organized by theme. Reproduced with permission under Creative Commons CC-BY license (22).

larger school when we already have our equipment set up. This means less change of scenery for the healthcare students, but usually the youth from the small school enjoy the chance for a field trip.

A key component of the HCTRS is the availability of healthcare training equipment for the youth to interact with. This requires trusting relationships within the host institution(s) and any partnered institutions, to ensure this expensive equipment can be borrowed and used for the trip. In northern British Columbia, we borrow equipment from several UNBC programs: the medical program, nursing, nurse practitioner, and health sciences. We also borrow equipment from the local college (The College of New Caledonia) to model medical laboratory technology sciences and medical radiography technology. We also occasionally borrow equipment from the hospital as needed and available, such as an ultrasound or a patient monitor. If students are coming from a program we have not had before and/or do not have equipment for, we work with them to identify needs and will reach out to our local connections, and/or they may bring

some supplies with them (their own, and/or borrowed from the school they are training at).

A typical trip:

- 1,000–2,500 kms traveled over a week.
- 3–6 different communities.
- 12 healthcare students representing 8–10 different healthcare careers.
- 2–4 university staff (admissions coordinator, communications officer, Indigenous coordinator, faculty lead).
- 10 presentations:
 - 60–80 youth per presentation (it’s important to not try to see too many students at once, or the small table presentations are too crowded and not everyone can see and engage/interact).

- o Each presentation includes ~12min of large group introduction where each healthcare student has 1min and 1 PowerPoint slide to answer the question “who am I, and why did I choose to become a [insert healthcare career]?” (youth sitting in bleachers or on the floor).
- o Following the large group introduction, healthcare students are divided into groups of ~6–8 and assigned tables to start at ([Supplementary Appendix 1](#)).
- o Small group presentations are meant to be interactive and give the youth something to do (intubate a dummy, look through a microscope at something interesting, try out a wheelchair, learn how to birth a baby, dress a wound, etc. ...). They also provide an informal opportunity for youth to ask healthcare students questions, which vary from questions about biology related to the presentation, or questions about admission to the training program and costs of study. Youth often learn things through this exchange: about the availability of student loans, or that the placenta must be birthed after the baby, for example.
- o Preferred total presentation time 1.25–1.5 h (depending on schedule and flexibility at each school).
- o One of the staff is responsible for assigning youth to starting tables, and then must calculate the time available divided by the number of tables at the session (typically 6–8 min per station), and then keep time and tell the youth to rotate (sometimes this means cutting off conversation, but if we do not do this, youth will not get a chance to see every table and when that happened in the past, they were not happy about it).
- The 10 presentations can be 2 per day (morning is probably best), or can be scheduled more variably. Healthcare students consistently tell us that interacting with the youth is the most meaningful part of the trip; but that it's also pretty exhausting.
- The remainder of the week schedule is filled with a combination of:
 - o Hospital/healthcare facility tours: typically 2–3 facilities along the way. A larger rural hospital and a smaller one, to give the students an idea of the scope of positions available, and the range of facilities. Seeing multiple of the same size hospital has little additional value. Involving healthcare providers if possible is helpful, but often they are busy and the Health Services Administrator (HSA) often does the tour. The HSA tends to be quite knowledgeable about what positions are available, number of beds, services provided, etc.
 - o Recreational opportunities. These depend widely on what the communities would like to showcase. We do not have a budget for recreation, so we try to ask community leaders if there are particular things that they'd like to showcase for this visiting group of healthcare students (a rather uncommon opportunity), to give them a taste of rural living. Sometimes the community will recommend a hike and send someone to guide us. Sometimes they will provide something more extravagant. Over the years we have done/seen: hiking, beach fires, canoe trips, horseback riding, a trip to the farmers market, whitewater rafting, helicopter tours, jet boat tours, museum tours, hot springs, a wildlife reserve, a very large ranch, an abandoned mine, swam in a backyard pool, been serenaded by the youth band, and more.

- The trips typically start Sunday with a commute to the initial community, Monday – Friday are presenting and visiting in different communities, then Saturday return home (7 days). For those who are traveling from outside the region, they will typically fly on Saturday and spend the night in the host community prior to the start of the trip, then at the end of the trip, they will generally spend another night before flying home on Sunday (9 days).

Healthcare student recruitment

By bringing together an interprofessional team of healthcare student facilitators, the HCTRS serves to provide a unique interprofessional experience to these healthcare students unlike anything available today in traditional training programs (at least in our region), while simultaneously providing rural communities with new insight into the variety of healthcare professions and career opportunities that exist within the modern healthcare landscape. Wide recruitment efforts targeting students from diverse fields of healthcare is key to ensuring both of these goals are met. Recruitment across diverse programs and institutions is complicated however, in that students in different training programs often have schedules that may conflict or overlap regarding previous education commitments and clinical placements. The HCTRS now recruits students from any healthcare program and any institution in the province of BC.

Recruitment begins between 4 and 6 months prior to the trip(s). We have an application form that is built in Qualtrics ([QualtricsXM²](#)) ([Supplementary Appendix 2](#)), and we rank and adjudicate applicants, to ensure students understand what the HCTRS is about (it's not just an opportunity to see rural communities). Applicants are scored using a rubric ([Supplementary Appendix 3](#)). Several medical students are involved in adjudicating the applications, and their scores are compiled, prior to an adjudication meeting. At the adjudication meeting, the faculty, staff and medical student team, review the scores, and then select students based on their scores, their careers, their diversity, and the trips they have chosen to attend. We aim for students with good scores, who represent diverse careers, and if possible diverse institutions and diverse lived experiences. We have funding for half of the student participants to travel from outside the region, so we aim for 6 students from our local institutions, and 6 from anywhere in the province. We aim for 8–10 different careers represented between the 12 total students (including 2 medical students who are involved in planning), and to have diversity in the lived experience of the group members. We tend to have >80% of applicants who are female, so we try to ensure there are some male students as well. If applicants are gender diverse, or disclose any differences in socioeconomic status, or ability (e.g., ADHD, anxiety, physical disability), they get additional points for diversity. It is particularly important in our region to role model Indigenous students in healthcare career training, as we have a high Indigenous population and not nearly the same percentage of healthcare providers who are Indigenous as the percentage of the population, so if applicants disclose Indigeneity, that is looked on positively as well.

2 <https://www.qualtrics.com>

Once a preliminary list of participants is created, the students are sent a welcome message and asked to confirm attendance within a week. If they can no longer commit, we reach out to the next best fit student. If they need longer to commit (to confirm with a preceptor that they can take time out of a placement, for example) we do our best to accommodate. Once we have a finalized list of students, they are sent more information on the trip ([Supplementary Appendix 4](#)), including the participant information form ([Supplementary Appendix 5](#)).

Planning throughout the year

We begin planning our destinations in the fall, for the next spring ([Supplementary Appendix 6](#)). Experience has taught us that high schools need lots of warning, as they have many activities in their students' schedules, and they aren't able to accommodate something like this at the last minute (or even with 6 weeks' notice). In the early years we would brainstorm possible communities, based in part on expressed community interest. Now that we have been to all the small communities in our region, we are planning repeat trips based on how long ago we were at each community. We finalize the schools and communities by December, so that in January we can begin recruiting students from other healthcare career training programs, knowing where the trips will be going.

After the adjudication process is complete and the students are selected for each trip, the remainder of the schedule needs to be planned/confirmed. The final schedule should include all activities each day including meals, the presentations at each school, time for setting up and taking down the presentations, recreational activities, local healthcare facility tours, checking in/checking out of hotels, and all transportation/travel time between each individual entry. Accommodations should be booked and confirmed several months in advance as smaller communities may have limited hotel accommodations available for a large group. Additionally, rural areas often have resource dependent economies that go through 'boom and bust' cycles, which greatly affect the availability of accommodations, as well as the costs. It has been found that having two students of the same gender share a room is preferable as this often allows friendships to form and saves costs. However, adjustments may need to be made depending on the participants.

Another consideration is to communicate with local restaurants well in advance to ensure they can accommodate larger group sizes. Just as with the hotel accommodations, food venues in smaller communities may not be able to easily accommodate large groups without warning. It is also important to ensure that restaurants can accommodate the dietary needs of the group. During the Roadshow, if the timing is tight, it can help to pre-order food so that dining can happen in the allocated window of time.

We do not have a budget for recreation. We ask our contacts and community leaders if there are particular things that they'd like to showcase for this visiting group of healthcare students, to give them a taste of rural living. It can help to remind them that this is an interprofessional group of healthcare students with some expressed interest in rural practice, and it's an uncommon opportunity for them to be able to showcase their community to such a diverse group of healthcare trainees.

Plentiful demonstration equipment is essential to providing interactive small group presentations. Securing equipment for each individual student based on their unique clinical training and interests will maximize high school student engagement. As above, much equipment needs to be borrowed, and relies on having trusting relationships with different departments, institutions, and the local hospital. Examples of the type of equipment that can be brought, is in [Supplementary Appendix 7](#).

A few months prior to the trips, a poster can be sent out to schools, to advertise that the Roadshow is coming to their school ([Supplementary Appendix 8](#)). An important element of planting the seeds of possibility, is to prepare students for the visit, and to hope that their parents/friends know about it and ask about it afterwards. The more conversation that happens about the possibility of a career in healthcare, the better.

On the trip itself, the days tend to be tiring, but also invigorating. Traveling together gives lots of opportunity for informal interprofessional sharing and for friendships to form. Though the students who volunteer to come on the trip have self-selected for the adventure, they may still be a bit shy at the start as they get to know one another. They will likely have a wide variety of experiences with youth (from none to plenty). If feasible, giving a chance to talk about their presentations the night before the first presentation (Sunday night dinner), can help to ease any concerns. After the first day of presentations, there will likely be some conversation about how it went, and more experienced students/staff can offer guidance, but in general, guidance should be minimal, so students can figure out how they wish to deliver their presentation (for some this is a new and somewhat scary experience).

Lastly, it's important to include program evaluation, to ensure ongoing quality improvement of the initiative. The data from the spring trips can be reviewed at the initial planning meetings the next fall, to consider any changes in policy for the next year's trips.

Conclusion

The Healthcare Traveling Roadshow is a Northern British Columbia initiative that aims to reduce disparities in the provision of healthcare within rural communities. Healthcare student facilitators engage rural high school students and showcase their careers as realistic possibilities, in a hands-on, near-peer format that encourages questions. In addition, healthcare students are given a unique exposure to rural communities showcasing the realities and potential benefits to practicing in such a setting following the completion of their training. This is all achieved with an interprofessional focus, which is particularly important for the rural health workforce ([31](#)).

It is important to reiterate that this is not a research project by nature, though it is well supported by research as outlined above. This initiative fits well within the 'scholarship of application' and faculty interested in delivering such an initiative, may wish to be thoughtful about how they articulate this work on their CV's. It is essential we do this work, with recommendations for national and international bodies concerned with the health of rural peoples, yet the academy is slow to accept the recommendations of Boyer and others ([35, 36](#)).

The HCTRS hopes to inspire similar initiatives in other areas that could benefit from a comparable program. This paper serves to share our framework for the implementation of a such an initiative, and we encourage anyone interested in developing their own version of this program to contact us if they require more information.

Data availability statement

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

Ethics statement

Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

KM: Conceptualization, Methodology, Visualization, Writing – original draft. MM: Methodology, Writing – review & editing. SM: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

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Supplementary material

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Empowering the future: improving community wellbeing and health literacy through outreach and service-learning

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Institutions training future healthcare professionals in healthcare and community engagement play a crucial role beyond traditional classroom settings. Recognizing their potential to support under-represented groups and minorities, institutions increasingly encourage engagement with schools and community organizations. However, work remains to advance meaningful and impactful educational outreach and service-learning programs. This manuscript synthesizes the perspectives of a group of medical school educators to discuss developing sustainable programs to engage youth in Science, Technology, Engineering, Math, and Medicine (STEMM) education with a focus on biomedical science. Through near-peer education and service-learning, healthcare students can impart knowledge, provide mentorship, promote enthusiasm for STEMM fields, and nurture health-related self-efficacy within individuals and communities. Collaborative efforts through student-as-teacher approaches bridge health-related disparities and cultivate healthier, more empowered futures for all. We advocate for community outreach strategies that target future health professionals early in their education and support the scholarship of teaching and learning and program evaluation. Successful long-term programs must ensure that results are systematically assessed, measured, and perpetuated. This perspective aims to highlight the role of service learning and community outreach in increasing individual health literacy and fostering an enduring interest in STEMM careers, thereby empowering the next generation of elementary and secondary school students.

KEYWORDS

assessment, student as teacher, community partnership, outreach/engagement, health professions education, scholarship/curriculum development, service-learning, empowerment

1 Introduction

For decades, higher education institutions have recognized that they can positively impact their local communities by engaging with individuals, particularly those from under-represented groups, in K-12 schools and other community organizations (1, 2). Strong connections between higher education institutions and the communities they serve are critical to improving community health through education and health workforce training (3, 4). Although the number of healthcare professionals is increasing faster than the global population is growing, the World Health Organization's National Health Workforce Accounts estimates that the health workforce shortage will still be approximately ten million people by 2030 (5). As is often the case, the consequences of this shortage will most likely fall on those underrepresented in science and healthcare fields, including ethnic and racial minorities, those with disabilities, and socioeconomically disadvantaged neighborhoods (6).

We believe that educational outreach and service-learning programs focused on Science, Technology, Engineering, Math, and Medicine (STEMM) have great potential for improving individual and community wellbeing, particularly in these underrepresented demographics. Moreover, community STEMM outreach activities promote interest in STEMM and facilitate the development of problem-solving and communication skills amongst participants, motivating them to engage in post-secondary STEMM education (7, 8). As a result, these individuals are more likely to have STEMM careers, improving their personal and community economic outlook, and helping to address the health workforce shortage (9, 10).

Many STEMM outreach programs focused on the education of K-12 students leverage the efforts of higher education students and faculty as instructors and educators (11–13). These programs impart knowledge and foster enthusiasm for STEMM amongst K-12 students, teachers, and parents/guardians while creating near-peer mentoring relationships that, in the best circumstances, lead to productive connections between communities and health professions institutions. This near-peer mentoring framework allows for education at multiple levels. K-12 students, teachers, and parents learn about healthcare and wellness, while students in higher education develop communication and leadership skills.

On the surface, many of these outreach and service-learning programs are designed to improve public health and STEMM education in the local community, while addressing accreditation standards (14–17). On a deeper level, these initiatives provide education and training to all program participants, empowering them to be change-makers in their families and communities (18). This work requires the investment of time, resources, and collaborative effort from a variety of parties including higher education institutions, students and faculty; K-12 schools, teachers and students; community and healthcare organizations; and families (19). Closer relationships between the community and the higher education institution also enable the institution to develop a better understanding of community needs (Figure 1). This is a win-win collaboration: each participant has something to gain from these programs and something to contribute, resulting in more empowered futures for all participants (11, 12).

Despite the benefits of higher education outreach and service-learning to the community, there are obstacles to establishing ubiquitous university and public school partnerships. First, although the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine have recommended an increase in engagement by colleges of science in pre-college education (20), outreach and service-learning are not accreditation requirements for all higher education institutions or programs. The Association of American Medical Colleges (AAMC) Liaison Committee on Medical Education (LCME) and the American Osteopathic Association (AOA) Commission on Osteopathic College Accreditation (COCA) require that medical schools incorporate service-learning into the curriculum (21, 22); however, this is not the case for most other STEMM disciplines. Second, with respect to medical school students specifically, the medical school service-learning requirement is not limited to engagement in K-12 STEMM education. Thus, the limited pool of medical students is spread throughout a variety of outreach and service-learning opportunities in addition to K-12 schools, limiting the number available to participate in neighborhood STEMM school programs (23). Finally, the process by which universities and public schools establish partnerships is variable, which could result in unintended, inequitable, or unsustainable programming.

Although these service-learning and student-as-teacher programs represent strategic community educational endeavors, there is only limited evidence of long-term sustainable program success (24–27). The lack of evidence can often be traced back to an absence of programmatic planning, and evaluation (28). Intentional planning and systematic data collection are essential for developing quality, sustainable programs.

This manuscript addresses higher education service-learning and outreach programming through diverse medical school faculty perspectives. Within a common ground, we discuss unique experiences in setting up, evaluating, and supporting these types of programs for K-12 students, educators, schools, families, and local communities (Figure 1).

2 K-12 students and community

To achieve positive impacts within their local communities, institutions are implementing outreach and service-learning programs that extend STEMM education beyond the confines of campus lecture halls and clinical settings and into their community environments (13). These community service programs are well-placed to teach scientific principles, model healthy behaviors, and clarify misinformation (29), fostering STEMM and health literacy and ultimately reducing health-related disparities. Education in science, especially regarding concepts of health, holds significant importance in K-12 schools due to its enduring impact on younger learners and their families: A child will live with their body their whole life. This represents opportunities for higher education programs to structure systematic strategies to not only fulfill accreditation standards but also to develop STEMM and health literacy in individual participants, nurturing the seeds of self-efficacy (30) and enhancing their ability to make informed decisions.

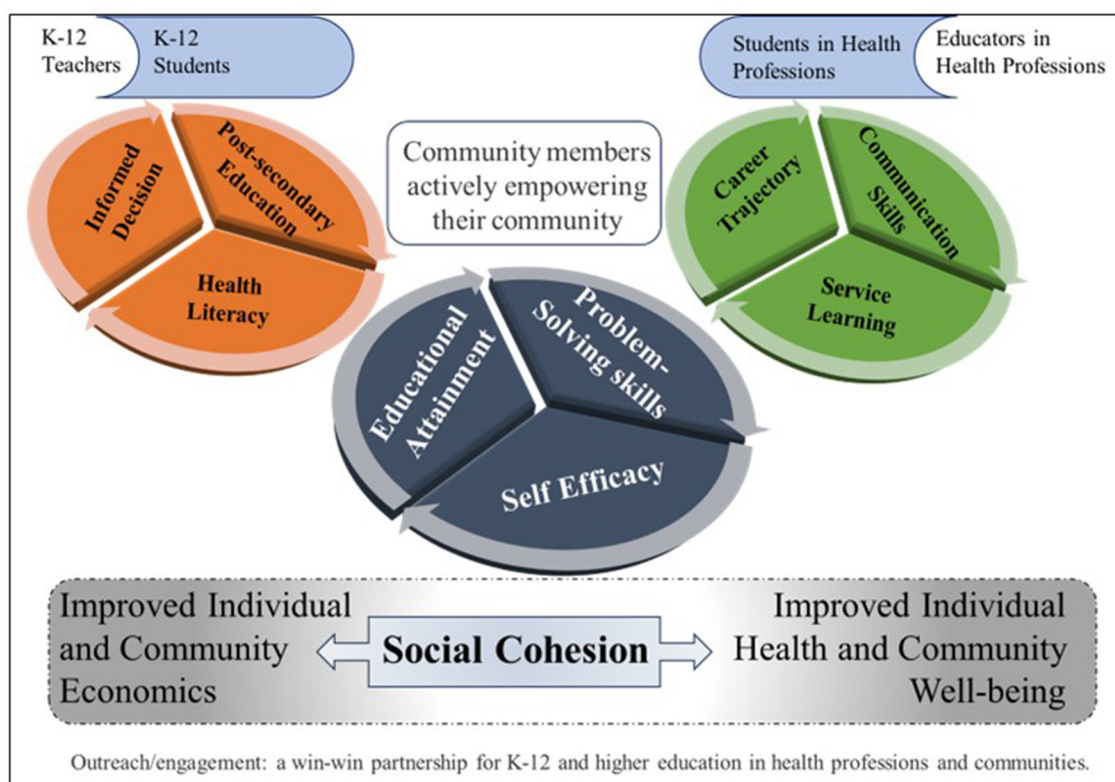


FIGURE 1

Health professions institutions focus on nurturing health literacy and self-efficacy among communities through service-learning programs for K-12.

The most common barrier to optimal learning in K-12 classrooms is the lack of resources to meet diverse student needs (31, 32). This is especially true in science and health classes where teachers may not have had an academic scientific career (33, 34). Outreach and service-learning programs can address these barriers by providing STEM role models that demonstrate examples of career pathways to scientific disciplines and careers (35), supplying an external source of short-term expertise and mentoring that emphasizes the “cool factor” of science education (36, 37), and increasing the educator-to-student ratio (38).

Many outreach and service-learning organizations focus on engaging students in science and public health awareness, yet stop short of measuring the effect on K-12 student self-efficacy, self-advocacy, or empowerment (39). Barriers to assessing impact may include an inadequate conception of the goals and outcomes of the program and an insufficient understanding of the difference between programmatic evaluation and outreach/service-learning scholarship based on theoretical and conceptual frameworks for learning. The field of outreach and service-learning would advance significantly if more program directors were supported in scholarly pursuits to study their programs.

3 Benefits for future healthcare professionals—a perspective from medical school programs

North American medical schools are engaging in outreach and service-learning, partly as a result of US accreditation agencies that mandate such activities. LCME (21) and COCA (22) state through Element 6.6 and Standard 8, respectively, that programs must provide a strategic plan for educational experiences through community services and scholarly activity. The plans must include cultural competency, health disparities research/scholarly activities, and service to the community in activities that respond to community-identified concerns. To accomplish accreditation requirements, strategies have been reported that place undergraduate medical education (UME) and graduate medical education (GME) students in health and STEM education settings as paraprofessionals for activities such as clinical case discussions, hands-on clinical skills workshops, class tutoring, and science activities (40). These endeavors can be prospectively extended to other higher education programs with similar accreditation requirements (14–17, 41).

Peer teaching is one such outreach and service-learning strategy, also stated as near-peer teaching (26, 27, 42, 43),

peer-assisted learning (44–46), peer tutoring (47), and peer instruction (48, 49). Under faculty guidance, higher education students in the role of teachers are expected to develop learning objectives, prepare materials in advance, create a plan for delivering content through didactics and active learning activities, mentor students, assess their tutees' understanding of the content after delivery, and make necessary adjustments to optimize the program (27, 45). These students may also be involved in research focused on their outreach and service-learning activities (26). They benefit by developing the ability to consolidate and communicate science concepts while becoming humanistic leaders. Consequently, students in healthcare become more confident in their communication, increasing the likelihood that patients will be able to comprehend the information that they provide (46). The development of these educational skills is an important element in the pathway toward career empowerment (45).

Examples of robust outreach and service-learning utilizing the peer teaching model have been put into practice by programs such as Anatomy Academy (50), Brain Explorers (51), and Community-Engaged Teaching and Learning (CETL) (52). Specifically, at Michigan State University, College of Osteopathic Medicine (MSUCOM), CETL was established on the premise that first- and second-year medical students, acting as teachers to contemporaneously closer generations, effectively empower underrepresented high school students and establish better critical learning processes. CETL fosters meaningful community partnerships with high schools surrounding satellite sites of MSUCOM in southeast Michigan through the delivery of biomedical sciences and wellness content. It is uniquely structured to generate research projects. Under faculty mentorship, higher education students learn from and serve their community in continuing educational actions that strengthen university-community connections and empower their participants.

These programs continue in the context of a post-pandemic world in which education is more focused on inclusivity in the classroom and community. We are keenly aware of important lessons learned in the past decade, which have been expressed succinctly by Kemp and colleagues in a recent newsletter publication of the Association of STEM Pathway and Bridge Programs (53).

4 The need to support faculty efforts in outreach and service-learning programs

Sustained and successful service-learning and outreach programs require collaborative long-term partnerships among higher education institutions, community schools/organizations, and educators. Higher education institutions should empower faculty members to mentor and support students engaged in service-learning and outreach. Previous work has revealed that lack of professional incentives, time, and funding are barriers to higher education faculty participation in STEM outreach and service-learning activities (54). While these barriers are significant, aligning faculty activities with the institution's mission can be helpful. Since most medical schools' mission and vision statements recognize the importance of serving the local

community, providing excellent education, and improving health, this alignment is relatively straightforward for medical school faculty. Outreach and service-learning programs directly support these institutional values. Although institutions, by their own mandates, should be supporting faculty in these efforts, faculty may need to self-advocate by articulating the value and alignment of their programs to administrators in order to secure internal funding, time, or other support.

Related to the barriers of lack of time and professional incentives, many faculty are concerned about achieving academic promotion and tenure, in addition to meeting the day-to-day expectations of their positions. We encourage faculty interested in community engagement to find ways to align their STEM outreach interests with their institution's promotion criteria. Over 30 years ago, Ernest Boyer urged academia to expand the definition of scholarship beyond scientific discovery and to include integration, application/engagement, and the scholarship of teaching and learning (SoTL) (55). In addition, SoTL can generate "promising practices," an outcome that supports and nurtures ongoing scientific discovery and knowledge generation, humbly recognizing educators' need for continual learning and adaptation to teach learners in different contexts (56). Effective outreach and service-learning programs can include many of Boyer's domains: Outreach and service-learning programs integrate and communicate knowledge, engage communities, and, when done well, incorporate SoTL to maximize the efficacy of the programming. For example, faculty embody their roles as teachers by supervising and mentoring medical students involved in STEM outreach and service-learning. They can develop research projects assessing learning or systematically evaluating the impact of their outreach or service-learning programs (54, 57).

Furthermore, outreach and service-learning can directly relate to the three central pillars of academia: teaching, research, and service. A conceptual framework on SoTL has been postulated to guide the development and dissemination of scholarly, pedagogical innovations as a path to developing promising practices for teaching and learning in public health (56). However, many institutions do not include specific guidelines for outreach in their promotion and tenure criteria. Nonetheless, there has been progress, with some prominent universities overtly stating outreach as a criterion or a pathway for promotion (19, 57). Outreach activities are not only a service to the community; they can be the focus of a faculty's academic teaching, research, and service missions in meaningful ways.

The outreach and service-learning framework provides opportunities for faculty and medical students to have research experiences (58, 59). The framework embeds multiple components for research, such as the epistemological justification, literature review, and responsible conduct of research. Additionally, faculty can use their outreach and service-learning activities to bolster the broader impacts of their grant proposals (60, 61).

Finally, most STEM outreach and service-learning programs readily fulfill faculty expectations for community service. We encourage fellow faculty who are passionate about STEM outreach to align their service-learning or outreach programs with the teaching, research, and service expectations of their academic positions. Documenting accomplishments within STEM outreach scholarship, teaching, and service can be

leveraged as integral components of their academic promotion portfolios. Therefore, although outreach is usually conceptualized as an altruistic activity, it can be mutually empowering for faculty, the institution, and the community.

5 Assessment and evaluation

Participation in STEMM outreach continues to gain momentum as academic institutions, individual labs, museums, and other organizations seek to improve STEMM education, access, and literacy. As the number of events, programs, and organizations devoted to this work continues to expand, effective evaluation is critical to be sure that the appropriate programs are receiving support and that those programs that receive support are successful (62–65). Outreach and service-learning evaluation starts with a clear understanding of each program, event, and/or organization's goals. These goals can vary greatly depending on the outreach program, but they must be clearly stated and understood for success to be measured. In their earliest stages, outreach and service-learning events and programs often struggle with this imperative step, either assuming the goals are intuitive or failing to narrow them down appropriately.

Frequent goals of outreach and service-learning include teaching students or increasing public awareness about a particular STEMM topic, providing resources for teachers, or even something as simple as engaging the public with science and public health content. When considering the goals of a program, one should think of goals for each stakeholder, as there may be different goals for each team member. Stakeholders can include the program's target audience and the entire community, in addition to higher education faculty, staff, students, and the institution, amongst others. Evaluations should measure the program's effectiveness in meeting each program goal for each stakeholder group (19).

Evaluation methods can be broad, and the use of a logic model to build and review programs or events is highly encouraged (66–69). The importance of starting with a grounded theoretical or conceptual framework that informs the logic model and research study cannot be overstated (70, 71). In the evaluation of an event or program, various methods can be used, and while it may seem intuitive, care should be taken to collect the appropriate data and select a method that effectively evaluates the program or event's stated goals. This further highlights the importance of setting goals for the program or event during development. These data elements can include demographics, pre- and post-assessments, surveys, interviews, focus groups, or any other type of evaluation. While the logic model outlines assumed causal connections, it may not represent direct cause-and-effect relationships. Given that many factors can influence a program's observed outcomes, it is crucial to consider unintended or unexpected positive, negative, or neutral outcomes. Alternative approaches can be utilized to structure authentic assessments, community development, and ethical principles, such as experiential learning (72) and the change model theory (73). In conclusion, various tools can be used to assess how a clear, long-term goal can be achieved through program engagement, enhancing reasoning skills, problem-solving abilities, teamwork, and communication skills. What is most important is that the chosen evaluation method provides an answer as to whether the program or event is meeting its stated goals.

The ability to evaluate the long-term effects of outreach and service-learning programs is particularly important. This is a wicked problem that needs to be revisited continually (74–76). Long-term tracking of outreach participants is challenging. Even when tracking is done, it is nearly impossible to untangle the large number of variables that may contribute to participants' behaviors and program success (77). Whether or not it leads to scholarship, program evaluation should inform necessary changes that meet community objectives and needs.

6 Solidarity in empowerment

Despite the outreach and service-learning requirements of accreditation standards (14–17, 21, 22) and the inclusion of community engagement into the mission, vision, and values statements of many institutions, there has been limited systemic support of research, scholarship, and dissemination of best practices in the areas of STEMM outreach and service-learning. Although there are many governmental and non-governmental organizations focused on STEMM outreach and service-learning, they are typically focused on coordinating and delivering programming to students. The leaders of outreach and service-learning programs require communities of practice to support their efforts (2). These communities of practice provide opportunities for networking between program leaders, which allows for the dissemination of promising practices and collaborative problem-solving among group members. The ability to discuss different methodologies for outreach work, planning, and evaluation is critical for the continuous improvement of these efforts.

The authors are part of two different groups that are filling this gap. The Association of STEMM Pathway and Bridge Programs (ASBPB) was founded in 2022 to support faculty and staff who are delivering STEMM pathways and bridges, including outreach and service-learning around the world (78). Community Outreach, Research & Engagement (CORE) was founded in 2022 as a community of practice specifically for outreach and service-learning in medical education (79). Both groups are focused on networking and leveraging the expertise of the members of the group. Members are invited to share their own innovative programs and outcomes, and the tools they have developed to plan, deliver, and assess them. These presentations to a supportive and engaged audience include robust Q&A sessions that have resulted in identifying best practices. Participants can also seek advice from the group about programs under development. Intentional mission, vision, and values statements guide these groups' evolution within specific frameworks, such as that of justice, equity, diversity, and inclusion. In addition to member networking and presentations, leadership invites external speakers to present on specific topics of interest, fostering the professional development and solidarity of the membership. Over time, members from different institutions have collaborated and presented SOTL projects at regional, national, and international conferences, generalizing best practices for the community of practice (80, 81). An annual peer-reviewed national conference, such as the ASBPB annual conference, can have several positive outcomes. First, it establishes a venue for networking with many like-minded professionals. Second, it provides an opportunity to present research in STEMM pathways and bridges, which

has been challenging to do in other venues. Third, it focuses members' attention on collecting data, evaluating progress, and identifying outcomes for their programs, thereby fostering a quality improvement cycle. Fourth, intentional programming at the conference extends faculty development opportunities focused on the STEMM pathway and bridge program creation, delivery, evaluation, and improvement. Non-profit organizations such as ASPBP can also advocate for pathway and bridge programming in STEMM with partner scientific organizations, leveraging the expertise of both. They can collaborate with philanthropic organizations to foster the development of research and scholarship in STEMM pathways and bridge programs through a call for research in this focus area. Finally, they can provide opportunities for volunteer leadership positions, further supporting higher education faculty's promotion and tenure needs. The diverse multi-institutional collaboration to improve the efficacy of pathway and bridge programs around the world influences the trajectory of program participants and empowers them to become agents of change and success in the lives of everyone involved.

7 Conclusion

Improving the capacity and quality of the STEMM workforce requires an investment in students early in their educational trajectory. It is incumbent on those working in STEMM to empower students to take control of their future. We believe that early STEMM engagement with K-12 students empowers individuals through health literacy, self-efficacy, and public health awareness. Introduction of K-12 students to individuals in STEMM careers can expose possibilities that might otherwise feel unattainable. In addition to empowering K-12 students, these educational interventions can also empower their families, K-12 educators, the community, and higher education faculty and students, leading to improved economic status, increased diversity of STEMM professionals, and ultimately improved health outcomes (Figure 1). We extend a clarion call to recognize, promote, evaluate, and sustain university and community partnerships that result in improved public health awareness, with a particular interest in understanding how these programs empower all involved.

Data availability statement

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

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Conflict of interest

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

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Exploring educational experiences that correlate with self-directed learning in college students seeking to pursue science, technology, engineering, math, and medical (STEMM) fields

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Educational experiences available to high school students have the potential to provide learning opportunities within science, technology, engineering, mathematics, and medicine (STEMM) that lead to student success in college and beyond. Therefore, the goal of our research was to identify whether participation in STEMM-specific outreach and pathway programs (OPPs), advanced placement/international baccalaureate (AP/IB), or dual enrollment correlate with self-directed learning (SDL) skills. Our population is composed of recent high school graduates matriculating into STEMM focused college programs. We collected responses from 339 students nationwide to assess their (1) experience with SDL, (2) the behavioral trait for SDL, and (3) the application of SDL in a newly developed situational judgment case. Our results demonstrate that those who have OPP experiences did not differ from their non-OPP counterparts regarding any aspect of SDL. However, dual enrollment significantly correlates with experience with components of SDL ($r = 0.206$, $p < 0.001$). Interestingly, AP/IB significantly correlates with the SDL behavioral trait ($r = 0.145$, $p < 0.05$) as well as the application of SDL skills ($r = 0.202$, $p < 0.001$), but not SDL experiences. This work identifies opportunities for improving the development of SDL within external and internal educational experiences for students interested in pursuing a career in STEMM.

KEYWORDS

self-directed learning (SDL), high school, outreach and pathway programs (OPP), advanced placement (AP), international baccalaureate (ib), and dual enrollment (DE)

1 Introduction

Self-directed learning (SDL) is a vital educational strategy, especially for students pursuing careers in science, technology, engineering, mathematics, and medicine (STEMM) fields. The concept of SDL was introduced by Knowles in 1975 and is composed of five components: (1) diagnosing one's learning needs, (2) formulating learning goals, (3) identifying human and material resources for learning, (4) choosing and implementing appropriate learning strategies, and (5) evaluating learning outcomes with or without the help of others (Knowles, 1975). Individuals who practice SDL take control of their learning, identify resources, and acquire knowledge independently. The ability to engage in SDL is paramount in rapidly evolving landscapes, such as STEMM, where technological advancements and data-driven insights are commonplace.

As students enter college, they face an abundance of new concepts and are expected to evaluate the credibility of ideas without relying on flawed or inappropriate sources. Moreover, success in STEMM fields is based on a continuous pursuit of knowledge, which requires skills that support lifelong learning (Loeng, 2020; Rillera Marzo and Marzo, 2018; Skrentny and Lewis, 2022). Therefore, it is essential to foster behaviors associated with SDL early in one's academic journey, preparing students to meet the demands of their chosen fields.

SDL is especially beneficial and necessary for navigating the complexities of STEMM subjects, where innovation and continuous learning are crucial for professional growth and advancement (National Academies of Sciences, Engineering, and Medicine et al., 2020). The behavioral trait of being a self-directed learner (SDL behavioral trait) is positively associated with work drive, sense of identity, self-actualization, and interest in science and math. In addition, the SDL behavioral trait is associated with higher grade point averages in U.S. middle school, high school, and college students (Lounsbury et al., 2009). The literature illuminates the relationship between SDL, academic achievement, and self-efficacy, as academic self-efficacy is one of the attributes present among self-directed learners (Cazan and Schiopca, 2014; Hood et al., 2020; Saeid and Eslaminejad, 2017). Academic self-efficacy is defined as the intrinsic belief that one will succeed in a task, which in turn affects other aspects of learning behaviors (e.g., initiation, time management, and motivation). Additionally, the "future time perspective," which is defined as the learner's ability to reckon with the future prospects of their goals based on current behaviors, was shown to significantly predict academic self-efficacy (Karataş et al., 2023; Saeid and Eslaminejad, 2017). Promoting SDL can directly impact self-efficacy and their subsequent achievement.

Students who practice SDL move beyond rote memorization and studying for a score; rather, students proficient in SDL analyze, process, and integrate materials into their existing knowledge with little guidance. Moreover, self-directed learners take on the responsibility of learning and become active participants in developing their thoughts, feelings, and actions necessary to achieve their learning goals. This ultimately promotes their academic and professional achievement. Indeed, academic success, as measured by grade point average and ACT scores, as well as cognitive factors such as verbal, abstract, and numerical reasoning, are associated with SDL (Lounsbury et al., 2009; Tekkol and Demirel, 2018). It is

also associated with academic self-efficacy, achievement motivation in students, and success in STEMM fields (Meng et al., 2019; Saeid and Eslaminejad, 2017). While SDL is entrenched within adult education, efforts currently exist within K-12 education to help students develop this critical skill (Alwadaeen and Piller, 2022; Bolhuis and Voeten, 2001; Stol et al., 2023; Voskamp et al., 2022).

1.1 Factors that impact SDL

While it is well established that SDL is important for adult learners, there is no clear understanding of what prepares individuals to engage in SDL. SDL is driven by behavioral factors such as personality traits, self-efficacy, and cognitive processes such as task switching, inhibitory control, and working memory (Cronin-Golomb and Bauer, 2023). It is unknown whether certain individuals innately express high levels of SDL readiness and the ability to apply SDL (SDL application), or if specific learning experiences improve SDL readiness. Lounsbury et al. utilized a large sample of middle school, high school, and college students and found the trait of being a self-directed learner had a positive relationship with grade-point-average. Furthermore, the SDL trait has a positive association with several other personality traits such as conscientiousness; emotional stability; extroversion; openness; agreeableness; optimism; work-drive; vocational interest- including interest in science, math, and medicine; and cognitive aptitudes (Lounsbury et al., 2009). The association between SDL and personality traits such as agreeableness, conscientiousness, intellect/imagination, extroversion, and emotional stability was also found among adult learners enrolled in health professional programs (Slater et al., 2017). Independent factors such as age and previous level of education also demonstrate an association with SDL in adult learners and adolescents (Slater et al., 2017; Uus et al., 2021). Indeed, an individual's ability to utilize SDL varies throughout their lifetime (Cronin-Golomb and Bauer, 2023). It is also possible that social determinants of learning, such as economic stability and social environment, can impact SDL as this has been associated with academic performance (Rasberry et al., 2019; Sanderson et al., 2021). Together, these indicate that a mix of personal and environmental factors plays a role in SDL. This interpretation is also supported by a recent systematic review of self-directed learning in undergraduate students (Wong et al., 2016).

1.3 Evolution of SDL and how it is assessed

The understanding of SDL has evolved due to variations in its implementation at differing educational levels and fields. This has led to a lack of standardized guidelines aimed at developing and assessing SDL skills among students. In response to this, Taylor et al. underwent a systematic review of SDL assessment in health professional programs (Taylor et al., 2023). They developed a seven-component SDL framework that builds upon Knowles's original conception of SDL after a review of the literature. This framework, while specific to health professions, can be adapted for broader use in STEMM education. We briefly elaborate on the framework

here; for a more complete discussion, please see the original sources (Knowles, 1975; Taylor et al., 2023).

Individuals must:

1. Take initiative of their own learning. This can be done independently or with others
2. Self-assess/diagnose their own learning needs. This leads to identifying gaps, developing self-awareness, and reflecting on what can enhance or limit their own growth
3. Formulate learning goals. They can work with others to develop a learning plan but are responsible for the planning
4. Identify resources. These resources can be material or human
5. Identify appropriate learning resources by appraising information resources for credibility and relevance
6. Choose and implement appropriate learning activities that develop and maintain competence and achievement of goals
7. Evaluate learning outcomes. This can be done individually or with the assistance of an evaluator's feedback on their information seeking skills. They should also evaluate learning results from formal and informal assessments and discover future learning needs

SDL has been assessed in a variety of ways. Self-assessment and perception-based methods are the most common (Cadorin et al., 2017; Taylor et al., 2023). However, other methods, such as knowledge- and reflection-based assessments, have been utilized. Moreover, SDL itself can be measured by exploring the SDL behavioral trait, readiness to apply SDL, and SDL application (Ricotta et al., 2022). Indeed, Taylor et al. (2023) found that it may be beneficial to measure SDL in multiple ways, as assessing multiple aspects of SDL was found to improve study quality (Taylor et al., 2023). The benefit may be due to an increase in the amount of data available or the use of an assessment less prone to social desirability response bias.

1.4 Educational opportunities that have the potential to promote SDL

Participation in formal educational programs such as Advanced Placement (AP), International Baccalaureate (IB), and dual enrollment courses (where high school students are enrolled in college or university courses) can significantly increase interest in STEMM careers and pave the way for entry into the STEMM field (Jewett et al., 2022; Smith et al., 2018). AP, IB, and dual enrollment are considered advanced offerings for high school students, but their innerworkings differ. Both AP and IB programs are designed to provide high school students with coursework that aims to develop critical thinking, analytical skills, and a deeper understanding of fundamental concepts. AP courses typically occur over a year and multiple courses can be taken at a time, while IB is a program that encompasses six courses across two years and is recognized internationally. Even though these programs have different structures, they have many similarities. For example, students who participate in AP and IB are typically high-achieving students (Warne, 2017), and prior research indicates that these students achieve similar graduation success at college (Schumacker, 2014). Students in both programs can take a subject examination

after completion and may be granted credit based on the policies of the institution of higher education they attend. While IB is a comprehensive program, both educational experiences are taught by high school teachers. In contrast, depending on specific state and districts' policies, dual enrollment may occur in a college or university setting alongside adult learners, and successful completion results in postsecondary credit. Due to the setting, individuals are expected to be more self-directed in their learning. Indeed, higher levels of self-directed learning skills are associated with academic success in college (Tekkol and Demirel, 2018).

1.5 Research focus

Participating in advanced offerings have been associated with college readiness and can improve pre-college competencies (An, 2013; Wyatt et al., 2015). However, opportunities to improve pre-college competencies exist outside the formal educational process. Taking part in OPPs focused on STEMM early in the educational process can foster a sense of inclusion and encourage students to continue to pursue STEMM in higher education (DuBois et al., 2011; Jung et al., 2023; Rocha et al., 2022a; Rocha et al., 2022b). However, it is unknown if participating in these programs is positively associated with behaviors linked to academic success, such as the components of SDL. We hypothesized that AP, IB, dual enrollment, and STEMM OPPs are potential opportunities for establishing SDL and associated skills in the academic life of high school students. It is further speculated that the aforementioned programs help to reduce achievement gaps and help students with successful college matriculation and completion.

In this study, we explore the following questions among matriculating college students:

1. What type of educational experiences correlate with SDL?
2. Are there student demographics that correlate with SDL?

2 Materials and methods

2.1 IRB approval

The Oakland University Institutional Review Board approved this study in August of 2022 (Protocol # 2022-346). All participants were informed of confidentiality and gave informed consent before participating in the study.

2.2 Recruitment

We recruited 339 first-year college students who graduated from a U.S. high school between September and October 2022 through Centiment LLC's data collection platform, as well as by word-of-mouth. All participants were screened to ensure interest in STEMM-related fields, and the data presented in this manuscript are part of a larger study.

Due to a technical error made when designing the survey attention check question, only 288 of the 339 participants were

TABLE 1 Demographics of the individuals enrolled in the study population.

Gender*	Percentage (%)	Number (N)
Female	54.3%	184
Male	43.1%	146
Non-binary	2.4%	8
Prefer not to respond	0.3%	1
Race/Ethnicity**		
AA/Black	33.6%	114
Asian	6.2%	21
Hispanic (any race)	28.6%	96
Native American	2.9%	10
Pacific Islander	0.6%	2
White	39.2%	133
Multi-racial	5%	19
Other	9.4%	32
Prefer not to respond	2.7%	9
Income		
< 25,000	24.0%	81
25,000–49,999	30.4%	103
50,000–74,999	17.1%	58
75,000–99,999	13.0%	44
100,000 or more	11.5%	39
Prefer not to answer	4.1%	14
First Generation College Student		
Yes	56.0%	190
No	43.7%	148
No answer	0.30%	1
Advanced Placement/International Baccalaureate (AP/IB)		
Yes	58.1%	197
No	41.9%	142
Dual Enrollment		
Yes	59.9%	203
No	40.1%	136

*One participant selected male and non-binary. **Individuals were allowed to select multiple fields. 5% of respondents are bi/multiracial: 0.6% Asian and Native American, 1.2% African American and White, 1.2% Asian and White, 0.3% Native American and White, 0.6% African American and Asian, 0.9% Native American and African American, 0.3% Asian and Pacific Islander, and 0.3% African American, Native American, and White.

allowed to complete the situational case and the SDL scale by Lounsbury et al. (2009). As such, those analyses are focused on individuals that completed these sections.

2.3 Demographic information

Demographic information gathered from participants can be found in Table 1. Specific components of demographic information include race and ethnicity, gender, age, estimated

household income, number of individuals within the household, first-generation college status, and ZIP Code. For our analyses, individuals who self-selected Black/African American, Pacific Islander, Hispanic, and Native American were considered underrepresented minorities (URM) according to the National Science Foundation definition (National Science Foundation, 2023). Educational opportunities explored are 1) participation in AP or IB, 2) dual enrollment status in high school, and 3) OPP experiences. In this study, both AP and IB programs were considered as one variable due to the programs occurring in a high school setting, being taught by high school teachers, and similarities in student populations, outcomes, and requirements for students to achieve a certain score to qualify for college credit or being allowed to pass out of a college course. Moreover, the High School Longitudinal Study of 2009 recently updated by the National Center for Educational Statistics combines AP and IB program participants to report the results of their studies (Dalton et al., 2018). This differs from dual enrollment programs as they may occur in a college or university setting, successful completion leads to postsecondary credit, and most differently from AP/IB, are taught by college or university faculty.

2.4 Measuring OPPs

A survey was administered to respondents comprised of questions regarding the quantity of different OPP experiences (0, 1, 2, 3, and 4 experiences) and measuring SDL in three ways: the SDL behavioral trait (Lounsbury et al., 2009), SDL experiences, and SDL application (see section 2.5 and Supplementary material). Individuals were asked the following questions to assess OPP experiences:

1. Have you ever participated in a program or outreach activity geared at recruiting young adults, adolescents, or children into the science, engineering, technology, math, or medical fields?
2. Have you ever participated in science fairs outside of those that may have been required for school?
3. Have you ever participated in Math Olympics, Science Olympics, robotic clubs or competitions, or any other science, tech, engineering, math, or health-related educational competition?
4. Have you ever participated in an after-school, before-school, weekend, or holiday/summer break science, tech, engineering, math, or health-related program class or camp?

This allowed us to explore how increasing the number of OPP experiences impacted SDL. The type of OPP experience was not included as a factor in the analysis. The survey questions can be found in the Supplementary materials.

2.5 Measuring SDL

SDL is a complex process that involves a range of competencies, including self-assessment, goal setting, identifying resources, and evaluating outcomes. Multiple assessment methods should be used to measure SDL accurately. Indeed, Taylor et al. recently

published a systematic review where they explored the types of SDL assessments in healthcare education research (Taylor et al., 2023). Higher quality was associated with studies that utilized more than one assessment or those that were knowledge-based rather than perception-based (e.g., focus groups, reflections, SDL readiness surveys, etc.). Thus, we utilized the theoretical framework postulated by Taylor et al. and measured SDL attributes within the study population using three distinct approaches. Specifically, we used 1) SDL experience, 2) the SDL behavioral trait, and 3) SDL application. This approach improves the validity and reliability of the overall measurement, caters to different learning styles and backgrounds, provides richer data for analysis, and aligns the assessments with the theoretical framework of SDL. By using various methods, educators can gain a better understanding of a student's SDL abilities in different contexts and ensure that the assessments are based on a solid conceptual foundation. The relationship between the scales is illustrated in Figure 1. Moreover, all three scales were mapped to the SDL framework as shown in Figure 2.

2.5.1 SDL experience

A previously developed 5-item survey was used to identify specific aspects of SDL that students had experience with (Kemp et al., 2022). All five items map to the seven components of SDL [Figure 1 and (Taylor et al., 2023)]. The aggregated total of all responses was used to determine total experience with SDL. The maximum score an individual could receive was five.

2.5.2 The SDL behavioral trait

The self-directed learning scale by Lounsbury et al. was selected to measure SDL as a behavioral trait. This scale is validated for use with high school and college students. This 10-item scale with responses made on a 5-point Likert-type scale measures the SDL behavioral trait among adolescents and young adults (Lounsbury et al., 2009). Lounsbury found a Cronbach's α of 0.87 in high school students and 0.84 in college students. The Cronbach's α calculated on these items for the current study of matriculating college students was found to be 0.87, which was expected given the similarity between populations. A composite variable was created that added all of the scores of the subcomponents together creating a scale from 10 (Strongly disagreed with participating in all 10 sub-components) to 50 (Strongly agreed with all of the components). We also mapped the Lounsbury scale to the seven components of the SDL framework (Figure 2), and explored the correlation between SDL experiences and the SDL behavioral trait among our participants. We found a weak, significant correlation between these two scales ($r = 0.283$, $p < 0.001$).

2.5.3 Situational judgment case validation and question selection

Although knowledge-based measures are good predictors of academic performance and achievement, research shows that performance measurements on situational judgment cases predict cognitive and related behavioral skills such as motivation, problem-solving, and coping (Cousans et al., 2017; Warwas et al., 2023). SDL is a good candidate to be tested via situational judgment cases due to these relationships (Lounsbury et al., 2009). Therefore,

we developed a representative situational case to assess the ability to apply SDL. Initially, two situational judgment cases with responses made on 5-point Likert-type items (central option available) were created. After validation, one case was dropped due to poor fit (see Supplementary materials for details on case development and validation). The Medical Education Research Study Quality Instrument guidelines were used for validating the case. This instrument identifies that theory, guidelines, experts, and existing instruments can be used to identify or refine survey instruments; the internal structure can be confirmed by reliability and factor analysis; and relevant evidence of relationships to other variables such as expert-novice comparisons and predictive correlation with other variables can be used for assessing validity (Cook and Reed, 2015). Below we briefly outline how the final case used for analysis in this study was developed and validated.

The situational judgment case was developed by three researchers (KK, DH, and ARN) and reviewed by experts. Twelve individuals with backgrounds in higher education, college administration, science, and medicine were presented with the case and asked to give their opinions as experts. The expert score was used to determine if each behavior was considered appropriate. The case was then mapped to the existing seven components of the SDL framework independently by two of the researchers (KK and ARN; See Supplementary Tables 1, 2). Two questions in the case did not sufficiently map to SDL components but were retained as they mapped to a related concept, self-efficacy (Hayat et al., 2020). Correlation matrix was constructed for the nine questions with six of the nine questions significantly correlated. All six of the retained items mapped to the SDL framework (Supplementary Table 2). The reliability of the final 6-item scale was found to be Cronbach's $\alpha = 0.75$.

A correlation was also run to assess how well the case aligned with the established SDL scales: the SDL behavioral trait and the SDL experience (Supplementary Table 3). This case had a significant, moderate correlation with the previously validated survey of SDL experience and a strong, significant correlation with the SDL behavioral trait ($r = 0.368$, $p < 0.001$ and $r = 0.557$, $p < 0.001$). A composite score was created for the judgment case and used for analysis. One participant was removed due to failure to respond to all of the questions. The final population for analysis was $N = 287$.

2.6 Neighborhood SES calculation

Neighborhood SES was calculated due to geographical location impacting educational attainment and opportunities (Banerjee et al., 2022; Levinson et al., 2021). ZIP Code information supplied by the subjects in the demographics portion of the survey was utilized to calculate the SES score for the neighborhood that the participants lived in based on U.S. census data. For details on this calculation and reasoning behind the measure see Hurse et al., 2023 (Hurse et al., 2023). Individuals' scores were normalized to their state SES metrics, arranged in ascending order, and partitioned into low or high SES groups (based on a median-split procedure). Nine individuals failed to provide their ZIP Code and were not included in the analysis involving this variable.

SDL Framework, Taylor et al, 2023	1. Take the initiative for one's own learning	2. Self-assess/diagnose one's own learning needs	3. Formulate learning goal	4. Identifying resources	5. Appraise information resources	6. Implement appropriate activities	7. Evaluate learning outcomes
SDL Scale, Lonsbury et al, 2009							
I regularly learn things on my own outside of class.	X	X	X	X		X	
I am very good at finding out answers on my own for things that the teacher does not explain in class.	X	X		X		X	
If there is something I don't understand in a class, I always find a way to learn it on my own.	X	X		X		X	
I am good at finding the right resources to help me do well in school.	X	X		X	X	X	
I view self-directed learning based on my own initiative as very important for success in school and in my future career.	X	X				X	
I set my own goals for what I will learn.	X	X	X			X	
I like to be in charge of what I learn and when I learn it.	X	X	X	X		X	
If there is something I need to learn, I find a way to do so right away.	X	X	X	X		X	
I am better at learning things on my own than most students.	X	X				X	
I am very motivated to learn on my own without having to rely on other people.	X	X	X	X		X	
SDL Experiences, Kemp 2022							
Identifying and synthesizing information relevant to your learning needs or desires	X	X	X	X		X	
Determining the credibility of sources in order to further your learning				X	X	X	
Reporting information to others that you have identified based on your learning needs or desires						X	X
Receiving feedback on your information-seeking skills and ability to assess information						X	X
Incorporating and improving information-seeking skills based on the feedback received regarding your skills	X	X	X			X	X
Situational Judgment Case							
Kiran has an exam in their chemistry class in two weeks. They are feeling nervous about the material and about how to prepare for the exam. Kiran has been reading the textbook and reviewing their notes. They recently took a practice quiz and did poorly. They are unsure how to proceed with the material. Kiran finds this frustrating because they aim to be a pharmacist. How would you rate the following behaviors on a scale regarding their usefulness to Kiran's future?							
Seek out videos and other materials on the subject and use this to prepare for additional practice questions provided by the professor	X	X	X	X		X (positive)	X
Memorize the correct answers to the practice quiz questions	X	X				X (negative)	
Review questions they get correct or incorrect to determine why they got them correct or incorrect	X	X	X			X (positive)	X
Seek feedback or help from the chemistry teaching assistant and/or the professor on the questions that they got incorrect	X	X		X	X	X (positive)	X
Set learning goals for the next two weeks and seek out materials and resources that can help them meet these goals and objectives	X	X	X	X	X	X (positive)	
Seek feedback from their teaching assistant or professor on the quality of sources they are using to learn the material	X	X		X	X	X (positive)	X

FIGURE 1

The Relationship between the SDL Measures and the SDL Framework. Pearson Correlations were run between the measures to determine the strength and direction of their relationship. All three measures map to the SDL framework. All figures were made using [Canva.com](https://www.canva.com).

2.7 Statistical analysis

All analyses were performed using IBM-SPSS statistics software (Version 29). A traditional threshold value of p-value of < 0.05 was used to determine statistical significance. These were uncorrected due to being planned comparisons in this exploratory investigation, but this decision is discussed as a limitation in this paper (see section 4.5). Pearson correlations were run between the three aforementioned SDL measures, the demographic variables, and the educational experiences. Two-sample independent proportions test were run to compare the SDL experience types between those who participated in AP/IB programs and those who did not and between

dual enrollment participants and those who did not participate in dual enrollment.

3 Results

3.1 Income has a weak positive correlation with SDL experiences

We first explored the correlation between SDL experiences and demographics. We found that while race, ethnicity, neighborhood SES, first-generation status, and gender did not correlate with SDL

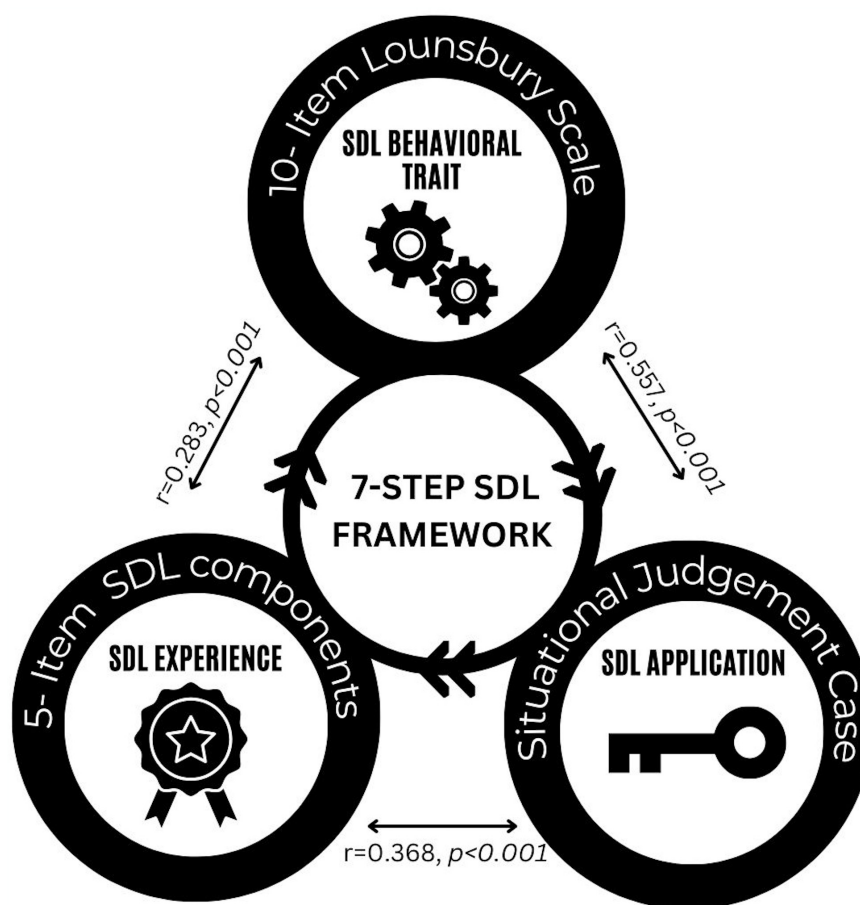


FIGURE 2

The SDL Behavioral Trait, SDL Experiences, and SDL Situational Case Were Mapped to the Seven Components of SDL Framework. The framework is shown at the top. The questions that map to the components for each measure are shown on the left. An "X" indicates the question maps to the component. All figures were made using [Canva.com](https://www.canva.com).

experiences, household income had a weak positive correlation with SDL experiences ($r = 0.116$, $p = 0.033$).

3.2 SDL experience correlates with dual enrollment, Not AP/IB or OPP

The relationship between education and SDL experience was then analyzed. There was a poor, non-significant correlation between the number of OPP experiences and participants' SDL experiences (Table 2). This was also true for AP/IB and SDL experiences. However, there was a weak, statistically significant correlation between components of SDL experienced by participants and dual enrollment ($r = 0.206$, $p < 0.001$).

We next explored if there were particular components of SDL that individuals who are dually enrolled are experiencing compared to those who were not dually enrolled. A higher proportion of those who were dually enrolled reported higher competencies in "receiving feedback on their information seeking skills" ($p = 0.044$; Table 3) and "incorporating and improving information-seeking skills based on the feedback" ($p < 0.001$; Table 3). Moreover, "reporting information to others" approached significance for those who were dually enrolled ($p = 0.051$; Table 3). While experience

with SDL did not correlate with AP/IB (Table 2), those who enrolled in AP/IB reported incorporating and improving information-seeking skills based on feedback at a higher incidence than those who were not enrolled in AP/IB ($p < 0.001$; Table 3).

3.3 The SDL behavioral trait correlates with AP/IB, not dual enrollment or OPP

Correlations were run to explore the relationship between the number of OPP experiences and the SDL behavioral trait. There was a poor, non-significant correlation found between these two variables (Table 2). Moreover, the relationship between AP/IB and the SDL behavioral trait was also explored. There was a weak, statistically significant correlation between the SDL behavioral trait and AP/IB ($r = 0.145$, $p = 0.014$). As the correlation between those who participate in AP/IB and those who report passing their AP/IB exam is very strong ($r = 0.963$, $p < 0.001$), we wanted to explore the relationship between the SDL behavioral trait and exam passage. The relationship becomes slightly stronger when focusing on those who report passing their AP/IB exams ($r = 0.159$, $p = 0.007$). In contrast, all correlations between the SDL behavioral trait and the other variables were statistically non-significant (Table 2).

TABLE 2 Correlations between SDL experiences, SDL behavioral trait, demographics, and educational experiences.

	SDL experiences <i>r</i> , <i>p</i> -value	SDL behavioral trait <i>r</i> , <i>p</i> -value
AP/IB	0.034, <i>p</i> = 0.537	0.145, <i>p</i> = 0.014*
Passed IB exam or received AP credit	0.063, <i>p</i> = 0.243	0.159, <i>p</i> = 0.007*
Dual Enrollment	0.206, <i>p</i> = < 0.001**	0.068, <i>p</i> = 0.248
Ethnicity	−0.01, <i>p</i> = 0.339	−0.012, <i>p</i> = 0.835
Gender	0.016, <i>p</i> = 0.766	0.089, <i>p</i> = 0.133
Income	0.116, <i>p</i> = 0.033*	0.032, <i>p</i> = 0.590
First generation	−0.050, <i>p</i> = 0.356	−0.009, <i>p</i> = 0.882
Number of OPP experiences	0.055, <i>p</i> = 0.310	0.040, <i>p</i> = 0.502
Race	0.049, <i>p</i> = 0.370	0.019, <i>p</i> = 0.744
Neighborhood SES	−0.032, <i>p</i> = 0.566	−0.030, <i>p</i> = 0.609
SDL Experiences	1	0.283, <i>p</i> < 0.001**

* *p* = < 0.05, ** *p* = < 0.001.

3.4 SDL application in a situational judgment case correlates with AP/IB participation

An analysis was run to assess how well the situational judgment case correlated with the various educational and demographic variables (Table 4). AP/IB participation had a weak and significant correlation with the situational judgment case ($r = 0.202$, $p < 0.001$). This increased slightly for those who passed their AP/IB exam ($r = 0.217$, $p < 0.001$). The other demographic factors were found to have a negligible, non-significant correlation with the situational judgment case (Table 4).

4 Discussion

Numerous advancements in science and technology have occurred over the past decade, with new concepts being introduced at an increasingly rapid pace (Author, 2019). Today's learners must practice self-directed learning to succeed in their professional pursuits, as they navigate a vast amount of information and build upon their existing knowledge. In this study, we used three measures of SDL, including a novel situational judgment case, to explore SDL in matriculating college students seeking to enter into STEMM fields. We explored the impact of various educational and demographic factors on the varied aspects of SDL. We hypothesized that AP/IB, dual enrollment, and STEMM OPP are potential opportunities for establishing SDL in high school students. Counter to our hypotheses, we found that OPP experiences did not correlate with the SDL behavioral trait, SDL experience, or SDL application in our novel situational case. Interestingly, while dual enrollment correlates with SDL experiences, it does not correlate with the other two measures of SDL. This is in contrast to AP/IB, which correlates with the SDL behavioral trait and SDL application, but not SDL experience. Our overall findings are summarized in Figure 3.

4.1 Educational experiences and SDL

While dual enrollment provides experiences with aspects of SDL, it does not appear to promote the development of the SDL behavioral trait. However, individuals who participate in AP/IB are more likely to possess the SDL behavioral trait and subsequently are more likely to apply SDL in a situational assessment. Both of these advanced programs intend to prepare students for future academic challenges; however, their populations and/or contributions to developing essential learning skills differ significantly. This could suggest that the structure and nature of the programs inherently support and draw different learners or aspects of learning, but this needs further research to clarify.

We were not surprised to find that participants who were dually enrolled tended to have more experience with performing self-directed learning. Self-directed learning (SDL) is a cornerstone of adult learning, and individuals taking college courses should have more experience with SDL as dual enrollment courses may sometimes occur in a collegiate learning environment. While enrollment in AP/IB does not correlate with SDL experiences, participating in AP/IB correlates with the behavioral trait of being a self-directed learner. This may indicate that those who are naturally higher in this trait may be drawn to AP/IB. Moreover, when given a situational judgment case that maps to components of SDL, only AP/IB participation correlates with performance on this measure. This may be because AP/IB select for individuals high in the SDL behavioral trait, and in turn, these individuals do better on the cases because they are self-directed learners. Suldo et al. found motivation and cognitive engagement increased AP/IB student success, which is similar to what is found in successful college students (Suldo et al., 2018). This may be further enhanced within our sample as we focused particularly on those interested in progressing to STEMM careers and the rate of those that endorsed “taking an AP/IB course” and “passing the AP/IB course” is much higher than findings from the general population taking AP/IB courses. Interestingly, OPPs did not correlate with any measures, and this work identifies opportunities to improve the promotion of SDL in OPP educational exposures.

4.2 Demographics and SDL

We found SDL application and the SDL behavioral trait did not vary based on demographic factors such as neighborhood SES, income, race, and/or ethnicity (Tables 2, 4). These findings are similar to the results found when self-regulated learning was measured in college students (DuBois et al., 2011). Moreover, Tekkol and Demirel found income did not have a relationship with SDL skills in college students (Tekkol and Demirel, 2018). However, for our study, income does appear to impact SDL experiences among the respondents. Those with higher incomes may be able to gain additional opportunities that provide exposure to more SDL experiences. However, students from lower familial SES background, impacted by household income, possess a component called grit. Grit is a quality that motivates them to achieve; however, these individuals may lack critical resources such as access to mentors, knowledge of structural components, and favor with gatekeepers which are essential to academic success (Kundu,

TABLE 3 Percent of participants that report experiencing SDL.

	Dual Enrolled	Not Dual Enrolled	<i>p</i> value	AP/IB	Not AP/IB	<i>p</i> value
SDL Experiences						
Identify and synthesize information relevant to your own learning needs	37% (75)	29% (39)	<i>p</i> = 0.114	36% (71)	30% (43)	<i>p</i> = 0.268
Determine the credibility of sources	49% (100)	40% (55)	<i>p</i> = 0.110	44% (87)	48% (68)	<i>p</i> = 0.496
Report information to others	35% (71)	25% (34)	<i>p</i> = 0.051	28% (56)	35% (49)	<i>p</i> = 0.232
Receive feedback on information-seeking skills	41% (83)	30% (41)	<i>p</i> = 0.044*	38% (74)	35% (50)	<i>p</i> = 0.657
Incorporate and improve information-seeking skills based on feedback received	32% (64)	15% (21)	<i>p</i> < 0.001**	29% (58)	19% (27)	<i>p</i> < 0.001**

The percent of those responding that they experienced components of SDL are recorded above. The participants were divided into those that participated in dual enrollment or did not participate and again for those that participated in AP/IB and those that did not. A two-sample independent proportions test was run. **p* = < 0.05, ***p* = < 0.001.

TABLE 4 SDL application correlates with AP/IB participation.

	SDL Application
AP/IB	0.202, <i>p</i> < 0.001**
Passed IB exam or received AP credit	0.217, <i>p</i> < 0.001**
Dual Enrollment	0.068, <i>p</i> = 0.249
Ethnicity	0.001, <i>p</i> = 0.990
Gender	0.062, <i>p</i> = 0.298
Income	0.034, <i>p</i> = 0.570
First generation	0.008, <i>p</i> = 0.897
Number of OPP experiences	0.061, <i>p</i> = 0.301
Race	0.016, <i>p</i> = 0.784
SES	0.031, <i>p</i> = 0.605

** *p* = < 0.001.

2017; Williams et al., 2019). Indeed, family income and SES has been shown to impact academic achievement (Suldo et al., 2018; Workman, 2022). Our data, however, reiterates the fact that students, regardless of demographic background, can possess the SDL behavioral trait and apply SDL. Beyond the current focus on SDL, factors such as agency, transitional knowledge, or interventions that promote a positive emotional experience are required for academic success in secondary education (Jury et al., 2017; Kundu, 2017; Williams et al., 2019).

4.3 Importance of SDL in high school and college

SDL has been identified as an educational asset since the 1970s. Knowles' seminal work on self-directed learning highlights its importance in educational settings. It emphasizes how SDL encourages students to take responsibility for their education and fosters critical thinking skills (Knowles, 1975). SDL is essential in high school and college to promote independence, critical thinking, and lifelong learning (National Science Foundation, 2023). SDL empowers students to explore their interests at their preferred pace. This results in developing problem-solving skills, adaptability, and efficient learning of new information and abilities. Our work finds participating in dual enrollment correlates with

SDL experiences; however, we propose that SDL experiences need to be promoted throughout high school and into college. Ways by which SDL are introduced and cultivated may need to vary as Uus et al. found SDL self-efficacy and SDL readiness vary based on age and year in school, geographical location, and gender in adolescents (Chen et al., 2022; Uus et al., 2021). A framework must be developed regarding the activities that constitute SDL and distributed to educators. A recent Dutch study found that the methods employed by teachers to develop self-directed learning, as well as an understanding of self-directed learning, varied. Moreover, the culture of the school impacted interpretations of SDL (Voskamp et al., 2022).

4.4 OPPs are Positioned to Incorporate SDL

Scholarship on OPPs shows that individual programs have been useful in promoting self-efficacy, a sense of belonging, and increasing retention of students in STEMM (Daniels et al., 2019; Kuchynka et al., 2022; Rocha et al., 2022a). However, it is unknown if OPPs promote pre-college matriculation competencies in adolescents. We became interested in exploring these competencies after identifying that high school students exhibited aspects of SDL due to participation in the Oakland University William Beaumont online enrichment program (Hurse et al., 2023). We have found OPP participation promotes perceptions of college readiness (publication in preparation). In fact, many of the skills learned from OPP experiences map to college readiness as defined by Conley (Conley and French, 2014). Due to this we were surprised to discover having additional OPP experiences did not correlate with SDL. Previous work illuminates a relationship between SDL, instruction method, and student interest. Schweder and Raufelder found that the incorporation of two self-directed intervals during the school year for German secondary students increased self-efficacy and interest throughout the school year (Schweder and Raufelder, 2022). It may be that specific types of OPP experiences promote SDL due to differences in instructional methods. It may also be that specific instructional methods employed during OPPs fail to engage with aspects of SDL. Many of the individuals in this study participated in multiple types of OPPs, which was not the focus of this investigation (see limitations section below). Thus,

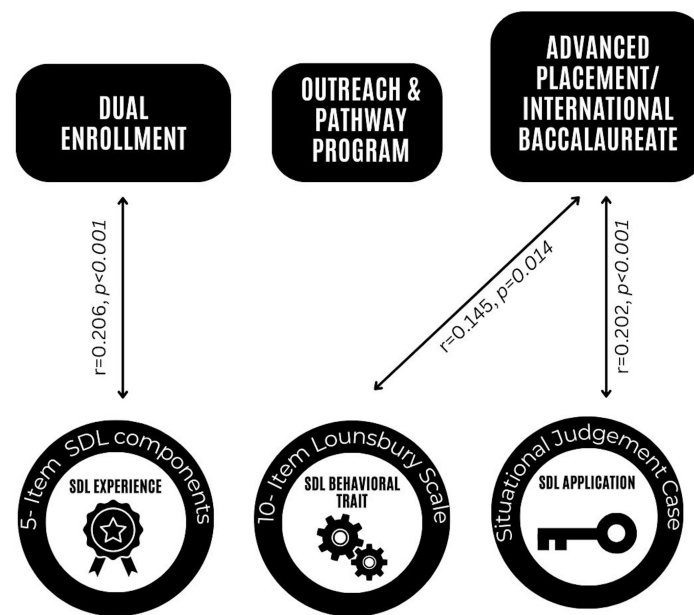


FIGURE 3

A Summary of the Study Findings. Correlations were run between the measures and the educational experience variables AP/IB, Dual Enrollment, and OPP to determine the strength and direction of their relationship. All figures were made using [Canva.com](https://www.canva.com).

the mechanism of instruction during OPP experiences may play a role in these findings and remains an area of future exploration and investigation.

Through this work, we have identified an opportunity to improve OPPs through the promotion of SDL related skills. OPPs are positioned to promote pre-college matriculation standards beyond subject matter knowledge. Incorporation of problem-based learning activities or research and design activities can be used to bolster SDL experiences. OPPs can also be used to emphasize the importance of SDL for college success and beyond.

4.5 Limitations

While our study has many strengths such as providing insights into rigorous SDL measurements and the relationship between SDL and various educational experiences, there are limitations. First, we did not evaluate how each of the individual educational experiences contributes to each of the seven components of the SDL framework. Moreover, the measures did not equally capture all seven components of the overall framework (Figure 2). We believe our use of multiple measures helps reduce this impact, but future studies call for a more focused approach to the different types of program structures.

We were unable to parse out the nuances between different types of OPPs, and AP/IBs given the diverse nature of these programs nationally. However, we do not see it as a major limitation because of the way educational research is studied. Student study populations typically have several experiences outside of formal education that they draw upon from their social, resistant, and navigational capital. These, among many others, could help them become self-directed, which they then would apply into their education and career aspirations (Strawn, 2003). Another

limitation of our study is that our groups are not mutually exclusive. A student may have experience in more than one program whether OPPs, AP, or IB. Although, the results are reliable, they may be partially confounded due to students having multiple experiences. While power is sufficient for the overall analysis, it is not for more advanced statistical techniques. Future studies could benefit from increasing sample sizes and integrating our insights statistically by employing a stepwise regression approach that inputs the most explanatory factors first.

Another limitation may lay in our method of calculating SES based solely on the students' provided ZIP Codes. While commonly used, this approach oversimplifies the complex nature of communities. Future research should consider a more multifaceted approach, exploring familial SES, neighborhood SES, and the SES of the area surrounding the school. These interconnected variables could allow researchers an even clearer picture.

5 Conclusion

The goal of our research was to assess self-directed learning among recent graduates matriculating into college who participated in various educational experiences. We found that in our population of students interested in pursuing a STEMM career, individuals enrolled in AP/IB have less experience with SDL, but participating in AP/IB correlates with the SDL behavioral trait and SDL application. This leads us to conclude that AP/IB may select for those with a predisposition towards SDL, while OPPs and dual enrollment do not. OPPs and dual enrollment both serve as ways to increase accessibility to all students. While we may recruit diverse candidates into the STEMM pathway through OPPs and dual enrollment, efforts must be made to ensure that

we are providing the experiences that will lead to their future success. This paper identifies an opportunity for the coalition of educators, community leaders, and industry professionals that seek to do this work to strengthen offerings to better prepare students for college and beyond.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Oakland University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AN: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. KK: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review and editing. CD: Data curation, Formal analysis, Software, Writing – review and editing. DH: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Visualization, Writing – review and editing.

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Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1393493/full#supplementary-material>

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Evaluation of content knowledge and instructor impacts in a middle school outreach program: lessons from Brain Explorers

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Despite general agreement that science outreach is important, the effectiveness of science outreach programs on participants' learning often is not assessed. Brain Explorers is a neuroscience outreach program that allows medical students to partner with Biomedical Sciences faculty to develop lesson plans with learning objectives, interactive experiments for middle schoolers, and assessments of learning. These lessons are then implemented through a community-level intervention in which medical students teach their lesson plans to middle schoolers and assist them in performing activities to reinforce the concepts. Importantly, the efficacy of these active learning interventions is assessed. Throughout the program's evolution, a variety of different forms of assessment have been utilized to examine student understanding. While the goals of outreach programs are varied, here we have focused on the evaluation of content knowledge gains laying out three unique evaluation methods including post-event, immediate pre- and post-event, and spaced pre- and post-event evaluation. Specifically, using Brain Explorers lessons as examples we explore the practicality and feasibility of various learning assessments in outreach programs, begin to examine the impacts of participation in these programs on the medical school instructors and encourage others in the field to implement assessment of their programs.

KEYWORDS

stem education, outreach, assessment, evaluation, K-12

1 Introduction

For years faculty, staff, and students at institutions of higher education have felt compelled to serve their communities by providing Science, Technology, Engineering, Math, and Medicine (STEMM) opportunities for community members, particularly K-12 students (Nation and Hansen, 2021). The reasons for conducting STEMM outreach range from a desire to give back to the community to improving representation in STEMM fields, among numerous others (Minen et al., 2023; Weekes, 2012). No matter the reason for conducting STEMM outreach, it is clear that engaging in this work provides value not only for the community but for the faculty, staff, and students that are participating (Vollbrecht et al., 2019; Saravanapandian et al., 2019). While conducting this work can be fulfilling and provide value to many stakeholders, it is important for outreach programs and events

to have clear goals. Some of the most commonly stated goals of STEMM outreach are to improve societal science literacy (Kelp et al., 2023), representation in STEMM fields (Shoemaker et al., 2020), and public attitudes toward science (Crawford et al., 2021; Vennix et al., 2018).

While an increasing number of STEMM outreach programs have clear goals and objectives, many programs still lack a clearly stated direction and purpose (Jensen, 2015; Abramowitz et al., 2024). In general, many STEMM outreach programs that fail to explicitly list their goals aim to improve attitudes toward science and/or increase science content knowledge. Regardless of whether or not a program has a clearly stated goal, many programs fail to assess whether they are meeting these goals (Minen et al., 2023; Varner, 2014; Sadler et al., 2018; Cicchino et al., 2023). As a result, there is a paucity of evidence-based research on the most effective practices when conducting science outreach. We, and others, have recognized that effective science communication at any level begins with the development of clear goals for the interaction (Gilbertson et al., 2024; Deal et al., 2014; Gall et al., 2020). However, truly understanding the effectiveness of an outreach activity or program requires not only careful planning and goal setting but also assessment and reflection (Restini et al., 2024). The present manuscript (1) describes an outreach program that engages medical students in the process of creating, delivering, and evaluating science lessons for middle school students, and (2) presents a variety of evaluation methods for assessing learning within outreach programs to serve as a model for other programs seeking to investigate the effectiveness of their outreach efforts.

1.1 Background and rationale

Brain Explorers is a service-learning program based at Western Michigan University Homer Stryker M.D. School of Medicine (WMed), in which medical students teach foundational neuroscience concepts to middle school students (7th and 8th grade) through a variety of one-hour events. On the surface, Brain Explorers is a community outreach program directed at middle schoolers from groups underrepresented in STEMM (including racial/ethnic minorities, low socioeconomic status, and individuals from rural communities), intended to increase interest in basic sciences through exposure to neuroscience with the hope of inspiring these children to become involved in STEMM as scientists, engineers, physicians, or in other fields. Lessons presented to middle schoolers focus on active learning and hands-on engagement that can be mapped to neuroscience concepts and appropriately tagged to Next Generation Science Standards [NGSS; (National Research Council, 2013)]. While assessing the overall success of these types of programs remains difficult due to the longitudinal nature of the greater goals and outcomes (mainly more underrepresented individuals in STEMM), studies that have aimed at examining this effect tend to demonstrate positive effects from a variety of forms of outreach (Vennix et al., 2018; Yawson et al., 2016; Zhou, 2020; Demetry et al., 2009; Mohd Shahali et al., 2019). Thus, we anticipate that outreach efforts aimed at underrepresented individuals in our program will increase representation at higher levels although it remains to be formally evaluated.

Another, potentially less obvious, goal of the program is to provide medical students with supplemental training in communication through service-learning which can help to meet LCME accreditation standard 6.6 (Restini et al., 2024; Liason Committee on Medical Education, 2023). Medical students are tasked with performing the entire teaching “loop”, including both lesson and assessment planning, execution of those plans, assessment of middle school students’ learning, and adaptation of their original lesson plan. During this loop, medical students have to distill complex scientific ideas down to digestible components while maintaining scientific accuracy and validity, something that they will be asked to do regularly as they work with patients in the future.

Among other possibilities, Brain Explorers yields two distinct assessment tracks to evaluate the program’s efficacy: middle school students (as pupils) and medical students (as teachers). Middle school students were assessed for comprehension of the concepts taught. Varying assessment types were utilized including both qualitative and quantitative surveys, as well as knowledge-based quizzes. Medical students were assessed for changes in their ability to communicate scientific ideas to a lay audience. (Essentially, if you can explain it to an eighth grader, then you can explain it to a patient.) They were also assessed for effects on their own understanding of the concepts they taught.

2 Theoretical framework

Brain Explorers is conceptualized through three unique yet intersecting theoretical frameworks. These include constructivism, experiential learning, and logic models for program evaluation. Brain Explorers’ overarching framework is Logic Models for Program Evaluation (Van Melle, 2016). Logic models require a complete program evaluation including identification of the “problem” being solved by the program, the mission of the program (purpose), necessary resources for the program (inputs), the activities being done to solve the problem (activities), the products of the program (output), and the expected results of the program (outcomes). The final piece of the logic model framework is evaluation of outcomes and outputs to determine the effectiveness of the program in solving the “problem”. Previous work has demonstrated the effectiveness of logic model for program evaluation in linking evaluation instruments to specific program objectives and better understanding which outcomes are being achieved and which need further attention (Helitzer et al., 2009; McLaughlin and Jordan, 2015; Friedman et al., 2008). This framework drove the initial creation of a program with a strong sense of purpose and an understanding of our goals and continues to drive iterative assessment of the program which has three primary goals, improving attitudes toward science in K-12 students, improving science content knowledge in K-12 students, and improving science communication skills in medical students. The focus of this manuscript is assessing science content knowledge gains in middle school students.

Under the umbrella of the Logic Models for Program Evaluation framework, two additional pedagogical frameworks help us to understand the work being done within the programs’ two primary populations, middle school students and medical

students. Constructivism drives our understanding of the middle school student experience (Olusegun, 2015; Zajda, 2021; Mann and MacLeod, 2015). Middle school students are given opportunities to construct knowledge of the nervous system through active learning lessons and hands-on experiences. A driving question or observable phenomenon is presented early in the lesson such as, “How do I know my arm is raised if I close my eyes and raise my hand?”, and activities are designed to allow students to explore that question or phenomenon. We believe that this constructivist framework provides the best opportunity for students to learn and engage with the content, and also generates greater interest in the scientific process of exploration and experimentation.

Finally, the Experiential Learning framework drives our understanding of the medical student experience (Kolb, 1984; Yardley et al., 2012; Porter-Stransky et al., 2023). This framework requires action, evaluation, reflection, and experimentation. By allowing our medical students to serve as the instructors responsible for content creation, delivery, and evaluation, we provide a concrete experience that they can reflect on and then make adjustments to future iterations of the same event. Following the classic see one, do one, teach one approach of medical schools the world over, medical students first participate as secondary instructors to observe a lesson in action (see one), they then create a lesson plan using the template (Supplementary material) and mock teach a lesson (do one), before finally taking their lesson plan into the middle school classroom (teach one). During the mock teaching event other medical students and faculty serve as the “middle school students” and provide feedback on the timing, suitability, engagement and content of the event.

3 Learning environment & methods

3.1 Middle school students

In order to reach as many students as possible across the broadest possible range of science interest, outreach lessons were delivered in a middle school classroom during students’ scheduled science classes (See Supplementary material for lessons). Each academic year Brain Explorers visited the 8th grade classes a total of 4 or 5 times to deliver novel neuroscience lesson plans. As such, each lesson described below was not necessarily presented to the same group of students. The middle school was located in a rural Midwest town (Porter-Stransky et al., 2024). Students had limited prior exposure to neuroscience. Approximately 18 middle school students were in each of the 8th grade classes visited. First and second year medical students served as the instructors for these lessons. At least one medical school faculty member was present to observe medical students and help as needed. The middle school science teacher was also present during these sessions. Lessons were designed to include didactic content delivery combined with active learning. All lesson plans created by Brain Explorers are designed to meet the Next Generation Science Standards (NGSS). Lesson plans were developed using a standardized lesson plan template (Supplementary material 1) to ensure that future instructors could replicate the lesson.

To assess the effectiveness of lesson plans in increasing content knowledge for middle school students, a variety of methods can

be utilized. This includes differences in timing of assessments as well as the use of various assessment types. Over the years we have utilized several different evaluation formats in our own program. In this manuscript we lay out three unique methods of assessment that were used over the course of two years (2021–2023) including immediate post-event assessment, immediate pre- and post-event assessment, and spaced pre- and post-event assessment. The type of questions used in assessments to evaluate content knowledge gains has varied within our own program. At times we have asked students to answer two open-ended questions, one which assesses material covered during the lesson and another which evaluates neuroscience content that is not covered during the lesson. At other times, we have utilized simple multiple choice question quizzes. These quizzes have been in the form of simple paper copies and others have been in an electronic game format such as Kahoot!. Here we describe each of the assessment types we have utilized in assessing content knowledge. Data were analyzed and graphed using GraphPad Prism.

All assessment of K-12 student learning was approved by the WMed Institutional Review Board. Specifically, It was determined that it meets the criteria for exempt status as described in 45 CFR Part 46.104(d) Category 1: Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students’ opportunity to learn required educational content or the assessment of educators who provide instruction. Furthermore, the middle schools in which the outreach events were conducted agreed to these assessments being done within their school and used for research.

3.1.1 Immediate post-event assessment

The immediate post-event assessment is probably the simplest and most time efficient method of assessing content knowledge. In the example presented here (Supplementary material 2) students participated in a review quiz at the end of the lesson to assess knowledge of content from the lesson in the form of an online trivia competition using the platform Kahoot! (Oslo, Norway). In this platform points are awarded for correct answers based on speed with faster answers earning more points for students than slower answers, and incorrect answers earning no points. This assessment type is anonymous as students can make up their own names for the event. This style of assessment allows for the determination of the percent of students who answered each question correctly and is generally compared to chance probability (25%).

3.1.2 Immediate pre- and post-event assessment

The immediate pre- and post-event assessment was given as a short paper quiz. The pre-event assessment is taken by students at the beginning of the event before any content is delivered that day. Then content is delivered through the lesson for the day before a second quiz is given at the end of the event, again with our instructors still present. In this case, assessments included both a single written response as well as multiple choice questions (for an example see Supplementary material 3). Benefits of both multiple choice and short answer questions are discussed later. Students

were asked to include their name on both the pre- and post-event assessment so that scores could be matched for later analysis.

3.1.3 Spaced pre- and post-event assessment

This assessment style is very similar to the immediate pre- and post-event assessment with the primary difference being the timing of assessment. The pre-event assessment is taken a day or two prior to instructors coming to the classroom. The post-event assessment is taken by students 1–2 weeks after the lesson took place. These assessments are both taken online by students during normal class hours. All students have a school-issued Chromebook on which to complete the assessment. In this case students were asked to answer two short written response questions. One question was based on content taught during the lesson while the “control” question was based on content that was not covered during the event (for example see [Supplementary material 4](#)).

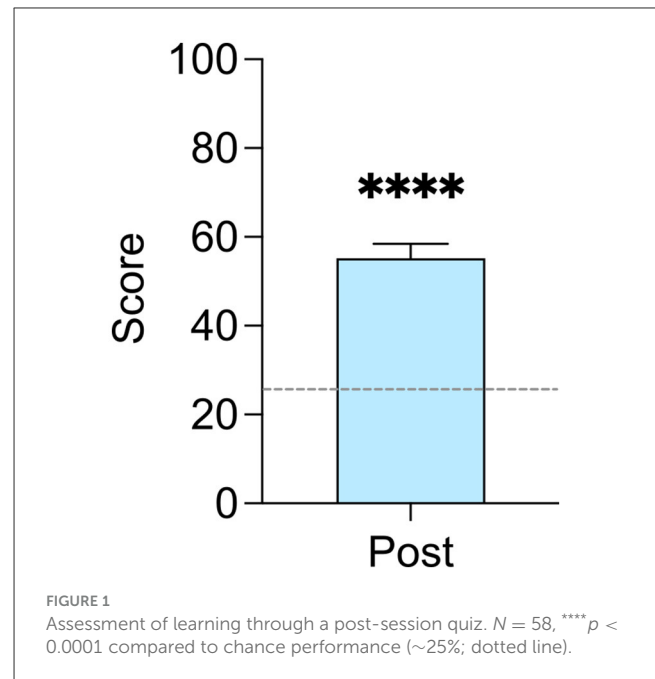
3.1.3.1 Scoring of written responses

When scoring written responses, a rubric was created to help reviewers to rate responses. Responses ranged from “idk” (I don’t know) to detailed responses involving specific content learned in the event. For an example reviewer scoring guide see [Supplementary material 4](#).

3.2 Medical students

Medical students received course credit for participating in service-learning across a variety of possible sites. Most of the students participating in Brain Explorers were receiving credit as part of this Active Citizenship course. To investigate the effects of participation in Brain Explorers, medical students who had taught Brain Explorers lessons to middle schoolers were invited to participate in a focus group. A qualitative approach was chosen specifically due to (1) the program’s nascency, (2) the desire to better understand the service-learning experience through open-ended questions, (3) the small sample size of medical student volunteers annually, making quantitative data insufficiently powered for quantitative analysis, and (4) the complexity and lack of standardization in evaluating communication skills.

Participation was optional and did not impact course credit. A semi-structured approach was used with open-ended questions that asked about medical students’ motivations for participating in Brain Explorers and how they viewed the experience as impacting them. The focus session was conducted on Microsoft Teams, recorded, transcribed, and anonymized. Applied thematic analysis was conducted to evaluate this qualitative data ([Guest et al., 2012](#)). Two authors, including a medical student researcher who had not volunteered with Brain Explorers (TC) and a faculty member (KAPS) read the transcripts multiple times and generated initial codes. Then, we discussed together the codes that each identified and collaboratively agreed on terminology. Transcripts were reread and the codes were applied. Finally, we organized the codes into themes. The WMed Institutional Review Board determined that this project met the criteria for exempt status as described in 45 CFR Part 46.104(d).



4 Results

4.1 Middle school student assessment

To evaluate the effectiveness of lessons in improving science content knowledge, we have utilized a variety of unique evaluation methods. The simplest assessment evaluated knowledge following a lesson by using a post-event quiz. To promote learner engagement, we used a trivia game creation platform called Kahoot! (Oslo, Norway). This platform allows for the creation of multiple-choice questions and audience members login and respond to questions to compete against each other to get the most right and to answer the fastest. Based upon the number of possible answer options, one can calculate the score that a student with no content knowledge would receive on average through random choices. For example, questions with four answer options would reach approximately 25%. Students performed significantly better than chance on this post-session quiz (Figure 1, one-sample t -test, $t_{(57)} = 9.038$, $p < 0.0001$).

Although administering only a post-session quiz is efficient, it is possible that some students had content knowledge before the lesson and thus could perform above chance levels. Therefore, during other events we have also used a pre- and post-event design whereby middle schoolers complete identical assessments before and after the lesson. With two separate lessons on different occasions, we observed a significant increase in student scores following the lesson (Figure 2, paired t -tests; 2A, $t_{(66)} = 8.836$, $p < 0.0001$; 2B, $t_{(68)} = 14.151$, $p < 0.0001$). These examples utilized both multiple-choice and open-ended questions.

Finally, to test for longer-term retention, to eliminate potential impact of the instructors’ presence, and to control for content taught vs. not taught, we have used a pre-post design spaced across multiple weeks. The first assessment was completed by students prior to having met the Brain Explorers instructors and again 1–2 weeks after the Brain Explorers visit. Interestingly, in

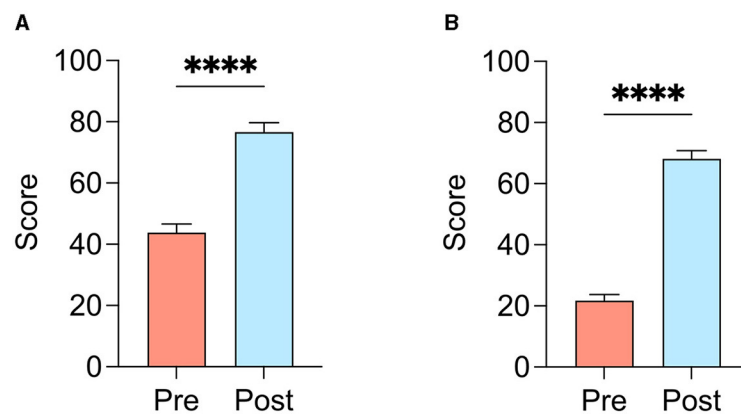


FIGURE 2

Assessments of learning through in-class pre- and post-session quizzes. (A, B) Middle school students' scores improved after the sessions on somatosensation (A) and learning and memory (B). $N = 67-69$, **** $p < 0.0001$.

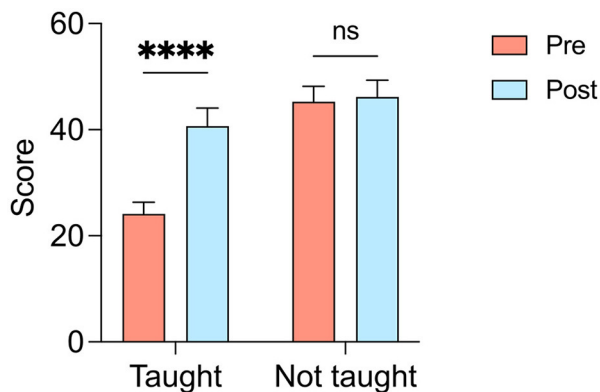


FIGURE 3

Assessment of learning through spaced pre- and post-session quizzes including a control question. $N = 58$, **** $p < 0.0001$, ns = not statistically different.

this assessment, we utilized two open-ended questions, one which tested a primary focus of the event and another that did not. Despite the long delay, middle schoolers scored significantly better during the post-test on the question about content that was taught but not on the question about a neuroscience topic that was not covered during the lesson (Figure 3; two-way repeated-measures ANOVA; main effect of content, $F_{(1,57)} = 19.440$, $p < 0.0001$; main effect of time, $F_{(1,57)} = 12.042$, $p = 0.001$; interaction, $F_{(1,57)} = 13.342$, $p = 0.0006$; multiple comparisons with Bonferroni corrections, content taught $p < 0.0001$, content not taught $p > 0.999$).

4.2 Medical students

Applied thematic analysis of the qualitative data yielded insights into why medical students chose to participate in Brain Explorers and how they felt that the experience impacted them. Following each theme, a representative participant quotation is provided. Medical students' discussions of their motivations for volunteering for Brain Explorers clustered into two themes:

Theme 1: Desire for professional development. This theme centered on how the experience would benefit the medical students. Comments focused on gaining new experiences, potentially out of one's comfort zone, to build their skill set.

"I tend to be like a lot more introverted so I thought it would be kind of interesting to branch out and kind of give it a try."

Theme 2: Desire to positively influence children with science. Some participants provided altruistic reasons for joining Brain Explorers. They reflected on their prior experiences as middle schoolers and sought to inspire the children through science outreach.

"I just remember like middle school being just so fun, and I remember these science events really sticking with me throughout the years, and, I thought it'd be a great way to like, pay it forward and kinda pay it back."

When asked about how participating in Brain Explorers impacted the medical student volunteers, their responses revolved around two themes, both relating to communication:

Theme 3: Self-perceived improvement of communication skills. Multiple participants expressed that the experience of teaching the lesson plans to the middle schoolers improved their ability to effectively communicate. They learned the importance of assessing the knowledge levels of the audience members and practiced making on-the-fly modifications either within a session or between classes.

"...that aspect of Brain Explorers is really beneficial too... knowing that if you're going to explain something complex to an audience it's important to... gauge their baseline or gauge their background knowledge in more ways than one."

"...from the first time doing it to the second time doing it, umm, you see what does work, what doesn't work, how you can be more efficient."

Theme 4: Increased confidence communicating scientific content. Building upon the general communication skills in Theme 3, some participants also expressed an increased confidence in being able to communicate complicated scientific

concepts. They recognized the difficulty in distilling complex scientific information for lay audiences and that this skill will be important in their future careers as physicians. Although the experience of teaching within the Brain Explorers program increased their confidence, some acknowledged that there was still room to grow in science communication.

“...something that, really, I think is important to me is learning how to kind of simplify complex things for people who, don’t have maybe have the health literacy, or just don’t have a science background.”

Lastly, experiences like Brain Explorers can yield another ancillary opportunity for medical student professional development. The aforementioned thematic analysis was performed by a medical student, working with a faculty member, and resulted in an international poster presentation and contributions to the present manuscript. Thus, in addition to community outreach and developing communication skills, Brain Explorers provides opportunities for medical students to engage in evidence-based practice in education and scholarship. Other medical students have gained research experience through systematically evaluating their lesson plans and middle schoolers’ performance on the assessments. To date, Brain Explorers has yielded two medical student local/regional presentations with 5 student authors, 4 presentations at national or international meetings with 6 student authors, and 2 manuscripts with 4 medical student authors.

5 Discussion

The importance of science outreach cannot be overstated. Trust and interest in science remains a challenge. Despite a brief increase in trust in scientists during the pandemic, levels of trust in scientists continues to decline in the United States (Pew Research, 2023). For many youth, both in the United States and abroad, attitudes toward science have been noted to decline as they progress through their education (Murphy and Beggs, 2003; Kapici and Akcay, 2016; Tytler et al., 2008). Many professionals involved with STEM outreach hope that by providing access to science professionals and interesting materials beyond what they might otherwise receive, we can stimulate greater interest in science among younger generations. It is important to note that while this may in fact be true, the evidence for long-term effects of science outreach is difficult to collect and even more difficult to interpret. Despite these challenges, it is important to continue to work toward this goal. Science professionals should know that evidence and evaluation is a critical driver of progress. Science communication and outreach done poorly may even have detrimental effects (Simis et al., 2016; Ecklund et al., 2012; Davies, 2008; The National Academies Press, 2017). To be sure that our programs and outreach events are meeting the goals set, continued evaluation should be seen not only as interesting and useful but as necessary. While we continue to evaluate our goals of reaching an underserved audience, as well as improving attitudes toward science, these are beyond the scope of this manuscript and have been reported elsewhere (Vollbrecht et al., 2019; Gall et al., 2020). As science outreach continues to gain a foothold within academic circles it has become clear that many of these programs lack a

basic evaluation of their effectiveness and this lack of evaluation hinders the progress and success of these programs (Jensen, 2015; Abramowitz et al., 2024; Varner, 2014; Stofer et al., 2023; Borowiec, 2023). Here we have focused on short term evaluation methods that can be used in assessing content knowledge gains achieved through outreach efforts as well as evaluation of the impact of involvement in outreach on those students serving as instructors.

To evaluate the effectiveness of our lessons in improving science content knowledge we have utilized three unique evaluation methods. We have evaluated content knowledge at the conclusion of a visit, we have evaluated content knowledge at the beginning and the end of the visit, and we have evaluated content knowledge before and up to 2 weeks after a visit. These assessments have utilized a variety of question types including multiple choice questions and written responses. While each assessment type has its pros and cons, across multiple lesson plans and evaluation methods we have consistently demonstrated effective increases (or perceived increases) in middle school student content knowledge.

5.1 Immediate post-event assessment

There are many ways to assess content knowledge following an outreach event. Immediate post-event assessment is likely the simplest and most time-efficient way to assess content knowledge as it can take relatively little time depending on the assessment type that is used and can even be incorporated as an interactive element. Having a single post-session quiz provides students and instructors an assessment of the learners’ content knowledge and takes less time than having both pre- and post-session quizzes; however, it does not directly capture learning due to the session alone. For example, some students may arrive with a baseline knowledge of the subject and thus could score above chance prior to the lesson. However, significant prior knowledge of the content is unlikely here, because the middle school participants had not yet taken a cell biology course, let alone neuroscience. Here we utilized a trivia-style online platform to assess content knowledge. This game allows students to anonymously compete against their classmates to answer the most questions correctly. Faster responses earn more points. While this gamification encourages participation from students and increases excitement for the assessment, it also runs the risk of decreasing the accuracy of responses due to the students’ desire to answer quickly. Regardless of this potential decrease in scores, we saw students performing significantly greater than chance in this type of assessment (Figure 1). Even this quick assessment type can provide valuable insight into what students struggled with and what was conceptually easier for them to grasp, especially when reviewed on a question-by-question basis.

5.2 Immediate pre- and post-event assessment

When students are tested at the beginning and end of the session, significant gains in content knowledge are expected to be observed. We observed this in the two lessons reported here that were assessed in this manner (Figure 2). The immediate pre- and post-event assessments in this manuscript included both multiple

choice questions as well as an open-ended question. While the immediate assessment is one of the simpler ways of assessing students due to time constraints within classrooms and ease of access to the students there are some obvious tradeoffs. First, there is no guarantee that content will be retained long-term as the assessment is done within minutes of the event conclusion. Second, by testing immediately prior to the event students are likely cued toward seeking out answers to some of the questions on the assessment impacting their scores on the post-event assessment. Finally, time with students is limited and including two assessments in your event can decrease the amount of time for content delivery or activities.

5.3 Spaced pre- and post-event assessment

Assessing content knowledge further removed from the intervention generally leads to a decrease in observed gains compared to immediate assessment but suggests greater retention depending on the length of time that passes from intervention to assessment. Here we demonstrated significant gains even after 1–2 weeks passed following the outreach lesson (Figure 3). The pre-event assessment was also done prior to the outreach team's arrival at the school to prevent any bias or accidental discussion of content prior to students taking the assessment. These assessments did not include any multiple-choice questions and were unique in that there were two open ended questions one of which we planned to cover in the event and one that we did not plan to cover in the event. This assessment type allowed measurement of specific gains in the content that was taught during that lesson. While a pre-post design can be effective at providing a baseline before the intervention as well as assessing knowledge after the intervention (especially in this spaced pre-post design), one should be aware of potential repeated testing effects and regression to the mean whenever the same assessment is given twice (Marsden and Torgerson, 2012). A randomized post-only design can control for these potentially confounding variables; however, it requires a large number of participants and random assignment to groups—both of which may not be feasible in STEMM outreach studies (Friedman et al., 2008).

5.4 Question types: multiple-choice vs. open-ended

When choosing an assessment not only should one consider the timing of the assessment relative to the event but also the format of the questions used on the assessment. Two common question types are multiple-choice questions and open-ended written response questions. Multiple-choice questions are easy to grade on the back end, and easy to evaluate for knowledge gains by determining if scores improve significantly. Multiple-choice and open-ended questions generally test different levels of learning with multiple-choice questions generally considered to be easier allowing for cueing of responses. Often multiple-choice questions are thought to test a lower level of knowledge or understanding because these are

cued responses (Schuwirth et al., 1996; Melovitz Vasan et al., 2018; Polat, 2020), although carefully crafted multiple-choice questions can certainly still test high level thinking (Scully, 2019). Open-ended or free response questions on the other hand may test higher levels of comprehension and learning. However, these question types require a more careful analysis of the responses to evaluate content knowledge and in particular to measure content knowledge gains (Schinske, 2011), although analysis of these responses has received considerable attention from those looking to effectively automate the process (Sychev et al., 2019; Zhang et al., 2022; Pinto et al., 2023). Thus, utilizing both forms of questions has the potential to better gauge the level of learning that has occurred.

5.5 Choosing an evaluation method

In this manuscript we utilized three different assessment methods to demonstrate the strengths and limitations of each assessment type. Choosing an evaluation method requires careful examination of one's program or event goals, the setting, access to the audience for follow-up and the time available.

When the primary goal of the event is content knowledge gains, a more rigorous approach including spaced pre- and post-event evaluation is desirable (as we demonstrated in Figure 3). Additionally, if long term retention and learning are critical goals, open-ended questions that require critical thinking skills are useful. Students' responses to these questions can be quantified using a rubric and then learning gains measured, as we demonstrated in Figure 2. Spaced pre- and post-event evaluations will provide a better understanding of an audience's long-term learning, and the open-ended question format may better demonstrate understanding vs. ability to simply identify facts or information from a multiple-choice question. However, depending on the format of the outreach session and the ability to contact participants after the event, this may not be an option. When there is not a feasible way of contacting the audience after the conclusion of the event an immediate pre- and post-event evaluation is preferable (as we did for Figure 2).

If the primary goal of your event or program is to improve attitudes toward science or engagement with science, more extensive content knowledge evaluation may be off-putting to participants, and a less rigorous evaluation method such as a simple post-event quiz or survey may be most appropriate (as we did for Figure 1). However, careful evaluation of the program's primary goal should guide the choice of the most appropriate assessment method.

The setting of the event should also be considered. All of the evaluations described here took place in a middle school classroom, where quizzes and testing are expected. If these lessons or activities were to have taken place at a science fair or open-house style event, a single post-event evaluation that took a gamified approach would have been most appropriate.

Whichever form of assessment is utilized, assessing content knowledge gains following outreach events can provide critical information for the improvement of these events and in helping to understand our audiences. What may be simple for one audience may be more difficult for another audience and each assessment

allows for the continued adaptation of a lesson to the specific audience demographic. Depending on the goals of your program or event, long term retention of information may be more or less important. This should be considered when determining the timing of your assessment, as a temporally distant assessment may better evaluate your goals than an immediate assessment. However, when one is involved in outreach it can be difficult to carve out additional time, or to follow up with attendees after the fact. In these cases, immediate assessments may be more attractive.

One of the three major goals of Brain Explorers is increased content knowledge for our middle school students. Thus, assessing these gains in content knowledge is critical for the mission of our program. Through increased knowledge we are hopeful that we can drive interest in the sciences as a whole. Although assessing attitudes toward science is beyond the scope of this particular article and has been discussed previously, it remains a critical component of our outreach efforts (Gall et al., 2020).

5.6 Evaluation of the impact of participation on medical students

Medical professionals, especially physicians, are often the only scientists with whom many people will interact during their lives. For this reason, it is critical to build the confidence of future physicians in their ability to communicate difficult scientific topics to individuals who may not be familiar with scientific terminology or jargon. With smaller cohorts of medical students participating in Brain Explorers, it will likely take several more years to obtain data beyond narrative responses. Despite this limitation, providing opportunities to improve communication skills is a goal of the program and therefore should be evaluated as possible. Focus groups provide an abundance of qualitative data and can be particularly useful in examining self-reported qualities such as confidence and motivations for participation.

Medical students sought out Brain Explorers primarily looking for opportunities to develop communication skills and give back to the community. From our focus group it became apparent that medical students feel they were able to meet these desires, with a perceived increase in communication skills and increased confidence in their ability to explain scientific content. Previous reports have indicated similar effects of service-learning on perceived communication skills (McNatt, 2020; Tucker and McCarthy, 2001; Hébert and Hauf, 2015). Future studies will continue to examine effects of communication skills beyond self-reported gains in communication skills, although significant challenges exist in meeting this need.

Finally, the development of curricular content for outreach programs, teaching it to students, learner assessment, and programmatic evaluation offer scholarship opportunities not only for faculty but also medical students. Scholarship of teaching and learning (SoTL) is necessary to advance the field of education, and outreach and service-learning programs are ripe for SoTL (Restini et al., 2024). Such scholarship opportunities may be increasingly valuable for medical students' future careers and earning a residency placement (Wolfson et al., 2023).

6 Limitations and conclusions

Assessing the impact of STEMM outreach programs is crucial to ensure that such programs are meeting their goals. Through examples from our Brain Explorers program, the present work provides a variety of methods for learner assessment within outreach programs. Each assessment method has advantages and disadvantages. Furthermore, the outreach setting or participants' demographics could influence which assessment methods are acceptable or practical. The assessments of middle schoolers' learning within Brain Explorers were conducted in a rural, midwestern town with relatively small class sizes. Assessment on the impact of medical student participation in the outreach program as instructors was in a midwestern medical school. Without appropriate program evaluation, it is possible to overlook that what is effective in one population or setting may be ineffective in another population or setting. The data and evaluation methods presented here are heavily focused on content knowledge gains. This is only one possible goal, and often not the primary goal of STEM outreach work. We encourage evaluation of all program goals including improving attitudes toward science (Gall et al., 2020; Yawson et al., 2016; Septiyanto et al., 2024), increasing representation in STEM (Vollbrecht et al., 2019; Carver et al., 2017), and improving science literacy (Struminger et al., 2021; Arthur et al., 2021) among others.

While it is important to thoughtfully create an assessment plan, we caution against harming the participant's experience for the sake of experimental design. Indeed, rigor in assessment of STEMM outreach should be valued but not if it alienates or potentially traumatizes participants within the outreach activity (Friedman et al., 2008). Over-zealous assessment could ultimately diminish goals of STEMM outreach. This highlights the need for thoughtfulness in all outreach efforts and programs' evaluations of their efforts. Thus, while our data is limited to a specific goal of one specific outreach program, we believe that this limitation serves as a call to all involved in outreach work to continue to develop program goals and evaluate the effectiveness of these programs in reaching their goals. As more programs continue to evaluate and report their effectiveness, the outreach community can learn and grow, developing best practices from the combined efforts of all of our programs.

Data availability statement

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

Ethics statement

The studies involving humans were approved by Western Michigan University Homer Stryker M.D. School of Medicine Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

PV: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CC: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. JM: Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. TC: Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. KP-S: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1446205/full#supplementary-material>

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A preliminary study of educational experiences that promote perceptions of college readiness in individuals from lower socioeconomic backgrounds interested in pursuing a career in science, technology, engineering, math, or medicine (STEMM)

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Introduction: College readiness encompasses many different domains, including content knowledge, metacognitive skills, communication skills, learning strategies, and transitional knowledge. College readiness impacts academic achievement; moreover, student perceptions regarding college readiness impact their behavior and decision to attend college. High-achieving students from lower socioeconomic status (SES) areas possess grit and intelligence, but systemic barriers and inequities can interfere with the achievement of academic success in part due to reduced college readiness.

Methods: In this study, we explore if educational opportunities, such as outreach and pathway programs (OPP), Advanced Placement and International Baccalaureate, and college dual enrollment, impact perceptions of college readiness in a nationwide sample of 339 matriculating college students who wish to enter into Science, Technology, Engineering, Mathematics, and Medicine (STEMM) related fields.

Results: OPPs ($p = 0.005$) and dual enrollment ($p = 0.002$) are predictive of higher perceptions of college readiness. When individuals are partitioned into low and high SES by a median-split, OPPs ($p = 0.015$) and dual enrollment ($p < 0.001$) are predictive for students from low SES areas only.

Conclusion: This work indicates the importance of educational opportunities in improving perceptions of college readiness for students from low SES areas and potentially how resources may be better allocated in the future.

KEYWORDS

low socioeconomic status areas, STEMM outreach, pathway programs, dual enrollment, college readiness

1 Introduction

1.1 College readiness

College readiness is a crucial factor determining students' success in transitioning from high school to higher education. It includes academic preparation and the development of specific attributes essential for a college environment. College readiness refers to the level of preparation that high-school students should possess to meet college-level expectations, which are vital for matriculation into college and developing specific attributes that help them succeed (Conley, 2007). Traditionally, college readiness was measured through factors such as the percentage of students taking remedial classes in college, standardized test scores (e.g., ACT and SAT), or academic achievement during the first year of college (Conley, 2007). However, college readiness goes beyond content knowledge to encompass metacognitive skills, learning strategies, and transitional knowledge (Conley and French, 2014). Conley's definition of college readiness includes four components: Key Cognitive strategies (e.g., problem formulation, research, and communication), key content knowledge (structure of knowledge, attitudes toward learning, and technical knowledge and skills), key learning skills and techniques (ownership of learning and learning techniques), and key transition knowledge and skills (e.g., contextual, procedural, cultural) (Conley and French, 2014).

1.2 Impact of individual and area socioeconomics on educational attainment

Socioeconomic status (SES) significantly impacts educational experiences and outcomes (Levy, 2022). High family and neighborhood SES impact educational attainment (Conley and French, 2014; Nieuwenhuis and Xu, 2021). Those in high SES areas have access to resources that are not available to those in lower SES areas. Indeed, Martens et al. (2014) found living in public housing had a negative impact on health and education outcomes, but living in a high SES area when living in public housing was protective and helped mediate some of the effect. Moreover, a meta-analysis found educational outcomes are influenced by four neighborhood characteristics: neighborhood poverty, a poor educational climate, the proportion of ethnic/migrant groups, and social disorganization (Nieuwenhuis and Hooimeijer, 2016). The inequalities in accessing quality education are similar to the inequities in healthcare access, severely affecting academic progress, college readiness, and career opportunities for students from economically disadvantaged backgrounds (Ali et al., 2005; Aikens and Barbarin, 2008; Brown et al., 2016; Sanderson et al., 2021). There is a strong correlation between economic inequality and student achievement gaps in school districts across the United States (U.S.) (Hung et al., 2020). This economic inequality manifests in academic performance disparities and extends its influence on social capital, which is pivotal for college readiness. Social capital refers to the networks, relationships, and resources students can access via their family and community, which

greatly help navigate the academic landscape and boost college preparedness (Hung et al., 2020).

Research on high-achieving students from economically disadvantaged backgrounds shows they have strength of will but also require agency or resources and support to achieve what they desire (Kundu, 2017). This is bolstered by findings that report what high-achieving secondary students living in low-SES areas perceive as being beneficial for their success. The two most prominent factors have been reported to be facilitating networks between students and mentors and creating a culture of hope in which students are seen as fully capable of succeeding (Williams et al., 2019). Students from economically disadvantaged families in higher education express feelings of not belonging, negative self-perceptions about their ability to succeed, and fear of failure. These factors serve as barriers to their success; however, opportunities that help them identify how their values are reflected in the educational space promote a sense of belonging within higher education, which is protective (Jury et al., 2017). Previous research has demonstrated a relationship between perceptions, intentions, and behaviors. Perceptions influence intentions to perform, as well as lead to beneficial behaviors (e.g., help-seeking, academic persistence, etc.) in higher education (Roland et al., 2018; Bornschlegel et al., 2021) that will make it more likely that the student will succeed (Ellis and Helaire, 2023). In addition, self-efficacy, the belief of an individual in their ability to achieve, positively affects academic success in college and beyond (Honicke and Broadbent, 2016; Hayat et al., 2020).

1.3 Educational experiences that promote college success and entry into STEMM fields

Educational experiences, particularly positive ones, can increase interest in STEMM fields. Moreover, these experiences can cultivate skills needed for college success. Advanced offerings such as advanced placement (AP), international baccalaureate (IB), and dual enrollment courses (where high school students are enrolled in college or university courses) are promoted by school districts across the US and are utilized by students to signify their readiness for college. AP and IB courses take place in a high school setting, are taught by high school teachers, and provide rigorous coursework that requires the application of critical thinking and analytical skills and develops a deeper understanding of fundamental concepts. AP courses typically occur over a year and multiple courses can be taken at a time, while IB is a rigorous program composed of six core classes, takes place over 2 years, and is recognized internationally. Students must take an IB examination to receive an IB diploma. Like in IB programs, students who take AP can opt to take an end-of-course examination. Those who take and pass their individual content IB and AP course examinations may be awarded college credit contingent on the policies of the college or university. Students who participate in these programs achieve similar graduation success at college (Schumacker, 2014). In contrast, dual enrollment may occur at a college or university setting alongside adult learners, online, or be taught in a high school setting by teachers who are also adjunct faculty. Successful completion results in postsecondary credit.

Students who participate in these advanced offerings often enroll in college (Speroni, 2011); however, there is some debate over whether

Abbreviations: SES, Socio-economic status; OPP, Outreach and Pathway Programs; STEMM, Science, Technology, Engineering, Mathematics, and Medical; URM, Underrepresented minorities; U.S., United States.

or not these programs themselves promote college success. There are conflicting results from studies, with many studies set at a particular college or region of the US. This has the potential to introduce other variables that can impact results. However, an analysis performed by the Institute of Education Sciences over five studies found dual enrollment increased high school attendance and graduation and college degree attainment (Works Clearinghouse, 2017). There were also positive effects on college readiness; however, there was no impact on academic achievement in college (*ibid*). Moreover, those who were dual-enrolled in a 4-year college were more likely to matriculate than those who were not dual-enrolled (Wyatt et al., 2015), and dual enrollment was shown to promote college readiness (An, 2013). These studies are supported by work from the National Center of Postsecondary Research that explored the impact of AP and dual enrollment on Florida graduates. They find that AP and dual enrollment both promote college enrollment and bachelor's degree attainment; however, location mattered, as those who took dual enrollment courses at their high school did not have increased college enrollment or bachelor's degree attainment. In addition, students who participated in dual enrollment were more likely to attend college directly after high school, while students who participated in AP were more likely to enroll in a four-year college, but both groups had similar levels of bachelor's degree attainment (Speroni, 2011). In contrast, Klopfenstein and Thomas found that AP experiences did not promote first-semester grades or retention (Klopfenstein and Thomas, 2009). Moreover, merely taking AP courses does not impact ACT/SAT scores or matriculation into college (Conger et al., 2023). However, students who take and pass the AP exam obtain a higher ACT score (Warne et al., 2015). Similarly, studies exploring the impact of IB programs have found that their outcomes are comparable. A single-site study exploring the impact of IB on honors college students found no difference in GPA when controlling for gender or minority status; however, completion of four or more courses led to greater persistence, and qualitative data suggested that IB students were more prepared to adjust to the rigors and expectations of college (Conley et al., 2014).

External educational experiences may also promote college readiness. Outreach and pathway programs (OPP) offer numerous benefits, including the important factor of fostering partnerships between K-12 educators, students, communities, and higher education institutions to enhance educational opportunities for children and adolescents from all economic backgrounds (Muijs et al., 2004). Furthermore, they promote self-confidence and increase student retention rates in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) (Rocha et al., 2022a, 2022b). Due to how these programs are structured, many OPPs are positioned to enhance equity and inclusion in STEMM by improving postsecondary education preparation through mentorship and the creation of networks. Ideally, OPPs will build skills that foster success and create a culturally responsive learning environment where diverse individuals can learn and work collaboratively. Despite the recognized benefits of OPPs, there is a need for more comprehensive studies to examine their impact on students' perceptions of college readiness, especially those interested in STEMM fields.

This study aims to explore the relationship between the perception of college readiness and educational experiences among high school graduates during their first semester of college. The educational experiences are OPPs, dual enrollment, and AP/IB. We also explore the relationship between demographic factors such as race and

ethnicity, first-generation college status, household income bracket, and community SES on perceptions of college readiness.

Our research adopts an equity-oriented framework, concentrating on the equitable distribution of resources and opportunities through educational experiences. In this preliminary study, we investigate if OPPs, dual enrollment, and AP/IB participation can level the playing field for students from lower-income backgrounds regarding their perception of readiness for college. The goal is to provide actionable insights for K-12 educators, higher education institutions, and communities, enabling them to foster inclusive practices that ensure equal educational opportunities for all students, irrespective of socioeconomic status.

2 Methods

2.1 IRB approval

The Oakland University Institutional Review Board approved this study in August of 2022 (Protocol # 2022–346). All participants were informed of confidentiality and gave informed consent before participating in the study.

2.2 Equity-based research framework

The project followed an equity-based research framework, as proposed by Venkateswaran et al. (2023). The research team is composed of individuals with differing experiences concerning immigration status, race and ethnicity, religion, ability status, socioeconomic, and expertise that acknowledge that worldviews and experiences have the potential to impact work. To combat this, the team continuously reflects on how their experiences may impact the work. It centers this work on examining how the assets and aspirations of students can counter socioeconomic factors that can negatively impact access. Our work is focused on highlighting the fact that while students may have aspirations to succeed in STEMM-related fields, there are significant disparities in college-related outcomes such as enrollment, retention, and graduation rates, particularly for students from lower socioeconomic status (SES) backgrounds. The research highlights the importance of OPPs and dual enrollment in potentially reducing the differences in college readiness and success, thus promoting educational fairness for all students who aspire to pursue STEMM-related fields.

2.3 Participant recruitment

Three hundred and sixty-five individuals who recently graduated from high school and had newly matriculated into college were recruited via word of mouth and through Centiment LLC's data collection platform between 09/2022 and 11/2022. Individuals were from 40 US states and Washington D.C based on the 316 unique ZIP Codes reported out of 330 confirmed ZIP Codes (95.75% unique codes; Figure 1). Individuals with an interest in healthcare, biomed, medicine, or physical/chemical/biological science occupational fields were recruited regardless of their educational experiences prior to college. An effort was made to limit white only, non-Hispanic

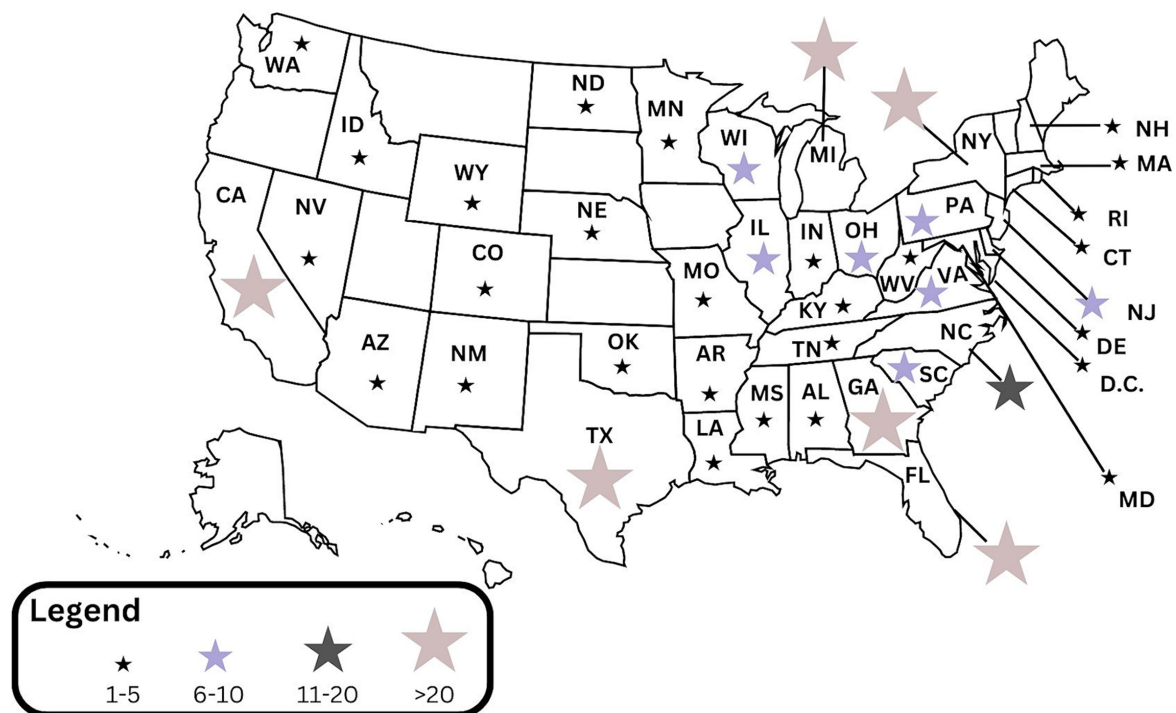


FIGURE 1
Location of participants across the US. The reported ZIP codes were used to map participant locations.

participants at 60% to match current U.S. demographic data based on the 2020 Census which reports the U.S. white, non-Hispanic population is 57.8% (Jensen et al., 2021). Participant data was collected anonymously and stored according to the approved IRB protocol.

2.4 Measures

This research was accomplished using a survey designed to focus on quantitative measures about participation in OPP experiences and perceived readiness for college education in STEM-related domains. Beyond the focus on quantitative measures, a few qualitative questions were included to allow for open-ended responses and further contextualize the responses seen in the quantitative measures. This design is beneficial for multiple reasons, including (1) ease of administration and data collection, (2) sampling from a nationwide sample, (3) incorporating a diverse array of SES demographics, and (4) the use of quantitative statistical analysis techniques.

2.4.1 Survey questions

Three hundred and thirty-nine individuals completed the survey and thus met the criteria for inclusion. Demographic information gathered from participants can be found in Table 1. Specific components of demographic information included race and ethnicity, gender, age, estimated household income, number of individuals within the household, participation in advanced placement/international baccalaureate, participation in dual enrollment programs, first-generation college status, ZIP Code, and age. For the purposes of this analysis, individuals who self-selected Black/African

American, Pacific Islander, Hispanic, and Native American were considered as underrepresented minorities (URM) according to the National Science Foundation definition (National Science Foundation, 2023). In this study, both AP and IB programs were considered as a single group for analysis due to the programs occurring in a high school setting, being taught by high school teachers, and similarities in student populations, outcomes, and requirements for students to achieve a certain score to qualify for college credit or being allowed to pass out of a college course.

The survey (see Supplemental material) was composed of questions regarding the types of OPP experiences that they have had, what they learned from these OPP experiences, and their self-perception of college readiness. Individuals were asked if they felt prepared for college (binary response yes/no). The specific items assessing OPP experiences are shown below and were coded as binary (yes/no), resulting in an overall total of 0 to 4 experiences:

- 1 Have you ever participated in a program or outreach activity geared at recruiting young adults, adolescents, or children into the science, engineering, technology, math, or medical fields?
- 2 Have you ever participated in science fairs outside of those that may have been required for school?
- 3 Have you ever participated in Math Olympics, Science Olympics, robotic clubs or competitions, or any other science, tech, engineering, math, or health-related educational competition?
- 4 Have you ever participated in an after-school, before-school, weekend, or holiday/summer break science, tech, engineering, math, or health-related program class or camp?

TABLE 1 Demographics of the individuals enrolled in the study population.

Gender*	Percentage	Count
Female	54.3%	184
Male	43.1%	146
Non-binary	2.4%	8
Prefer not to respond	0.3%	1
Race/Ethnicity**		
AA/Black	33.6%	114
Asian	6.2%	21
Hispanic (any race)	28.6%	96
Native American	2.9%	10
Pacific Islander	0.6%	2
White	39.2%	133
Multi-racial	5%	19
Other	9.4%	32
Prefer not to respond	2.7%	9
Income		
<25,000	24.0%	81
25,000-49,999	30.4%	103
50,000-74,999	17.1%	58
75,000-99,999	13.0%	44
100,000 or more	11.5%	39
Prefer not to answer	4.1%	14
1st generation college student		
Yes	56.0%	190
No	43.7%	148
No answer	0.30%	1
Advanced placement/International baccalaureate		
Yes	58.1%	197
No	41.9%	142
Dual enrollment		
Yes	59.9%	203
No	40.1%	136

*One participant selected both male and non-binary.
** Individuals were allowed to select multiple fields. 5% of respondents are bi/multiracial:0.6% Asian and Native American, 1.2% African American and White, 1.2% Asian and White, 0.3% Native American and White, 0.6% African American and Asian, 0.9% Native American and African American, 0.3% Asian and Pacific Islander, and 0.3% African American, Native American, and White.

We utilized correlation and logistic regression analyses to identify experiences that impact perceptions of preparedness for individuals from both low and high-SES areas. We also identified and mapped out the skills, knowledge, and behaviors learned from participation in OPPs that promote college readiness based on Conley’s four principles of college readiness (Conley and French, 2014).

2.4.2 Coding free responses

Free responses were coded based on Conley’s four principles of college readiness and knowledge needed for their future career path and academic self-efficacy using the deductive qualitative framework (Gale et al., 2013). Responses that did not map to Conley’s four

principles were coded under “other.” Two individuals coded the responses separately. The initial rate of agreement was 94.2%. A third reviewer resolved any disagreements.

2.5 Data analysis

2.5.1 Community SES calculation

We calculated the SES scores for the community that the participants lived in during high school based on U.S. census data as in a previous publication (Hurse et al., 2023). Briefly, the ZCTA5 codes for the reported ZIP Codes were determined using the free, publicly available UDS Mapper tool, funded by the Health Resources and Services Administration, Bureau of Primary Health Care, and coordinated by the Robert Graham Center (<https://geocarenavigator.hrsa.gov/>). Two members of the team utilized the US Census website and the ZCTA5 codes to extract reported data for owner-occupied housing, median home values, percent in the workplace, *per capita*, and percent bachelors from the following tables DP03, DP04, S0601 (2021 ACS 5-year estimates data profiles; <https://www.census.gov/>). The data was normalized using values from the state from which the ZCTA5 code originated in part because of the variability across the US states regarding socioeconomic factors. The normalized values were then summed as previously reported (Hurse et al., 2023). The ZCTA5 codes and US Census data were extracted between December 2022 and August 2023 by two members of the team. Two additional key personnel reviewed the extracted data for accuracy. When discrepancies were flagged, a team member reviewed the data tables to confirm that there was a discrepancy and the error was corrected. Individual’s scores were normalized to their state SES metrics, arranged in ascending order, and partitioned into low or high SES groups (based on a median-split procedure; median-4.427, IQR-5.570-3.642) to aid in the exploration of this data and make the conclusions more generalizable across states. Nine individuals failed to provide a valid ZIP Code and were not included in the analysis involving this variable.

2.5.2 Statistical analysis

These data were analyzed using SPSS version 29 software, and due to this being a preliminary investigation, an uncorrected threshold *p*-value of ≤ 0.05 was used to determine statistical significance. Pearson correlations were run between the perception of college readiness (also called “college readiness”) and the following variables: the number of OPP experiences, participation in AP/IB, participation in dual enrollment programs, race, ethnicity, income, and first-generation status. This was done to determine the strength and direction of the association, allowing us to identify relevant variables for our model. Multiple logistic regressions were run between the independent variables the number of OPP experiences, AP/IB, and dual enrollment, and the dependent variable perception of college readiness (also referred to as college readiness). Multiple logistic regressions were also run between the type of OPP experiences (independent variables) and college readiness as the dependent variable. We did not compare the types of experiences, as this was not the focus or intention of the investigation, and individual programs may vary in terms of their quality. After a median split procedure, bifurcating the sample by SES status into low and high, separate multiple logistic regressions were conducted as defined above. The independent variables were (1) Number of OPP experiences, (2) AP/IB, (3) Dual Enrollment, and the dependent variable perception of college readiness.

2.6 Figures

All figures were created using the online website Canva.

3 Results

3.1 Participation in OPPs or dual enrollment predicts perceptions of college readiness

The collection method resulted in a sample that is predominantly White/European, African American/Black, and majority female. African-American/Black individuals are overrepresented in the sample (33.6% vs. 13.3% U.S.), and White/European individuals are under-sampled (39.2% vs. 50.5% U.S.). Twenty-eight percent of individuals identified as Hispanic of any race (see [Table 1](#)). Approximately 84% of the students in our survey responded that they felt prepared for college. Race, ethnicity, income, or first-generation status did not correlate with perceptions of college readiness ([Supplementary Table S2](#)). However, participation in educational experiences beyond those required for graduation from high school did correlate with feeling prepared for college (AP/IB, dual enrollment, or OPPs; [Supplementary Table S1](#)). Interestingly, participation in OPPs ($p = 0.005$) and dual enrollment predicted perceptions of college readiness ($p = 0.002$), but AP/IB did not ($p = 0.763$; [Table 2](#)). Further analysis found participation in STEMM program classes

and camps outside of school drives the model ($p = 0.003$; [Table 3](#)). Individuals were split into low SES and high neighborhood SES groups based on the median, and a multiple logistic regression accounting for neighborhood SES was performed. We found the model was significant only for individuals that were from low neighborhood SES areas regarding dual enrollment ($p < 0.001$) and OPP participation ($p = 0.015$; [Table 4](#)).

3.2 Students identify gains in skills that relate to college readiness and academic self-efficacy due to their OPP experiences

While previous work has shown dual enrollment increased perceptions of college readiness ([An, 2013](#)), little is known about the impact of OPP experiences on this measure. Therefore, we focused our qualitative analysis on addressing this deficit. Two hundred and seventy-nine participants reported having at least one OPP experience, with 217 (78%) stating that they obtained at least one skill due to the experience. The majority of these individuals responded when allowed to elaborate on the skills they learned through OPP experiences 85% ($N = 185$). Two Hundred and six skills were extracted from these 185 open-ended responses. They were then mapped to Conley's principles of college readiness or "other" if they did not fit the predefined categories. Twenty percent of comments were coded to cognitive strategies, 28% to content knowledge, 23% to learning skills/techniques, and 4% to transition knowledge. Another 24% of comments were coded as "other." Examples of the comments can be found in [Figure 2](#).

TABLE 2 Perception of readiness increases with more OPP experiences or dual enrollment.

	<i>B</i>	df	χ^2	<i>p</i> value	Odds
Number of OPP experiences	0.381	1	7.823	0.005**	1.464
Dual enrolled	1.087	1	9.880	0.002**	2.965
AP/IB	0.99	1	0.91	0.763	1.105

Multiple logistic regressions were run.*Individuals were divided into groups by the number of OPP experiences (0, 1, 2, 3, and 4). Dual enrollment and AP/IB are binary choices. The dependent variable is the perception of college readiness and the independent variables are the number of OPP experiences, dual enrollment, and AP/IB.

TABLE 3 Participation in STEMM classes and camps is driving the OPP and readiness model.

Have you ever participated in...	<i>B</i>	df	χ^2	<i>p</i> value	Odds
STEMM program or outreach recruitment activity?	0.597	1	3.256	0.071	1.817
External science fairs?	0.305	1	0.779	0.377	1.356
STEMM educational competition?	0.138	1	0.158	0.691	1.148
STEMM program class or camp outside of school?	1.025	1	8.987	0.003**	2.786

Multiple logistic regressions were run. The dependent variable is the perception of college readiness. The independent variables are shown in the leftmost column.

TABLE 4 OPPs and dual enrolment participation impacts students from low SES areas more than those from high SES areas.

		<i>B</i> 95% CI [Lower, Upper]	Beta	<i>p</i> value
Low SES				
	Constant	0.776 [0.585, 0.967]		<0.001
	Number of OPP	0.056 [0.011, 0.101]	0.201	0.015*
	Dual enrollment	0.230 [0.106, 0.355]	0.304	<0.001**
	AP/IB	−0.033 [−0.148, 0.082]	−0.045	0.570
High SES				
	Constant	0.904 [0.700, 1.108]		<0.001
	Number of OPP	0.038 [−0.009, 0.086]	0.139	0.115
	Dual enrollment	0.062 [−0.061, 0.185]	0.083	0.320
	AP/IB	0.069 [−0.056, 0.195]	0.092	0.278

A multiple logistic regression was run using median SES split. *Individuals were divided into groups by the number of OPP experience types (0, 1, 2, 3, and 4). Dual enrollment and AP/IB are binary choices. The dependent variable is the perception of college readiness and the independent variables are number of OPP experiences, dual enrollment, and AP/IB.

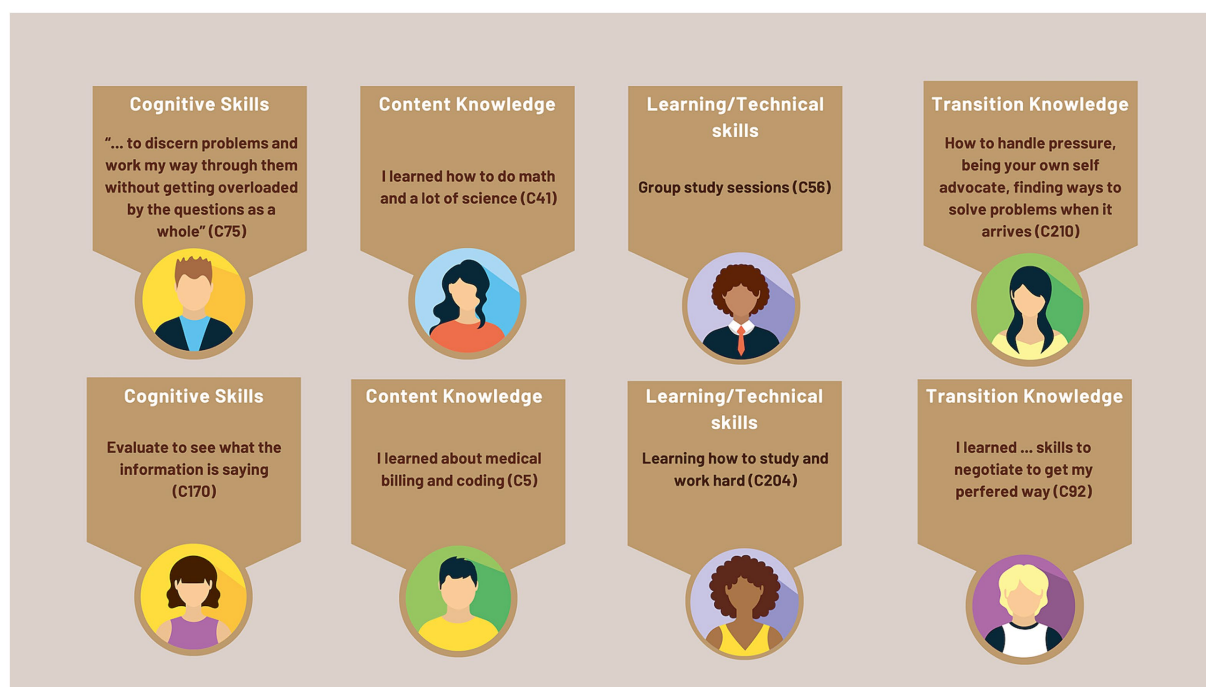


FIGURE 2

Comments from participants regarding what they learned from OPP participation. Individuals were given the opportunity to elaborate on the skills they learned. Examples of those that map to Conley's college readiness are above.

4 Discussion

4.1 Impact of educational experiences on college readiness

The main goal of our study was to explore what educational experiences influence the perception of college readiness amongst matriculating students pursuing a career in STEMM. Approximately 84% of the students in our survey responded that they felt prepared for college. Further analysis shows that participation in educational opportunities, like dual enrollment, AP/IB programs, and OPPs, correlates with perceptions of college readiness (Supplementary Table S1). When we explored these relationships by conducting a regression analysis, we found that OPPs and dual enrollment participation significantly predicted the perception of college readiness. Indeed, when participants were allowed to elaborate on skills gained from participation in OPPs, 76% of skills could be mapped to Conley's principles of college readiness. Further analysis finds the OPP and readiness model is driven by participation in classes and camps outside of school. However, when this data was separated based on SES (median split procedure), dual enrollment and OPP participation predicted perceptions of college readiness only for students from low SES areas ($p < 0.001$ and $p = 0.015$, respectively). Income, race, ethnicity, and first-generation status, differing from some previous investigations, did not correlate with perceptions of college readiness. It is important to note that while household income factors into SES, it is not the sole defining factor. Moreover, neighborhood factors such as the SES of an area, the quality of schools, and the norms and expectations of the community all play a role in achievement (Moore et al., 2007; Nieuwenhuis and Xu, 2021; Levy,

2022). Similar to our findings, a study by Cannady et al. (2017) found that income, race, ethnicity, and first-generation status factors did not predict whether individuals entered a high-skilled STEMM career vs. a high-skill non-STEMM career. However, they found taking an advanced math course, taking an advanced science course, expecting to go into a science or engineering career, and factors like being male or having married parents all were significant predictors of entry into a high-skill STEMM career (Cannady et al., 2017).

An earlier study found dual enrollment predicted college GPA and reduced the likelihood of remediation in students with lower SES (An, 2013). This may be because dual enrollment bolsters Conley's key components of college readiness. Conley's principles of college readiness are built upon four components: key cognitive strategies, key content knowledge, learning skills and techniques, and transition knowledge and skills (Conley and French, 2014). Possessing each of these four components of college readiness is important to succeed in college. While the components "key content knowledge" and "transition knowledge and skills" can be classified as technical information needed to be successful in college, it is the softer skills, such as key "cognitive strategies" and "learning skills and techniques," that are required to skillfully manage and sift through information that suit one's own learning needs. OPPs have been reported to increase a sense of belonging, self-efficacy, and content knowledge (Jury et al., 2017; Kuchynka et al., 2022), all of which may contribute to Conley's four components of college readiness. Figure 3 illustrates the relationship between external educational opportunities, college readiness, and perceptions of preparedness for college.

Students from low-income backgrounds who demonstrate high levels of achievement possess grit (Kundu, 2017). Grit refers to the ability to persevere and stay focused despite significant obstacles. It is

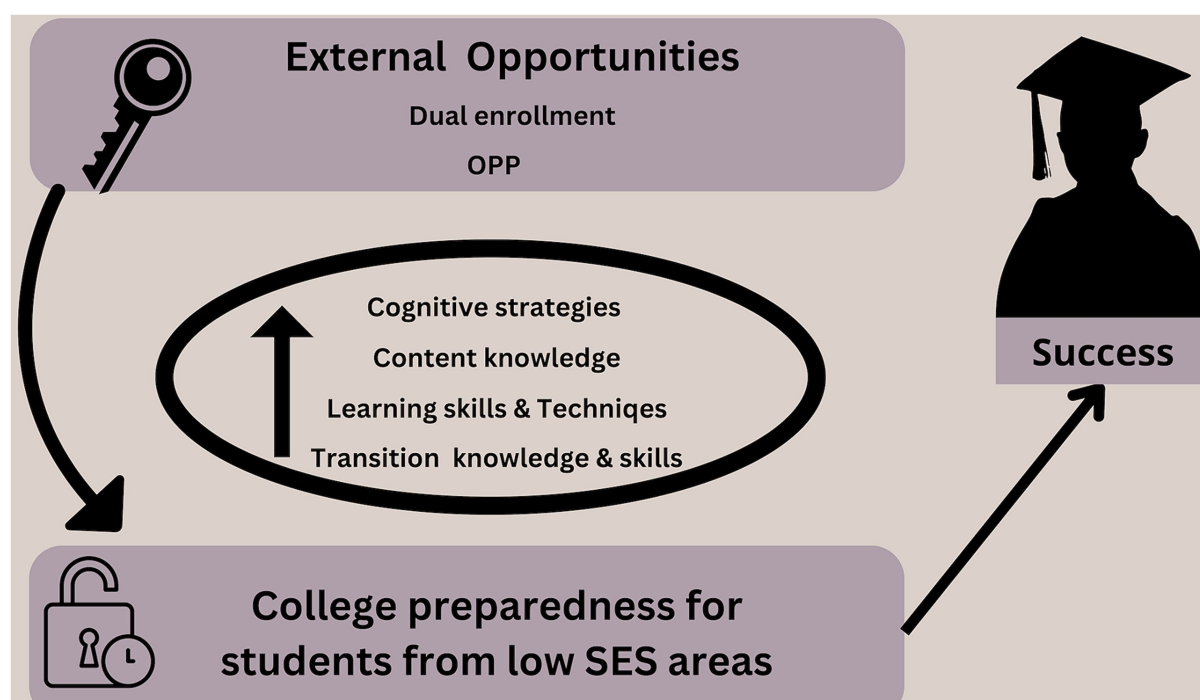


FIGURE 3

External opportunities improve perceptions of college preparedness. External opportunities improve perceptions of college preparedness of students matriculating from low SES areas by increasing the four key components of college readiness as explained by Conley. This in turn leads to success and achievement in college.

related to determination, resilience, self-discipline, and focus in pursuit of long-term goals within the field of education (Bashant, 2014). All of these are aspects that any student must maintain; however, they are of particular importance for STEM-focused students. Grit, perseverance, and resilience are better indicators of success in college than GPA and SAT scores (Duckworth et al., 2007), with grit promoting college success and academic achievement (Reysen et al., 2019). However, “agency” is very important when assessing academic achievements. Research shows three emerging themes: mental health, networking, and goal formation, as beneficial for the success of students from low SES backgrounds (Kundu, 2017). While individuals from low SES areas may have grit, they do not always have agency, and both are needed to navigate and succeed in STEM-focused programs and fields.

The rise of social media and improved internet connectivity has brought about a significant change in how students access college-related information. This is particularly beneficial for those who have limited familial experience with college (e.g., first-generation students). Social media platforms have boosted students’ confidence in their ability to apply to and succeed in college, in addition to enhancing their networks and providing valuable collegiate insights (Wohn et al., 2013). Social media use can enrich transitional knowledge, agency, and critical learning skills necessary for self-efficacy and persistence in education, with notable benefits for Black students in urban areas (Brown et al., 2022). While social media platforms offer a wealth of information, students may need help interpreting and utilizing this knowledge fully and effectively (Brown et al., 2016). This is where external educational opportunities can play an important role. These programs and resources act as a vital scaffold,

providing students with the necessary framework to understand, integrate, and apply the information gleaned from social media. Moreover, these educational opportunities bridge the gap between information access and comprehension by offering structured learning environments, mentorship, and tailored guidance. They play a pivotal role in translating complex online information into actionable knowledge, thereby enhancing students’ transitional skills and reinforcing self-efficacy in the educational realm. In essence, external educational opportunities are vital in translating the potential of digital platforms into tangible educational success. Furthermore, external educational opportunities, like dual enrollment and OPP programs, help reduce disparities. Lane et al. found that a STEM intervention program that targeted underrepresented students attending college enhanced college readiness as defined by Conley (Lane et al., 2020). We surmise that they fulfill the two most prominent factors: (1) creating networks between students and mentors and (2) building a culture of hope in which students are seen as fully capable of succeeding (Williams et al., 2019).

4.2 Why dual enrollment improves perceptions of college readiness

Currently, students seeking to gain exposure to college-level courses take AP courses, attend IB programs, or engage in dual enrollment. Of these options, dual enrollment has been shown to promote matriculation and retention rates. Moreover, those who were dual-enrolled in a 4-year college were more likely to matriculate than those who were not dual-enrolled (Wyatt et al., 2015). This may

be related in part to an increased perception of readiness. As with a previous study (An, 2013), we found dual enrollment increased perceptions of college readiness among our STEM-focused students. Indeed, they also found those dual enrolled had statistically more characteristics associated with Conley's Concepts of College Readiness compared to those who received college credit before enrollment and were not dual enrolled. We did not find evidence that AP and IB participation predicted the perception of college readiness in our model. We speculate this is because students can take these courses but fail the exam or elect not to take the exam. Moreover, any student who answered that they took AP/IB courses was included, regardless of the number of courses taken or passed. Interestingly, the majority of our respondents indicated passing their AP/IB exams. We did not account for the number of courses taken and exams passed. Future studies will need to explore the quantity and quality of AP/IB courses as an important factor in influencing perceptions of college readiness.

While participation in dual enrollment and accelerated courses is beneficial, access is not equitable (Taylor et al., 2022). Davis et al. found individuals enrolled in accelerated courses in Minnesota were more likely to be high-income, white, and female (Davis et al., 2017). Haskell et al. found that the enrollment of low-income and underrepresented minorities (URM) students in dual enrollment and early college high school programs in Utah was significantly lower than that of traditional school enrollment (Haskell and Gore, 2016). This was similar to findings by Miller et al. (2017) survey of dual credit enrollment within Texas (Miller et al., 2017). This highlights that while dual enrollment can increase access to college courses, especially for those in low SES and rural areas, states must prioritize promoting its availability and benefits to increase equity.

4.3 Why OPPs improve perceptions of college readiness

OPPs present a great opportunity to develop skills associated with college readiness. Positive experiences in OPPs increase the likelihood of attending college (Zhou, 2020). Previous work shows that OPPs, in addition to improving content knowledge, have a positive impact on high school graduation rates, promote understanding of college culture, increase networking opportunities, provide a sense of belonging, and provide behavioral and psychosocial support (Domina, 2009; DuBois et al., 2011; Jung et al., 2023). Indeed, we found that individuals in the current study were able to identify skills associated with all aspects of Conley's college readiness. Moreover, they were able to identify other skills, such as leadership and social skills, as having improved/developed due to program participation. Although the majority of individuals who participated in OPPs said they learned skills, approximately one in five students (22%) stated that they did not. We speculate that this is in part due to OPPs varying in program structure, content, and quality. To address these components, it is important that programs include diverse leadership, consider the cultural background of participants, and utilize student-centered design (Crews et al., 2020; Luecke et al., 2023). Mentorship and networking opportunities are invaluable, and these components should be better incorporated into the program design. This is particularly important if the goal is to increase retention of URM, women, and individuals from lower

socioeconomic backgrounds in STEMM, as these prove beneficial (Dennehy and Dasgupta, 2017; Daniels et al., 2019; Jung et al., 2023; Kaggwa et al., 2023).

5 Limitations and future directions

Although our study offers valuable insights, it has some limitations. We were unable to thoroughly evaluate the structure, components, and quality of the educational opportunities in which the participants took part. Because of the inherent variability among instructors and course designs across the United States, future research should strive to incorporate validated metrics or assessments of student perceptions regarding these course elements to ensure a more nuanced understanding of their impact.

In the absence of a theoretical justification, our analysis did not factor in the relative importance of the four components of OPPs in influencing student perceptions of readiness. However, our findings suggest a notable correlation between components related to extracurricular engagement (STEMM camps and classes outside regular school hours) and increased perceptions of readiness. Future studies could benefit from integrating these insights, employing a stepwise regression approach emphasizing these significant factors first. It is noteworthy that these factors appear particularly salient for participants from lower SES areas. Additionally, a more nuanced outcome may be found with a scaled as opposed to binary representation of perceptions of readiness.

Calculating SES based solely on students' ZIP Codes has limitations. This approach oversimplifies the complex nature of communities. Future research should consider a more comprehensive approach, such as focusing on the SES of the school, parents, and students or a weighted combination of these factors. Personal drive and interest, knowledge, preparation, teacher qualifications, access and opportunity, and perception of ability all play a role in overall academic success (Kerr et al., 2018; Chen et al., 2020). While ZIP Code data is useful, it may only partially capture the nuanced economic and social environments students experience. ZIP Codes can encompass diverse populations with varying access to resources, and economic conditions within a single ZIP Code can be quite diverse. The median-split procedure was justified in this context to simplify the analysis and allow for more straightforward comparisons between groups. However, it may still obscure the gradient of SES effects.

While a positive relationship exists between perceptions of college readiness and OPPs or dual enrollment for those interested in STEMM associate fields, it is possible that this is only true for those entering college. We did not explore how OPPs and dual enrollment impact individuals that matriculate into trade programs or go directly into the work force. This would be of interest for future studies. Moreover, it is possible that the relationship between perceptions of college readiness and OPPs and dual enrollment are not causal. However, the qualitative data analysis presented in this study, and a previous study exploring the impact of dual enrollment and its impact on college readiness (An, 2013) provide evidence that dual enrollment and OPP experiences promote college readiness. This leads us to conclude that causal relationship is unlikely.

Lastly, our study primarily focused on the perceptions of readiness without directly measuring subsequent academic

success. While perceptions are critical in shaping behavior, their alignment with actual performance remains uncertain. Thus, future research must measure both perceived readiness and actual performance outcomes to fully understand this dynamic, possibly in a longitudinal design that tracks students through college completion.

Despite these limitations, we remain confident in the robustness and quality of our design, data, analysis, and conclusions. This study lays a foundation for further exploration and deepens the understanding of educational preparedness, catalyzing more comprehensive future research in this field.

6 Conclusion

Our research delves into the crucial topic of college readiness, explicitly focusing on how OPPs and dual enrollment improve perceptions of college readiness in matriculating college students, particularly those hailing from low SES areas. Our study illuminates the multifaceted influences on college readiness, which in this study is described as extending beyond traditional academic measures to include factors like self-efficacy, social capital, and the development of metacognitive learning strategies and transitional skills.

Our core finding is a strong positive relationship between participation in OPPs and dual enrollment programs and the perception of college readiness among students from lower SES backgrounds. This readiness is not just an academic preparation but a holistic development encompassing cognitive strategies, content knowledge, learning techniques, and transitional knowledge as outlined by Conley (see Figure 3). Our research underscores the vital role of extracurricular engagement, in enhancing students' readiness perceptions. This insight is essential, considering that traditional metrics often overlook these critical components of preparedness.

By adopting an equity-oriented framework, our research contributes significantly to understanding educational inequalities and the mechanisms that can alleviate them. It emphasizes the importance of inclusive educational practices and the provision of diverse opportunities for students from all backgrounds. Our study also adds to the body of literature, highlighting the need for a broader perspective on college readiness that transcends conventional academic benchmarks.

In conclusion, our research reaffirms the multifaceted nature of the perception of college readiness and emphasizes the need for equitable access to educational resources. By bridging the gap between perception and reality in college readiness, we pave the way for a more inclusive and effective educational landscape. Our study serves as a call to action for continued exploration and implementation of strategies that foster a supportive and enriching educational environment for all students, regardless of their socioeconomic status.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Oakland University IRB, Protocol # 2022–346. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. CD: Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. DH: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. KK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

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

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Supplementary material

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Reaching the top of Bloom's Taxonomy: an innovative pilot program for preclinical undergraduate and medical school students to create curricula for STEMM outreach/service-learning programs

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Bloom's Taxonomy is an andragogical tool that classifies educational objectives, learning activities, and assessments into distinct levels of cognitive thinking. Preclinical medical sciences educators aim to promote higher-order thinking in their curricula to help students develop clinical decision-making skills and foster deep learning. However, many courses and curricula remain focused on lower levels of Bloom's Taxonomy because they are easier to implement and assess. Meanwhile, many service-learning opportunities for medical students focus on developing affective faculties over higher-level cognitive processing of curricular material. We describe a model program in which undergraduate pre-medical education (UPE) and undergraduate medical education (UPE/UME) students at Boston University Charles River Campus (BU CRC) and Boston University Aram V. Chobanian & Edward Avedisian School of Medicine (BU Chobanian & Avedisian SOM) simultaneously engaged in service-learning and the Create level of Bloom's Taxonomy by developing a supplementary high school (HS) medical science curriculum based on content and instructional models from their preclinical courses. Activities such as mock patient cases, simulated patient interviews, and physical examination training contributed toward a HS curriculum that promotes healthy habits; increases community public health self-efficacy; sparks interest in Science, Technology, Engineering, Math and Medicine (STEMM) concepts; and educates about medical careers through engaging lessons and activities focused on human anatomy and physiology.

KEYWORDS

Bloom's Taxonomy, create level, outreach, service-learning, self-directed learning

1 Introduction

At the core of any undergraduate pre-medical education (UPE) and undergraduate medical education (UME) curriculum are the objectives to comprehend, as well as apply, a vast amount of anatomical and physiological information. A good scientific foundation forms the knowledge base needed to understand the mechanisms of disease and treatment, while critical thinking is essential for clinical decision-making in the forms of diagnosis, selecting treatments, and interpreting results.

Published in 1956, the *Taxonomy of Educational Objectives* outlined by Benjamin Bloom and his colleagues describes three domains of learning: cognitive, affective, and psychomotor (Bloom, 1956). The cognitive domain encompasses intellectual skills foundational to academic learning, and thus is often the major focus of most educational curricula. Bloom's Taxonomy is a hierarchical framework featuring six distinct levels of processing within the cognitive domain, progressing from simple recall to complex creation. Curricular designs that move students through each stage help ensure a comprehensive development of cognitive skills, preparing learners to apply their knowledge effectively in varied contexts (Adams, 2015).

The six levels of Bloom's Taxonomy are:

- 1 Remembering – involves recalling factual information and basic concepts.
- 2 Understanding – entails interpreting information and explaining ideas.
- 3 Applying – using information, methods, and concepts in new situations, such as problem-solving.
- 4 Analyzing – breaking down information into its components to explore relationships between concepts.
- 5 Evaluation – assessing new situations based on defined criteria and assessment algorithms, such as evaluating the effectiveness or validity of a solution.
- 6 Creating – synthesizing knowledge to generate novel ideas, perspectives, and/or products.

Generally, Levels 1–2 (Remembering and Understanding) are considered as lower-order thinking on the taxonomy while Levels 3–6 (Applying to Creating) are considered as higher-order (Thompson and Lake, 2023).

As the upper levels of Bloom's Taxonomy are better aligned with critical decision-making and long-term retention, medical science educators have been interested in devising and modifying training curricula to promote immersion at these hierarchical levels. However, research has found that many medical programs focus disproportionately on the lower levels of Bloom's Taxonomy, with few opportunities to take learning to the higher levels (Blanco et al., 2014).

Separately, medical institutions have introduced service-learning programs as components of their preclinical curricula because of the benefits to both the community and the medical students (Stewart and Wubben, 2014). These programs involve direct student involvement with partnered organizations to address local community needs, and typically enhance the preclinical learning experience by explicitly fostering faculties in the affective domain of learning as outlined by Bloom and his colleagues, including altruism and dutifulness (Bloom, 1956; Bartz et al., 2022).

However, the utilization of service-learning programs to enhance cognitive, particularly within the Create level of Bloom's Taxonomy, has not been well documented in the current literature. In this paper, we describe the adaptation of the Anatomy Academy curriculum (Diaz et al., 2019; Adams et al., 2021; Wisco et al., 2022) entirely designed by UPE/UME students specifically for a community partner in Boston, MA. This serves as a model of curriculum generation and self-directed learning for service-learning experiences for UPE/UME students that provides unique learning opportunities via simultaneous development of cognitive faculties at the Create level and meeting the needs of local communities.

2 Andragogical framework

2.1 Anatomy academy: a health education program that fosters interest in STEMM

Anatomy Academy is a community-based educational program that originated in Los Angeles, CA in 2012, designed to improve the health self-efficacy of K-12 students and improve the overall community public health awareness. Anatomy Academy aims to promote healthy lifestyle habits, spark interests in STEMM, and help students learn about medical careers through engaging lesson plans and hands-on activities focused on human anatomy and physiology. UPE/UME students at Boston University Charles River Campus (BU CRC) and at Boston University Chobanian and Avedisian School of Medicine (BU Chobanian & Avedisian SOM) serve as program Coordinators and Mentors through the Anatomy Academy Clubs on both campuses and are involved with creating and updating curricular materials that are modeled after their own course learning experiences.

The HS Anatomy Academy lessons are weekly 1 hour long sessions that take place after the HS students are released from school. These sessions are held 10 times per semester on a two-semester academic calendar. The UPE/UME students serving the community as program Coordinators and Mentors of K-12 students also function as creators and teachers of the content. In the context of their own education, they are operating at the highest levels of Bloom's Taxonomy, thus benefiting their own preclinical education.

During each lesson, two UPE/UME mentors lead the session while the other UPE/UME mentors help facilitate the dissemination of content through engaging activities. UPE/UME student teachers serve as patient actors during the beginning of the sessions when the HS students practice interviewing a patient. Typically, the class is arranged with two to three HS students sitting together with one or two UPE/UME students. This allows the HS students to ask the UPE/UME students questions throughout the lesson and encourages the HS students to stay on task.

2.2 Match Charter Public High School (MCPHS)

The High School (HS) Anatomy Academy program is currently offered to students in grades 9–12 at the Match Charter Public High School (MCPHS) in Boston, MA. The university-community partnership with MCPHS significantly benefits the community by addressing educational, health, and professional development needs. This collaboration provides high school students with exposure to medical professions, fostering interest in healthcare careers and improving health literacy in a predominantly minority community and serving the need for more ethnic and gender diversity in science and medicine.

The MCPHS serves a diverse student body of 1,225 students from pre-kindergarten-12. The school boasts a minority student enrollment of 99% and maintains a student-teacher ratio of 10:1, with 124 full-time teachers and 2 school counselors. Academically, the school faces challenges, with only 16% of students achieving proficiency in math and 31% in reading, figures that are consistent with district averages but lower than state averages, where 33 and 47% of students are proficient in math and reading, respectively. The student population is evenly split by gender, with 51% female and 49% male students. In state rankings, Match Charter Public School falls between #719–958

for elementary schools and #369–492 for middle schools in Massachusetts, based on performance metrics including state-required tests and graduation rates, as well as their preparedness for high school. The Anatomy Academy program's implementation in a high school with a significant proportion of students from minority backgrounds addresses the critical need for greater ethnic and gender diversity in science and medicine (Match Charter Public School, n.d.).

3 Learning objectives

The structure of the Anatomy Academy curriculum benefits both the HS students that go through the program and the UPE/UME students that create the curriculum and teach the program. Thus, there are learning objectives for both the HS students and the UPE/UME students.

HS student learning objectives

- 1 HS students will develop increased awareness of health and confidence in a clinical setting.
- 2 HS students will have opportunities to develop their self-efficacy with regard to increased knowledge of careers in medicine that inform an interest in exploring and pursuing healthcare careers.
- 3 HS students will become proficient at basic patient intake interview skills.
- 4 HS students will be able to describe the basic conceptual physiology of common diseases that family members and friends can understand.
- 5 HS students will reinforce foundational human anatomy concepts taught in their regular school curriculum.
- 6 HS students will demonstrate best practices for starting and maintaining a healthy lifestyle (e.g., vaccination, hand washing, visiting a PCP, smoking cessation).

UPE/UME student learning objectives

- 1 UPE/UME students will apply their knowledge and understanding of scientific principles taught in their program curricula.
- 2 UPE/UME students will increase in confidence of bedside manners and patient interviewing skills as a result of teaching HS students foundational patient interaction techniques.
- 3 UPE/UME students will have greater confidence in performing physical exam maneuvers after teaching foundational maneuvers to HS students.
- 4 UPE/UME students will create curricula for the HS students that they teach based on their knowledge and understanding of scientific and physical exam skills.

4 Experiences to date

4.1 Incorporating UPE/UME student experiences into the design of a curriculum

The highest-order level of thinking in Bloom's Taxonomy – Create – involves reorganizing ideas and elements into new

structures to synthesize original ideas, projects, and/or solutions. This level of engagement leads to enhancements in problem-solving abilities and preparation for real-world challenges. Currently, the literature on creation opportunities in a curriculum predominantly documents instances of students generating question repositories, or presenting knowledge in alternative media formats (van der Vleuten and Swanson, 1990; Feijóo-García and Gardner-McCune, 2019). However, the benefits of such products are often limited to the boundaries of the institution's student body and faculty. For instance, supplemental practice question banks primarily improve the course for instructors and future cohorts. In contrast, service-learning experiences offer UPE/UME students opportunities to create products that benefit local community members outside the school. These experiences are uniquely valuable to medical student education, as the affective faculties fostered through service-learning promote public health self-efficacy and cultural competence.

The UPE curriculum for healthcare classes varies by course and College, but all relevant courses focus on introducing pertinent basic anatomical and physiological concepts to students, rather than developing patient interviewing skills and survey medical careers. Thus, when UPE students help develop the HS Anatomy Academy curriculum, they also gain a unique opportunity to explore the relation of concepts in human biology to medicine. The incorporation of peer tutors, interactive sessions, and clinical relevance into the Anatomy Academy curriculum aligns with recommended best practices for optimizing anatomy instruction, scaled down to a high school level (Baker, 2022).

The primary pre-clinical course for UME student instruction at BU Chobanian & Avedisian SOM is the Principles Integrating Science, Clinical Medicine, and Equity (PISCES), which features three foundational modules followed by eight systems-based (e.g., cardiovascular, neuro/psych) modules. Longitudinal threads that include oncology, infectious disease, anatomy, microbiology, pharmacology, and pathology, as well as the school's health equity curricular themes are woven into the modules. The preclinical curriculum, called the Advanced Integration in Medicine, focus on integrated cases based on the BU Core patient presentations organized by clinical areas and disciplines (Chobanian and Avedisian SOM Curriculum, n.d.). PISCES employs a flipped classroom andrological design and an instructional approach through Case-Based and Team-Based Learning that teaches the thought process of diagnostic schema.

The HS Anatomy Academy program mimics the college and medical school educational environment; therefore, the HS students are taught foundational knowledge through pre-class work, and in-person instruction provided by UPE/UME students is dedicated toward guiding the HS students through mock or real anonymized patient cases from initial presentation to discharge. This instructional style helps prepare the UPE students for future medical school instruction, and the UME students for their clerkship years by helping them reason through the clinical decision-making that they will use via teaching. The process for all students promotes cognitive operations at higher levels of Bloom's Taxonomy, transitioning students from Remembering and Understanding (pre-class work) to Applying, Analyzing, and Evaluating (in-class patient cases), and finally to Creating (the HS curricula).

4.2 Outreach/service-learning that improves public health self-efficacy

We illustrate the creation of the HS Anatomy Academy curriculum as an example of how UPE/UME students at any institution can reinforce the concepts they are learning in classes through the creation of a product that benefits a community's public health self-efficacy.

Modeling UPE courses that provide an overview of key topics in healthcare, and the instructional approach utilized in PISCES, UPE/UME introduced a new organ system in each weekly session to the HS students at MCPHS. The depth of material was adjusted accordingly to the developmental understanding of HS students. We applied a four-part framework to each session to maintain course consistency. In each class, students were introduced to one new disease, one new diagnostic technique, one new physiological concept, and one relevant treatment, management, or prevention strategy. This incremental presentation of new information was designed to minimize cognitive load on the HS students, freeing more bandwidth for reviewing and reinforcing previously covered material.

HS Anatomy Academy also employed a case-based instructional approach, first introducing students to a patient case, followed by pertinent physiology and covering management of the condition last (Figure 1). This approach aimed to enhance student engagement, especially since the hour-long sessions were held after a full day of regular classes. Educating students about their health and promoting health consciousness is one of the core goals of the program; thus, sessions begin with the aspects of medicine likely to be most interesting and engaging for the HS students. At the conclusion of each session, relevant physiological concepts were presented and connected to the material taught in their core science classes. Therefore, the UPE/UME students coordinated their curricular creations with both the MCPHS science and BU Chobanian & Avedisian SOM preclerkship curricula. The purposeful coordination educates HS students about medical diseases and reinforces their understanding of basic high school science. Additionally, the curriculum introduced students to healthcare careers and stimulated their interest in the medical field specifically.

In a typical one-hour session, students engaged with a mock patient presentation through an interactive actor session. Groups of approximately three HS students and two UPE/UME mentors

simulated a clinical encounter, with one UPE/UME student acting as the patient and the HS students taking on the role of healthcare providers. The other UPE/UME student assisted in guiding the history-taking process. After this interactive session, the class reconvened, and the UPE/UME students reviewed the key history points gathered during the acting session. They then provided a brief interactive lecture in which the new physiology, diagnostic, treatment techniques for the session are introduced (Figures 2–4). All HS-UPE/UME interactivity were monitored by teachers and approved by faculty advisors of BU Chobanian & Avedisian SOM.

Throughout the presentation, HS students were engaged with open-ended questions designed to stimulate critical thinking and apply clinical information to the case. Example questions include: “Do you think it’s normal to hear crackling when you listen to someone’s lungs with a stethoscope?” or “Have you heard of an infectious disease doctor before?” Additionally, multiple-choice questions, modeled after medical student board exams, were posed to reinforce the material covered in the presentation (Figure 5). These questions were tackled in small groups, aiming to solidify the students’ understanding. Each learning session also included at least one hands-on activity to further retain HS student engagement while encouraging them to draw connections between the information presented and real-life disease management. For example, HS students were asked to create a working model of the lungs out of a balloon and a water bottle.

Full slide decks from the pulmonary and the infectious disease lessons are provided as [Supplementary materials](#).

To further enhance the HS students’ medical reasoning and exposure to clinical skills, three of the ten HS Anatomy Academy sessions per academic year were held at the Clinical Skills Simulation Center (CSSC) at BU Chobanian & Avedisian SOM. UPE/UME mentors met with the HS students at MCPHS and accompanied their commute to the CSSC via on-campus shuttles, a transportation solution that incurs no cost to MCPHS nor the UPE/UME mentors.

The CSSC is equipped with adult auscultation mannequins capable of producing normal and abnormal cardiovascular and pulmonary physical exam sounds, as well as functional patient exam rooms fitted with exam tables and aneroid sphygmomanometers. During the HS Anatomy Academy clinical skills sessions at the CSSC, groups of approximately four HS students and one UPE/UME mentor rotated between exam room stations dedicated to specific physical

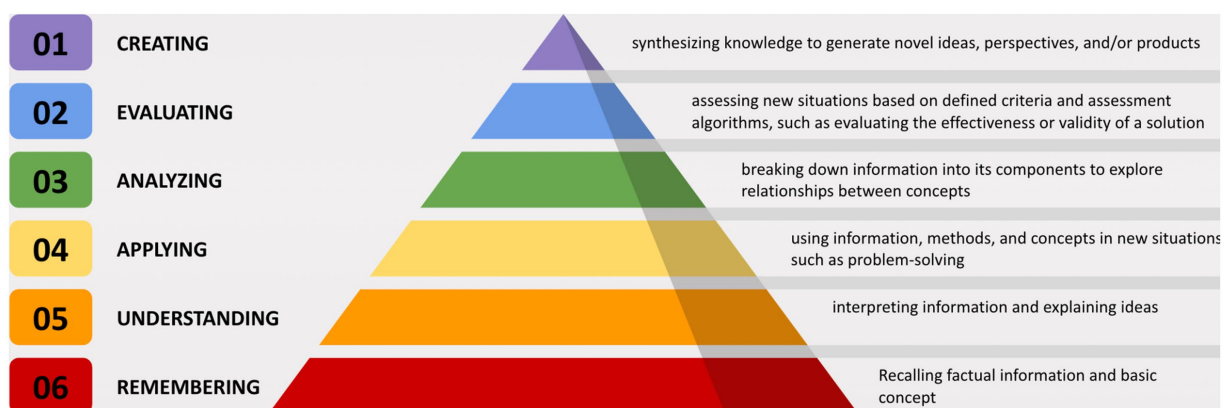
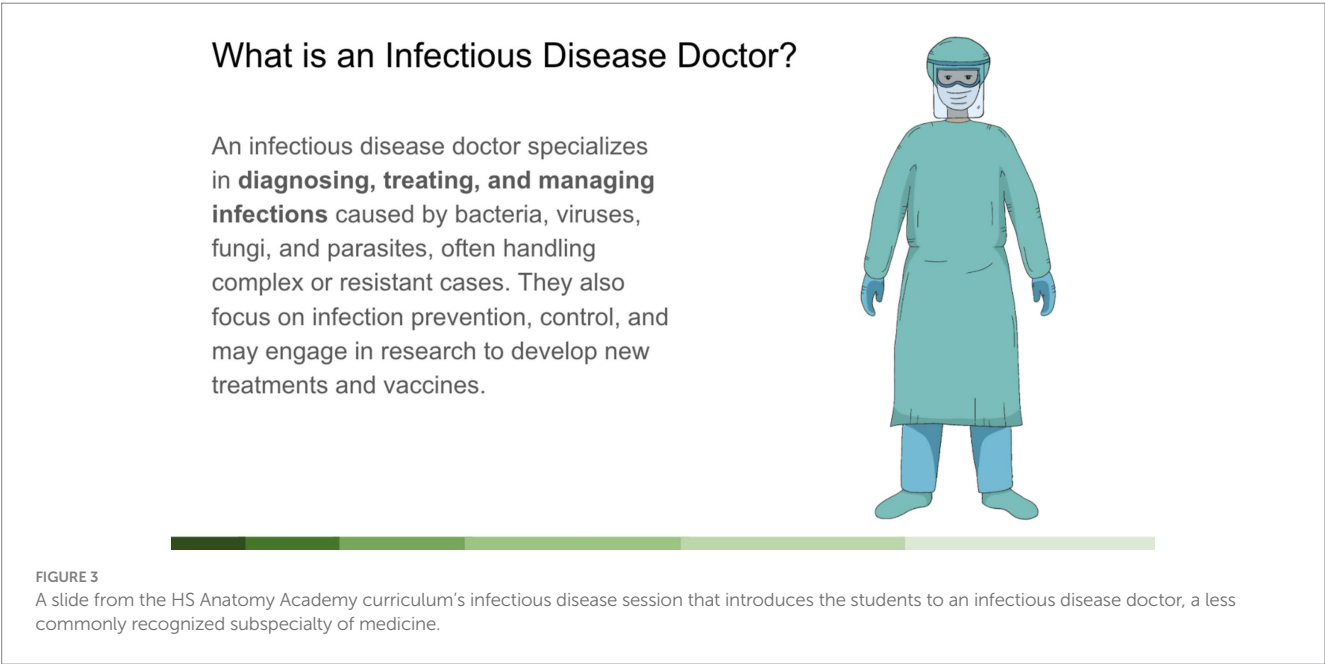
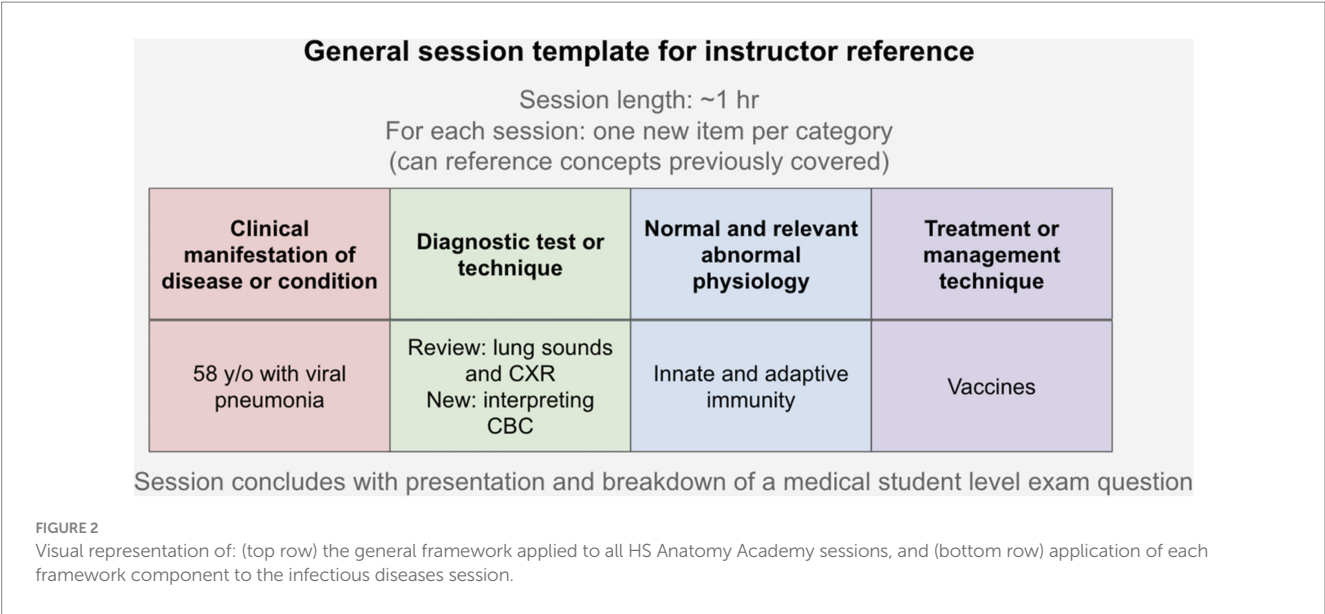


FIGURE 1
Visual representation of the six levels of the cognitive domain of Bloom's Taxonomy.



examination skills, such as cardiovascular auscultation, blood pressure management, and patient intake interviewing. Through these interactive activities, UPE/UME mentors reinforced their own patient care skills taught in their preclinical curriculum by teaching HS students the foundational bedside manner and examination maneuvers used in primary care settings.

4.3 Alignment with recommended quality assurance standards

The HS Anatomy Academy curriculum aligns closely with key recommendations from well-regarded literature on curriculum quality assurance, including the 2022 FIP Global Framework for Quality Assurance of Pharmacy Education (Chung Sea Law, 2010; Ebel et al., 2019; Meštrović et al., 2022; Ibad, 2024):

- 1 Anatomy Academy employs competency-based education by designing sessions that introduce a new disease, diagnostic technique, physiological concept, and management strategy, which build both the foundational and applied knowledge of students incrementally. This alignment with the FIP’s emphasis on defining and systematically assessing competencies ensures that high school students gradually acquire essential health-related skills.
- 2 Anatomy Academy tailors the depth of instructional material to the developmental understanding of a high school audience. This aligns with the FIP’s recommendation for contextual relevance, which encourages educational content to be accessible and meaningful for learners at different stages.
- 3 End-of-class reflections among UME and UPE mentors, along with formal assessments at the conclusion of the academic year,

Diagnostic Testing

You listen to Thomas' lungs and hear **wheezing** when he breathes out.

You decide to order a **chest x-ray** to further examine Thomas's lungs.

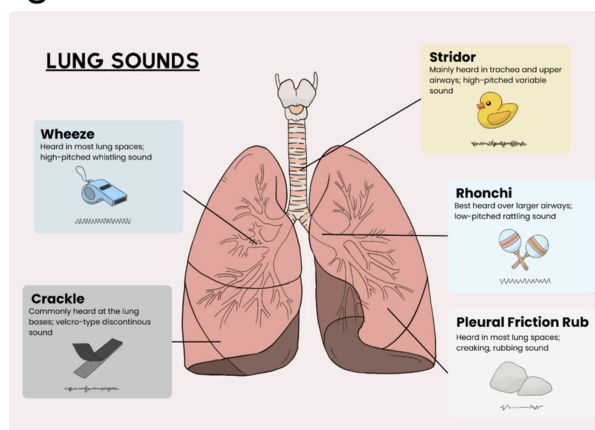


FIGURE 4

A slide from the HS Anatomy Academy curriculum's pulmonary session that introduces the students to basic anatomy and physiology of the lower airway from a clinical perspective.

Mike, a 52-year-old man with hypertension, developed mild symptoms of COVID-19, including a low-grade fever, cough, and body aches, two months after receiving his second dose of the COVID-19 vaccine. Despite testing positive for SARS-CoV-2, his symptoms remained manageable at home, with no significant breathing difficulties or need for hospitalization. Which of the following is **the least likely** factor that may have contributed to Mike getting COVID-19 despite being vaccinated?

- Vaccine effectiveness wanes over time
- He may have contracted a different variant of COVID-19 than the one in the vaccine
- Mike may have not had a strong immune response to the vaccine
- The vaccine is typically ineffective after 2 months

FIGURE 5

A slide from the HS Anatomy Academy infectious diseases presentation displaying a mock UPE/UME student-level exam question. The UPE/UME mentors will help the HS students dissect the question stem line-by-line and walk students through understanding each answer choice.

demonstrate a commitment to the FIP principle of continuous improvement and are elaborated upon in Section 4.4.

- The program exemplifies FIP's call for stakeholder involvement as it involves coordination among local educational institutions (MCPHS and BU Chobanian & Avedisian SOM) to align content with both high school science and medical preclerkship curricula. This collaborative approach not only ensures curricular relevance but also fosters global collaboration, with potential for scalability and adaptation by other institutions.
- The incorporation of clinical skills training into the curriculum demonstrates an integration of technology and innovative teaching methods, another FIP priority, by utilizing simulation techniques that promote active learning and student engagement.

In summary, the HS Anatomy Academy curriculum exemplifies several FIP recommendations for enhancing quality in education, particularly through competency-based, contextually relevant, and continuously improving teaching methods that are responsive to the needs of students and communities alike.

4.4 Future directions

The quality of the HS Anatomy Academy curriculum will be assured and assessed through progressive monitoring of the HS students' learning, monthly discussions between the program directors and UPE/UME mentors, and a formal narrative analysis at the end of the 2024 academic year. Additionally, as informal

progress assessments of the curriculum, UPE/UME mentors involved in teaching a session meet for 10 min at the conclusion of class to discuss HS student learning and engagement throughout the session. The mentors will share how students learned and retained information throughout the session, and which activities promoted their learning. Such preliminary results will help fine-tune the curriculum as it executed during its debut year. For instance, if the HS students are not able to engage effectively with the multiple-choice questions embedded in the session presentations because they are too difficult or too easy, questions for future sessions will be modified accordingly.

Additionally, we will formally assess the program's efficacy in meeting our learning objectives for both the UPE/UME mentors and HS student mentees via a mixed-methods approach. Mentors and students will respond to surveys involving a combination of Likert-scale questions and free text (please refer to the [Supplementary materials](#)). The UPE/UME mentor survey will evaluate the mentors' perceived impact of their involvement with HS Anatomy Academy in their confidence in recalling medical knowledge, explaining medical concepts to patients, and bedside manners. The HS student survey will evaluate the student's perceived impact of their HS Anatomy Academy experience in their confidence in recalling medical knowledge, explaining medical concepts to family and friends, and understanding of healthcare career avenues. We will carefully review the results of the surveys and make adjustments to our program as needed.

5 Discussion

It is established that encouraging learning engagement beyond the levels of Remember and Understand into Apply, Analyze, and Evaluate along Bloom's Taxonomy yields a greater understanding of the material ([Thompson and Lake, 2023](#)). Similarly, the value of service-learning opportunities for medical student education is already well documented. Service learning has been shown to not only increase medical students' sense of social responsibility, but also volunteerism has been shown to have a positive effect on medical students' grades and USMLE scores ([Blue et al., 2006](#); [Meili et al., 2011](#)).

Unfortunately, opportunities to reinforce knowledge and understanding of preclinical undergraduate and medical school courses at the Create level of Bloom's Taxonomy are uncommon, and the vast majority do not involve service learning. For instance, the Mohammed Bin Rashid University of Medicine found increased student satisfaction and perceived depth of knowledge upon completion of a program in which preclinical students generated weekly formative multiple-choice practice questions for each other. However, the results were based on subjective measures rather than objective student performance on an end-of-module assessment, and the program does not provide any benefit to individuals or communities outside the academic course ([Lakhtakia et al., 2022](#)). Such limitations are echoed by medical and non-medical programs at other institutions, in which the student-generated products primarily serve the academic community they emerge and thus align better with curricular improvement initiatives rather than community outreach ([Zurcher et al., 2016](#); [Sibomana et al., 2020](#)).

Meanwhile, a longitudinal service-learning program developed by Baylor University offers avenues for students to positively impact local communities by connecting participants with a network of approved

community sites curated by the program directors, spanning various social determinants of health from food insecurity to incarceration. However, the program is primarily focused on helping students gain exposure to the structure and operation of community programs, rather than Create a novel product or idea to help serve the communities being addressed ([Wong et al., 2022](#)).

An earth sciences outreach program conducted by Louisiana State University (LSU) was among the only studies we encountered that included both Creation and service-learning opportunities. In the program, LSU undergraduates create presentations on volcanoes for K-12 students to enhance the grade students' understanding of the topic. However, impact on the K-12 students was determined subjectively and indirectly via focus group interviews with the K-12 instructors. Furthermore, it was only predicted, not determined, that the creation opportunity for LSU undergraduates would lead to improved retention and understanding of materials ([Nunn and Braud, 2013](#)).

The HS Anatomy Academy curriculum described in this paper provides a model opportunity to merge service learning projects with the Create level of Bloom's Taxonomy for the preclinical and premedical undergraduate fields. Developed according to the unique needs and requests of MCPHS students, our materials expand on the model employed at LSU by supplementing presentations of anatomy and physiology with hands-on learning with elementary skills in patient examination, mock patient interviews, and discussions of healthcare professions. Furthermore, higher-order learning can be motivating to prime future healthcare professional generations to Create at earlier stages in their career journeys, which will benefit both student academic growth and their broader communities.

While evaluations of the Anatomy Academy program described in this paper are presently being conducted, based on existing research surrounding Bloom's Taxonomy and service-learning programs we predict that this curricular model will be more effective than other service learning programs in deepening the understanding of taught materials for both the HS and UME students involved in the program. Other universities and health professions schools may consider implementing our dual learning model for their community partnerships.

Data availability statement

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

Author contributions

AS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing. MT: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing. SA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. KC: Data curation, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing. JW: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration,

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The HS Anatomy Academy curriculum is a collaboration between UPE students at BU CRC and UME students at BU Chobanian & Avedisian SOM, tailored to meet the needs of a high school located in the same city. It is only one instance of such a system; since each institution and surrounding environment have unique characteristics, the logistics of implementing outreach/service-learning opportunities with options for volunteers to engage in creation of curricula will vary based on specific community needs and other location-specific factors. However, the general approach can be applied at any

undergraduate and health sciences institution, with the instructional materials tailored to high schools, grade schools, or community members at large.

Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1446513/full#supplementary-material>

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Evaluating the implementation of a community engaged telehealth based intervention to improve health equity for the unhoused

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Unhoused individuals experience numerous barriers to healthcare access and higher morbidity and mortality rates than housed individuals. In collaboration with community-based organizations (CBOs) and healthcare profession learners we developed a program involving in-person and telehealth visits at a CBO clinic and via street medicine outreach to address healthcare needs of the unhoused in a small Southeastern city. In its fifth year of operation, from January through April 2024, we evaluated the program using key stakeholder interviews (patients, CBO staff learners) guided by the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework. A template analysis approach was utilized to evaluate barriers and facilitators to implementation outcomes. Results demonstrated consistent themes across stakeholders. Factors central to reach included advertisement by word-of-mouth, location convenience, and perceived service benefits. For learners, barriers to reach included clinic hours conflicting with academic schedules and apprehension of providing medical care in this setting. Regarding effectiveness, facilitating themes included opportunities for autonomy and enhanced understanding of treatment of underserved populations (learners) and improvement in health (patients, CBO staff). There were no consistently identified unintended negative consequences of the program. For adoption, all stakeholders described strong perceptions of trust in providers and the importance of team communication and coordination of care, in addition to the need to add disciplines included in the multidisciplinary care team. Facilitating implementation themes included comprehensive access for existing patients, while barriers identified were adequacy of access to social resources (housing, food, transportation) and continued increase in numbers of unhoused individuals outpacing available services. Themes facilitating maintenance included continued outreach efforts and integration into existing healthcare and community-based systems. The addition of additional services and specialties was consistently identified as essential to health status of the patients and an opportunity for growth of the program. This implementation evaluation involving key stakeholders of a community engaged telehealth-based intervention for the unhoused provides thematic considerations to guide program implementation and sustainability to improve health equity for vulnerable populations.

KEYWORDS

unhoused, homeless, dissemination implementation, telehealth, healthcare access

1 Introduction

The Institute of Global Homelessness defines homelessness as people without accommodation (sleeping in open or roofed spaced not meant for human habitation), those living in temporary or crisis accommodation (shelters, camps), and those living in severely inadequate and insecure accommodation (temporary sharing with others, overcrowding) (1). Approximately 1.6 billion people worldwide lack adequate housing (2). Unhoused individuals are at significantly higher risk of numerous, complex health problems leading to higher morbidity and mortality than housed individuals. Due to the living conditions of the unhoused, whether living on the street or in a shelter, this population is prone to encounter multiple health risks and negative health outcomes including but not limited to exposure to communicable diseases, poor nutrition, as well as psychological stressors (3). Increased morbidity and mortality are multifactorial but includes higher incidence of chronic medical conditions including cancer and heart disease as well as substance use disorder (4). The unhoused also have high-cost healthcare utilization patterns including lower ambulatory care use and higher emergency department use and hospitalization (5). There are various barriers that contribute to the complexities of providing healthcare to unhoused populations. Common healthcare barriers affecting health care access for the unhoused include unaffordable cost of care, being uninsured, and little to no transportation to obtain health services (3). In order to address the barriers to healthcare access for those who experience homelessness, it is imperative to present accessible health care services that target the needs of this population in order to reduce morbidity and mortality rates (6). Thus, innovative methods of care delivery are key to reaching this population. Utilizing telehealth has been proven as an important factor to help connect vulnerable populations to health care and eliminate barriers for those who are unable to obtain appropriate health care (7, 8). Programs which deliver telehealth to the unhoused are most successful when there is collaboration between agencies for arrangement of health services to meet patient needs (7, 8). Telehealth as a mode of delivery has proved to be effective in providing healthcare access for Veterans experiencing homelessness, with telehealth tablets being used to overcome health and travel related barriers (7). However, there are limited published implementation evaluations related to telehealth delivery in the unhoused population. The Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework is used to evaluate program implementation by assessing program internal and external validity to enhance the sustainability and generalizability of interventions. It is a useful tool for these evaluations as it can guide modifications or replications of effective interventions and is practical for local settings while focusing on the multi-dimensional impact related to population health outcomes. Its components include Reach (program contact with target population), Effectiveness (impact of the program on outcomes), Adoption (willingness of relevant individuals and groups to initiate the program), Implementation (consistency of programmatic elements with the intended program including resource utilization and adaptations), Maintenance (integration of the program into routine practice) (9). The RE-AIM framework has previously been utilized to evaluate telehealth within primary care during the COVID-19 pandemic as well as implementation of telehealth in oncology (10, 11). This framework has also been applied to the use of telehealth in the unhoused population to investigate the effectiveness

of various delivery models of primary care to people experiencing homelessness in England (12). The RE-AIM framework has demonstrated efficacy in these evaluation contexts.

2 Context

The CARES for the Unhoused program (CFU) serves the unhoused and those with unstable housing in Charleston, South Carolina, a small Southeastern city with limited infrastructure supporting the unhoused community including lack of Medicaid expansion leading to a significant number of uninsured individuals. CFU provides over 500 primary care visits for more than 250 unique patients each year with a demographic makeup (Table 1) that is mostly male (64.1%) and disproportionately African American (39%) compared with the South Carolina population (26%) (13) and predominantly uninsured (70.9%). CFU treats acute and chronic conditions and offers preventive care and specialist referrals as needed. The most common diagnoses treated are musculoskeletal conditions (22%), mental health conditions (21.7%) and cardiovascular conditions (21.3%). The program operates in partnership with two community-based organizations (CBOs) serving the unhoused and their respective staff social workers. Two attending family medicine physicians at the Medical University of South Carolina (MUSC) lead our program and oversee healthcare profession learners that include

TABLE 1 Demographic characteristics of patient population.

Variable	Frequency	Percentage
Sex		
Male	143	64.1%
Female	80	35.9%
Race		
Black or African American	87	39.0%
White or Caucasian	109	48.9%
Other	5	2.2%
Unknown	22	9.9%
Ethnicity		
Hispanic or Latino	2	0.9%
Not Hispanic or Latino	190	85.2%
Unknown	31	13.9%
Age		
0–17	4	1.8%
18–39	50	22.4%
40–59	114	51.1%
60 and up	55	24.7%
Insurance		
Private	11	4.9%
Medicaid/Medicare	54	24.2%
Uninsured/Self-Pay	158	70.9%

approximately 20 family medicine and internal medicine resident physicians per year and more than 100 MUSC medical and pharmacy students.

3 Key programmatic elements

Our program consists of three arms: (1) in-person visits at a CBO, (2) video visits at a CBO, and (3) street medicine outreach with CBO staff. For our clinic in-person and video visits we partner with The Navigation Center (TNC) which is a full spectrum drop-in social resource center focused on those experiencing homelessness. TNC provides physical clinical space to conduct visits. For telehealth visits, pre-professional students are in-person at TNC and facilitate visits between patients and remote attending physicians. For street medicine outreach, MUSC physicians and learners partner with TNC, the local homeless shelter (One80 Place), the Department of Mental Health and Emergency Medical Services. In person clinic and street medicine visits are conducted by resident physicians with either in-person oversight or tele-precepting. Tele-precepting is when a remote attending physician supervises healthcare profession learners that are in the same location as the patient, incorporating audio and video interface via cell phone, tablet or computer. The Doxy.me HIPPA compliant platform is used for video visits and tele-precepting on a laptop or tablet for both clinic and street medicine. Over 150 learners participate in the program annually. The program hours are 9 AM-5 PM every Tuesday and Thursday, a schedule developed with input from all stakeholders. Each day of clinical operations consists of a combination of each of the three visit types, with proportions based on the needs identified that day.

Our team completed a qualitative implementation evaluation of the CFU program using the RE-AIM framework measuring Reach, Effectiveness, Adoption, Implementation and Maintenance (9). This study was recognized as Quality Improvement by the MUSC IRB. Key stakeholder interviews were completed from January 2024 to May 2024 with patients ($n = 9$), CBO staff ($n = 3$) and learners ($n = 7$) to gain multidisciplinary perspectives on program moderators. Key stakeholders that were invited to participate were identified for CBO staff based on current staff members working in collaborating CBOs that had interacted with the CFU program. Healthcare profession learners were identified by having volunteered with the program in the past year. Patients were identified by having been seen for a medical visit by the program in the past year. Patient interviews were conducted by medical students that were not part of the healthcare team. Other key stakeholder interviews were conducted by a research coordinator not involved in program implementation. Interviews were completed in patient care sites including at the community organization facilities and street medicine outreach sites as well as virtually and lasted from 5 min to 30 min. All interviews were transcribed verbatim. Two trained coders utilized a template analysis approach (14, 15) in Microsoft Word, with an initial codebook derived from the RE-AIM framework to code the first set of two interviews. Template analysis utilizes a structured (“template”), yet flexible coding process for analysis of qualitative data. Since the interview guides in this study were based on the RE-AIM framework, template analysis allowed researchers to utilize an *a priori* template, based on the domains of the RE-AIM framework, while also allowing codes to be updated in the coding process. The codebook was updated in a

dynamic fashion, allowing additional codes to emerge from the data. After each round of coding, code definitions were refined and coding discrepancies between the coders were discussed to arrive at consensus. After coding was completed, themes were summarized and compared by role (patients, CBO staff, learners).

4 Discussion

An implementation evaluation of the CFU program was conducted using key stakeholder interviews including healthcare profession learners, CBO staff, and patients seen in different care settings to identify barriers and facilitators to reach, effectiveness, adoption, implementation and maintenance, based on the RE-AIM framework (9). Interview themes were similar by role and identified barriers and facilitators to implementation outcomes of the program, based on RE-AIM. See Table 2 for illustrative quotations. Identified program moderators can be utilized to enhance future adaptations of medical programs for underserved, vulnerable populations.

4.1 Reach

4.1.1 Opportunity to improve reach

Optimizing reach, and in this case the number of individuals served by a program, is central to maximizing positive impact. Patients within the CFU program were seen both at TNC and in the unsheltered community locations where they reside. Patients reported initiating participation in the program following hospital admission, being brought to TNC by someone, and having an outreach provider approach them. Patients suggested opportunities to improve reach by recruiting new patients including creating and promoting more awareness of the program via word of mouth, providing handouts, being present at events that provide meals, and visiting additional areas where the target population lives (parks, etc). CBO staff described the importance of encouragement and trust in reaching more patients and treating patients with high levels of respect to establish rapport. The importance of collaborations with other organizations that support this population was also a strategy suggested to reach more patients.

Strategies to enhance reach to recruit more learners (students, residents) included education on the positive learning effects of the program and future clinical career benefits. This increased awareness could be accomplished during orientation activities, and by ongoing informational flyers, email communication from medical university program directors, word of mouth from other residents and students that participate in the program, and communication from an appointed liaison between CFU and the medical university.

4.1.2 Facilitators/barriers to reach

Patients conveyed the need to have an innate desire to receive medical care, as someone that is averse to receiving medical care or adhering to medical recommendations will be difficult to reach. People who use substances and those with communicable diseases were mentioned as subpopulations that may be particularly difficult to reach due to fear of stigma associated with these conditions and concurrent patient reluctance to receive care. However, it was suggested that building rapport with these patients has proven

TABLE 2 Exemplary quotations by RE-AIM domain.

Themes	Patient	Learner	Community stakeholder
Reach			
Opportunity to improve reach	“Awareness is a big one...” “The people will come to where you are...instead of moving all over...Get one, get a couple of areas where they know you are going to be at certain times. Then they’ll come to you. The ones who want the help, you know...”	“...selling it as something that does help...just to know the community better and know what we can offer patients would also get people more interested, apart from just the pure volunteerism of it. It also has practical implications for our practice.” (resident)	“I think just trying to encourage [patients] for their general wellness...” “...many times, as long as it’s somebody I’ve built rapport with and I trust, they’ll allow me to bring a doctor out. We operate under the assumption that it is them allowing us to provide care to them.”
Facilitators/barriers to reach	“They have to want it. Drugs is the issue for most homeless people, alcohol; they do not want to give it up. Cannot be helped. You have to help yourself.” “Coming here, knowing I do not want to go back to the life I was living, these people really helped change the path I’m on....”	“I think a lot of people hear street medicine and fear, what are they putting themselves in the middle of, Is it going to be dangerous? Am I going to be interacting with potentially dangerous people?” Because I think so many people in the medical student position just have not had exposure to this community.” (student)	“Sometimes we get a tip from other people in the community that something more severe might be going on...then there’s more trust to be built...A lot of times, it’s communicable diseases. There’s a lot of shame and stigma especially with HIV. Despite a lot of resources and a lot of great people working in that field right now, it can be really tough to accept that help, especially when you are so vulnerable.”
Effectiveness			
Perceived benefits	“I enjoyed it. They talked to me and, you know, advise, get me to understand what’s going on here. They help me a whole lot.” “...the just reliability of it. I know every time I come here they are going to see me and they are going to help me.” “It has gone from helping me get off of an addiction to physical ailments, to my mental wellbeing.” “...if you reach out for help, you have got to try your hardest to listen to them and do what they [say]...they are here to help you, not hurt you.”	“It’s definitely a rewarding experience... personally fulfilling and made me feel like my job was making a difference and that I was having some purpose.” (resident) “...I’m seeing a direct impact of what I’m doing and how I’m caring for people who otherwise would not have had a way to get that care.” (resident) “The program has completely shaped me into a wonderful, well-rounded physician... every single one of my attendings are super positive and love to teach.” (resident) “...it has allowed me to remember why I wanted to go into healthcare.” (student)	“They know they have a place to come to and get some of the immediate needs they need, or at least to be able to talk to somebody, to check in. The clinic, obviously, is amazing, and then our peer support that we have with mental health and then the mental health services we have...It’s quite welcoming, I think, to meet them where they are.” “It’s providing really necessary healthcare for people who have limited access to it. So, it’s a really huge impact.”
Unintended consequences	“...no negative. Every time I come here the staff and the Center’s very helpful.” “No, it has not had any negative. It’s all been positive to me. If you want it, you have got to work with it, too.” “...at first a little negativity...But after a little while all that just fell out the way. Being street people, you are going to hear different things about [different people]. And that can put some negativity on someone who is really trying to help you.”	“The only negative thing that I witnessed or I’ve heard about is some people feel unsafe going to the homeless camps, which I think that has been addressed.” (resident) “Maybe being exposed to things that are negative, but that just happens any time you are in a patient encounter that if they have hard things going on.” (student)	“We cannot keep up with all of the requests. A lot of the calls that are coming in, we can only do so much, and that, to me, is a negative, that we cannot keep up with the pace of the folks...we are not able to meet all of the needs and all of the people that want help.” “Sometimes, it can get rough here, but most of the time you just have in your head that this is their unfortunate journey, and we just have to be there and support them, and we pray for them.”

(Continued)

TABLE 2 (Continued)

Themes	Patient	Learner	Community stakeholder
Opportunity to improve efficacy of care	“Maybe coming out more often.” “...just more resources...” “...add a little more volunteers to [the program].”	“There was a lack of testing and labs and medications sometimes...the tangible resources would probably be the one limitation.” (resident) “If we had more information up front...I did not have any idea what I was getting into...more up front education about what kind of issues we would be seeing might better set us up for success...” (resident) “Exposure...you just have to go in with an open mind and be exposed. I do not think there’s any other way to build confidence in this type of population without being around this type of population.” (resident) “At the very beginning I was nervous, not really knowing what to do and what to expect and where my role would be. After going a few times, I know what should be done, what’s expected.” (student)	“We need a clinical social worker, actually, so I would say funding would be the biggest need right now for us so that we can have those folks in here, helping us support those efforts to keep up with the pace.” “I have often found that if I have a patient need, [the program] will always get somebody there. So, the number of patients I have found to be no barrier at all. We’ve gone into very large camps [to see patients]. There’s always been time to see, upwards of 10 people living in an encampment.”
Adoption			
Patient-provider communication	“... the team was great and everything. Very informative, and, you know, you have got to listen completely all through it, you know? If you have got any questions, you have got to clarify it...they’ll give me an honest answer.”	“I think how important it is to build rapport with that patient population... it means so much more when you actually see them and you talk to them and when you remember their names, what kind of impact that has on them.” (student) “This community tends to be wary of outside people coming in because you do not know someone’s motives or intentions when they are coming into your space...Authority figures can be threatening ...I’ve been really impressed and surprised by the relationships that the staff involved in the clinic have been able to foster, to where [communication] has not ever been an issue.” (student)	“It’s a very unique circumstance to be able to interface with people who are in the situation that they are and not see them as that situation, but to see them as a human and treat them with dignity and respect.” “...it’s about building that rapport with them. The families love [this program]. I mean, I would love to expand that.”
Team communication	N/A	“The closed-loop communication is good, even if borderline redundant, I feel like it makes it more effective.” (resident) “I think students have to be comfortable with trying things and knowing that you are not immediately going to be good at them, but that’s why you have residents and others to assist. As long as students are encouraged and willing to ask questions, that’s the biggest thing, is just being willing to do and being willing to ask.” (student)	“The key to the success of what we do is that we are case-managing alongside the doctors and even mental health... We want to know what’s going on.” “You need to be prepared to have each other’s [team members] back...building that team trust is huge. So... working with folks that you come to know and come to trust in situations that can change very rapidly, obviously. It lets everybody do better work.”
Trust	“I always talk to [the program lead doctor]. If there’s an issue, I’ll bring it up, but I think she knows everything going on with me, so I do not have concerns. I do not know how she got involved on this level, but she did, and I’m grateful for that. And I will not do anything other than [what she says].” “I trust them...that’s why I come down here. But it’s up to me. And I know they are here on certain days. It’s up to me to get here.”	“...the openness of everyone there and just how much everyone trusted the program, I think would be the biggest things that surprised me...” (resident) “I think the teaching skills of the medical team have been phenomenal...they have been very helpful and very willing to ask questions and teach as needed without being overbearing.” (student)	“I love the way the residents are eager to learn. Some of them are deer-in-headlights. I can see it’s kind of scary sometimes, but it’s great to see compassion of these young doctors-to-be that want to help and be there, and eager to help a lot of folks that we have here.” “The way that rapport is built and maintained through street medicine, trust is huge. We’re going into where people live, often in very vulnerable situations.”

TABLE 2 (Continued)

Themes	Patient	Learner	Community stakeholder
Coordination of care	“...you do not have a car [to seek medical help]...I can understand how the various services come together and work together and you have a social worker and [other staff]. So I’m appreciative of it, and I do not want to abuse the system in any kind of way...getting my seizure medication is important.”	“We are all very cohesive and work well together...” (resident) “...the street psychiatry aspect is important...Once I wanted to go out in the afternoon [to see patients] and then we had people from the local mental health centers coming out with us...that was an excellent opportunity.” (resident)	“Even on odd hours, I’ve been able to get hold of someone for a quick text consult or telehealth link so we can make sure we are getting access to care. It’s nice to have a deep bench of available people. Medical students coming into the field doing eye tests is incredible to add onto doctors and residents doing care. It’s nice to be able to go out and offer a full range of services.”
Implementation			
Access	“Anytime I’m not feeling good, I come and the door’s open and they give me a time to come back to recheck me and everything.” “And it probably cuts out a lot of emergency room visits for you guys. When people get hopeless, they have nowhere to go, then rely on the hospital.” “Maybe come out there more often. And people will know you. They can depend on you to be at a certain place at a certain time. That’s the only thing...”	“That’s what shocked me, we have a good amount of resources that we offer, it’s well set up, and we get people to close the loop so things do not get missed.” (resident) “...being part of this program I saw that there are more people than I thought that really do want healthcare, but there’s no means of getting it to them...some of my frustration was that sometimes I still struggle for pathways to get people help when they are having these resource limitations.” (resident)	“I do not think there’s anybody who has been actively wanting to see a provider that has been told they have to wait an amount of time...everybody that I’ve interacted with has gotten care fast enough that they have been satisfied.”
Follow up	“I got medicine I got to pick up now. They got the medicines that I need, but it’s up to the individual to go get the medicine...I got to come back here to get it tomorrow...so they help you get the medicine.”	“...it’s hard for people to get transportation to get labs. The majority of them even walk, or take the bus, and cost is a barrier, but we do our best to try to aid...the team [tries to] coordinate something.” (resident) “I had to run to the pharmacy and pick up some medications for people or another provider would pick up meds and we could distribute when we went out.” (resident)	“...being able to provide labs and imaging at low or no cost is great. It’s wonderful.” “...especially clients that do not have a phone, it can be nerve-racking for some ...they are afraid of going into a medical building for bloodwork....[the doctors are] great about getting costs down when needed, when things are too expensive we are able to cover some costs.”
Maintenance			
Factors promoting sustainability	“Just because it’s consistent and reliable and dependable...”	“It is well-integrated. It’s part of our curriculum...if it was more voluntary, I think you would not have that much exposure because our hours are so difficult.” (resident)	“...the team’s flexibility to go where we need them, when it’s best for the client.it puts the client back in the driver’s seat, which is something they do not get to experience a lot with how they are living.”
Outreach efforts	“...social work, from the aspect of helping people with housing and food.”	“...I would [work] with a clinical psychologist or psychiatrist, a behavioral health provider. That was super helpful...I think a wound care provider could be very helpful.” (resident)	“...[patients] live outside, they are doing something to survive, trying to build a shelter or something happens...twist a shoulder the wrong way, tweak a back, and then they get laid up in the tent for a couple of weeks until we come across them and try to get them some help... physical therapy would be helpful.”

successful in facilitating trust and ultimately delivering any needed health care. Patients reported a common barrier to expanding treatment reach included lack of transportation to complete diagnostic workups such as labs or imaging, which is challenging since often these specific services cannot be delivered to them in the setting in which they reside.

In discussing willingness to participate in the medical program, students reported a common barrier to participation is their general lack of education and experience with the unhoused community and population, leading to fear of providing care in a potentially dangerous situation. Residents and students also reported that participating in this program was at times challenging with their existing schedules and that incentives to volunteer could be favorable to eliciting more participation.

4.2 Effectiveness

4.2.1 Perceived benefits

Describing positive and negative outcome effects of an intervention, including potential impact on quality of life, is vital to the understanding of comprehensive intervention effectiveness. By defining individual differences in intervention effectiveness, strategies can be created as opportunities to improve intervention efficacy of care.

All patients expressed appreciation for the program overall and specifically for provider reliability and the ease with which they could receive care in the setting where they reside or were already receiving services, with no additional need for travel. Patients noted that the providers really listened to them and were concerned, caring, and understanding and identified these as essential components of care delivery. One patient explained that he knew the provider was trying to help, so he was motivated to do his best to do everything the provider suggested. Benefits of the program that were discussed included support to end a substance addiction, gaining access to needed medications, and improvements in mental and physical health. Patients described the program as “helpful and wonderful” and one patient described the improved quality of life experienced after this program as he stated his “perception of life has changed...”

CBO staff described some of the multi-faceted benefits of the program, most notably offering essential comprehensive health care for unhoused individuals, who have limited access to care. The care can be obtained quickly and is flexible since it is provided in the setting where individuals reside or at a CBO where they are already seeking social services. The program was described as providing a source of comfort to this population, which they do not often experience from their lifestyle. CBO staff also discussed the benefits of the program to learners, as they can gain experience with this medical setting and population.

Similarly, learners stated they were able to learn more about resources for the underserved and unhoused communities through participation in this program, allowing them to feel more “well rounded” in their career training. They described their role in the program as “rewarding and fulfilling” as it provided tangible reminders and motivation of their desire to help others and enforced the reasons they chose a career in the health care field. Learners enjoyed seeing the direct impact their participation had, as they were able to provide health care to those that may not otherwise have had

access to medical services. They also appreciated the welcoming and enthusiastic response they received from unhoused patients with whom they engaged. For learners, providing care to this population demonstrated gaps in health care services and encouraged one resident to commit to continue to consider these gaps and implications for health care policy in the future.

4.2.2 Unintended consequences

It is important to identify negative or unintended consequences of interventions to help devise strategies to overcome these negative effects and maximize intervention adoption and sustainability.

One patient disclosed that they felt some personal negativity related to the program initially, likely due to negative discussions with others. However, this patient reported their negativity quickly dissolved and was unwarranted as they learned the providers intent was to deliver beneficial medical care. All of the other patients reported no unintended consequences or negative effects from the program, while some additionally emphasized the positive and helpful aspects of the program.

One resident and one student both described safety concerns related to the setting of this program, although both agreed the medical university had recently addressed this by starting initial triage for setting safety with outreach workers familiar with specific unhoused community camps. The medical university program sponsors also emphasize the optional nature of visiting specific sites based on individual comfort level of learners. Similarly, one CBO staff member described the occasional “rough” setting in which care is provided on the street to this population. Yet, all stakeholders emphasized gratitude for the support the program provides to the unhoused population.

4.2.3 Opportunity to improve efficacy of care

Patients only discussed a few opportunities for improving the efficacy of program care, which included more frequent visits with providers and additional program workers to expand program scope.

CBO staff agreed that additional program workers would be beneficial, including a program specific case manager or social worker. While one CBO staff member stated that they have always been able to have the program provide visit patients when requested, it was agreed that to have capacity to treat the increasing patient case load and expanding community locations additional staff will be increasingly needed. Additional clinical private space for exchange of health information was also identified as a potential area of need.

One healthcare professional learner discussed the program could benefit from additional resources (availability of on-site lab testing, affordable medications) to meet the increasing patient case load and complex medical needs. Other learners described the need for additional initial education prior to working with the unhoused population to have a more clear understanding of the unique challenges this population experiences, including basic education on housing infrastructure, medication costs, insurance, and addiction treatment. Efficiency challenges with EMR documentation related to lack of administrative support for the walk-in nature of appointments was also cited by learners. However, they also described the ability to learn processes quickly and gain confidence in their skills in this setting and appreciated the opportunity for autonomy, while having oversight and mentorship by the lead program attending physicians. Learners generally felt that after working a few shifts for this program,

they felt more comfortable in the setting. Learners cited increasing interdisciplinary team members involved such as nursing and pharmacy students and mental health providers, would benefit the program and patients.

4.3 Adoption

4.3.1 Patient-provider communication

Communication is central to the patient-provider relationship in the healthcare setting. Patients overwhelmingly reported that the medical team communicated with them in a way they were able to understand. The importance of listening, not rushing, and limiting use of technical terms during medical communication were identified as facilitators to improved communication. One patient specifically identified the importance of the way questions were asked as a factor which could either promote or impair effective communication.

Learners and CBO staff identified the importance of building rapport with patients when providing care and the importance of developing relationships over time, with a focus on individualized interactions based on respect. A student identified the concern for distrust of authority figures in this population and the need to foster relationships to limit the impact of this potential barrier.

4.3.2 Team communication

Interdisciplinary team communication was discussed with learners and CBO staff and included communication practices among health professions students, resident physicians, attending physicians, and CBO staff. Team communication was generally reported as effective and need for open communication was accentuated along with need for flexibility, trust, support and acceptability amongst all team members. The program learning environment was reported as open and inviting, and new learners reported initial benefit from receiving additional information and communication with more experienced team members. Learners reported attending physician supervision was available when needed with both in person and telehealth based precepting modalities. There was a specific theme discussed among learners related to “closed-loop communication,” which included informing members of the care team who were not present for the patient encounter of their responsibilities for patient care follow up. This was reported as effective, yet occasionally redundant leading to increased work load. Strategies to streamline follow up communication to limit burden for team members are important to sustain efficacy.

4.3.3 Trust

Trust was an important theme across multiple axes in the interactions between key stakeholders. Patients strongly reported trust in the medical recommendations of the care team, however; they also identified the individual motivation needed to seek help as part of the process of accessing care. While patients directly mentioned trusting the recommendations of the program medical director, one patient stated they were still attempting to find trust in the hospital system. Trust among medical team members (students, residents, and

attending physicians) was highly reported and the importance of an interdisciplinary team and leveraging of community resources was identified as critical to providing care. Finally, the importance of building and maintaining trust with patients was identified by two CBO staff members as essential to supporting unhoused individuals who may fear being stigmatized and who are often in vulnerable situations.

4.3.4 Coordination of care

Coordination of care was discussed by patients, learners and CBO staff. There was a focus on coordination of program medical care with mental health services and social workers and the need for flexibility with time and location to see patients since patients are potentially treated outside of typical business hours and in their own environment. CBOs directly and indirectly working with the CFU program as well as hospital systems were mentioned as integral to facilitate this coordinated care as was the closed loop communication described above.

4.4 Implementation

4.4.1 Access

Factors relevant for access to program care included frequency of encounters and clinic sessions as well as consideration for whether program availability was adequate to meet patient needs. Patients appreciated the consistency of the timing of clinic sessions with regard to available days and times. However, some patients did report potential benefit of increased options for times in clinic or additional time slots and continued expansion of access to resources to support patient needs. Learners noted the clinic has expanded over the course of the year and some learners were surprised by the size of the population served by this program, although also noted needed for additional expansion to meet growing patient demand. CBO staff believed that patients were typically seen within adequate amounts of wait times and reported the clinic walk-in structure without direct appointments had not resulted in prohibitive wait times.

4.4.2 Follow up

Patients reported that they were able to obtain follow up care including medication, lab work, and other services with few limitations. At times, accessing these follow up services required a return visit to TNC. Patient reported barriers for follow up services were transportation and more expensive medications without more affordable alternatives. Learners commented specifically on the limitations of transportation for lab work and medications and also noted that screening recommendations were less likely to be recommended or completed within this program. CBO staff appreciated the opportunity for patients to receive labs and imaging but identified that increased access to a variety of services and available care locations would be beneficial due to transportation barriers. Patients who may not have regular phone access were more likely to have challenges with follow up services. CBO staff commented on efforts of both TNC and MUSC to reduce costs and assist in transportation when possible.

4.5 Maintenance

4.5.1 Factors promoting sustainability

Patients endorsed that they would continue to receive care from the clinic, based on perceptions of consistency, reliability, dependability, and availability of the care provided. From a learner perspective, integration in the curriculum was noted as a facilitator. Others discussed intention for continued participation due to flexible program specific work hours. CBO staff discussed the sustained benefit of the clinic as a flexible option for patient care, outside of emergency care, that offers team-based outreach with flexible locations.

4.5.2 Outreach efforts

All stakeholders identified the potential benefit of additional outreach services including ophthalmology, dental, physical therapy, and mental health including psychiatry. In addition, opportunity for additional onsite or outreach services, including labs, was identified. Additional student services including physical therapy were identified as potential new multidisciplinary team members.

5 Limitations

There are a few constraints for this implementation study. There is the potential for response bias as individuals more likely to continue to receive care may be more likely to volunteer to participate in interviews about the program. Although interviews were not conducted by or in the vicinity of residents or attending physicians and were conducted by student volunteers not actively engaged in the care team at the time of the interview, the interviewers seen alongside the outreach team at times may have impacted perceived roles during interviews and the expressed opinions of patients. Due to the nature of the unhoused population, those that are more difficult to reach were inherently not included in interviews. Finally, the data collection focused on obtaining interviews from a variety of stakeholders limiting the number of individuals interviews within each group which can impact the sample size and representativeness of each group. We believe the consistency of themes across groups supports the themes and conclusions from qualitative interviews.

6 Conclusion

This implementation evaluation of the CFU program described the benefits and moderators of this innovative care model. The program provides convenient comprehensive medical care to the unhoused population using a hybrid model of telehealth and in-person care while concurrently providing needed hands-on educational opportunities for health professional learners. For long term improvement and sustainability of the program, it is necessary to have adequate resources, staffing, and space to meet increasing patient demand as well as added care involving additional areas of specialty to improve the breadth of services. For learners, it will be important to continue to adapt their educational schedules to allow for program participation while also providing initial training and education on the unique aspects of treating

this population. Based on the results of this study, recent efforts have centered around increasing point of care lab testing, enhancing access to cancer screening and other preventive health measures for patients, enhancing preparatory materials for learners, and further partnering with community-based organizations to expand staffing and the variety of services offered. To continue to provide the highest level of quality care, it is vital to maintain open communication among all program team members and patients as well as coordination of care with health care and community-based systems. The identified facilitators and barriers can be utilized in the future to modify and adapt program components to expand equitable health care access to a vulnerable population.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Medical University of South Carolina's Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants and where this was not possible verbal consent was obtained. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

EJ: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SM: Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. MB: Writing – original draft, Writing – review & editing. CS: Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing.

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federal and local healthcare spending; (2) use of telehealth to support HIV prevention and treatment; (3) use of telehealth to address behavioral health (BH) and substance use disorders (SUD); (4) use of telehealth to support of rural hospitals; and (5) evaluation of direct-to consumer telehealth.

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Teaching science in outreach programs may enhance health science communication and engagement in medical students

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Medical education increasingly emphasizes the development of communication, empathy, and teaching skills alongside scientific knowledge. Community outreach programs offer a unique opportunity for medical students to cultivate these competencies in real-world settings. This pilot study investigates the impact of participation in science outreach programs on the engagement and perceived professional development of medical students. Thirty medical students from the Virginia Tech Carilion School of Medicine volunteered in two community-based outreach programs—Kids' Tech University (KTU) and Medical Discovery of Careers (MedDOCs). These programs involved interactive, hands-on teaching of physiological concepts to middle and high school students. Engagement levels were assessed using a modified Utrecht Work Engagement Scale (UWES), comparing students' self-reported experiences during teaching versus studying. Thematic analysis was applied to qualitative reflections. Students reported significantly higher engagement scores while teaching compared to studying (5.8 ± 0.1 ; 4.4 ± 0.1) on a 7-point Likert scale, $p < 0.05$. Thematic analysis revealed four key themes: community engagement and social responsibility, personal and professional growth, educational creativity and communication skills, and inspiration through role modeling. Participation in community outreach programs may enhance medical students' engagement, communication skills, and sense of purpose. These findings support the integration of structured outreach opportunities into medical education to foster holistic professional development.

KEYWORDS

medical education, community outreach, student engagement, health communication, active learning, service learning

1 Introduction: background and rationale for the educational activity

Medical education presents numerous challenges, often prompting students to prioritize academics at the expense of their physical and mental well-being. The demands of rigorous coursework, exams, and the competitive pursuit of residency can narrow students' focus, limiting opportunities for personal and professional growth (Dyrbye and Shanafelt, 2016). Beyond mastering medical knowledge, medical students must cultivate essential skills critical for holistic patient care, such as communication, adaptability, empathy, and teaching. The shift to a pass/fail STEP 1 exam further underscores the need for students to distinguish themselves through extracurricular experiences that foster these skills.

Medical schools could address this need by offering meaningful, engaging opportunities that enhance students' competencies, for example, as supplemental training in communication that helps to meet the LCME accreditation standard (Restini et al., 2024; Butterfield et al., 2024; Vollbrecht et al., 2024). However, care must be taken to avoid contributing to burnout (Morcos and Awan, 2023) by adding extracurricular activities. Community outreach programs and service-learning provide an ideal platform for experiential learning, allowing students to develop practical skills while benefiting the community (Fatton et al., 2021). Outreach initiatives can, for example, involve students in health needs assessments and the development of health promotion interventions, potentially fostering a deeper understanding of social determinants of health and improving population health outcomes.

Furthermore, outreach programs provide students with a “boots on the ground” experience, enhancing their understanding of community health literacy and their ability to communicate effectively with diverse populations (Butterfield et al., 2024; Vollbrecht et al., 2024). This hands-on experience can foster critical communication and adaptability skills essential for addressing future patients' health literacy needs. Volunteering also may boost students' happiness and engagement, improving their relationships with peers and the community.

These experiences potentially enhance students' preparedness for the multifaceted demands of patient care while providing insight into the social and behavioral factors that impact health. Community outreach aligns with social learning theory (Cheng and Shelnutt, 2020), emphasizing learning through interaction, role modeling, and humanistic education to foster empathy. By teaching others, students may broaden their understanding of health concepts and expand their social awareness by witnessing the effect of health literacy on individuals. Despite other qualitative reports, few studies have quantified medical-student engagement while teaching community learners.

VTCsOM medical students were invited to volunteer in outreach community programs like Kids' Tech University (KTU) and Medical Discovery of Careers (MedDOCs). Recent literature highlights the value of such peer education and service-learning programs, where health professions students can develop mentorship skills while promoting STEM engagement and health literacy in their communities (Butterfield et al., 2024). Through interactive, hands-on activities in real-world settings, students help learners explore complex physiological concepts in an accessible way while simultaneously enhancing their own abilities to employ innovative teaching approaches, simplify intricate information, and improve communication skills essential for their future medical careers (Fatton et al., 2021).

This manuscript describes a Community Case Study and explores medical students' self-reported engagement when teaching science in community outreach programs. The authors hypothesized that medical students volunteering in these outreach programs would be more engaged in teaching compared to studying.

Note: Throughout this manuscript, the term “volunteers” or “students” refers to medical students. In contrast, middle and high school students are collectively referred to as “learners,” acknowledging their pivotal role in the educational process facilitated by the medical students.

2 Active learning: environment, approach, and objectives

The authors' approach is grounded in the belief that medical student teachers and learners construct their understanding through individual experiences and interactions. The teaching methods focus on physical engagement with the material, emphasizing active participation rather than content delivery. These methods encourage “learning by doing,” ensuring students and learners are not passive recipients of information but are involved in the learning process (Carvalho and West, 2011).

Medical students' training was a key part of this process before engagement with the community. To stimulate insight and ensure that students in the role as teachers/educators understand how the learners received or perceived the information, all volunteers experienced the activities as learners first. They practiced the same hands-on activities with their peers, which allowed them to become comfortable with the content and teaching methods. It also fostered insight as they “experienced” what the learners would experience later. This dual role as both teacher and student helped them better understand the challenges and perspectives of their audience and hopefully facilitate empathy.

Medical students leveraged interactive teaching methods to engage learners in outreach programs, utilizing various creative techniques to enhance understanding. These methods included manipulatives (Li and Carvalho, 2016; Giffen and Carvalho, 2015; Jazgape et al., 2021) and dramatizations (Dowlati et al., 2016; Connor and Carvalho, 2019; Halpin and Gopalan, 2021) to illustrate body parts and cost-effective approaches that utilize everyday household items (e.g., cotton balls represent ‘oxygen’ during the dramatization of gas transport), making abstract concepts more tangible. During outreach activities, medical students asked learners questions that sparked curiosity and helped learners focus on the task. Descriptions and lesson plans of the special senses and dramatization model are included in the appendices (Supplementary Appendices A–E). While this approach is intended to help medical students translate complex health science concepts for the learners in the community, this study did not directly measure comprehension or understanding.

2.1 IRB statement

The Virginia Tech Human Research Protection Program (HRPP) was consulted. At that point, it was determined that this protocol met the criteria for exemption from IRB review, as no sensitive or protected data were collected from either the medical students or children (learners) participants. This study was conducted in accordance with local legislation and institutional requirements.

2.2 Participants

Each class at VTCsOM, a medical school located in Roanoke, Virginia, consists of approximately fifty students, with some variation due to gap years or other factors. Students from all classes were invited to participate in KTU. In contrast, first and second-year students were specifically invited to participate in MedDOCs. Thirty medical students volunteered for these two outreach programs, representing

approximately 15% (30/200) of the total eligible student population across all four years. Twenty medical students were part of KTU, including twelve first-, six second-, and two third-year medical students. In MedDOCs, there were ten participants (five first- and second-year medical students), representing about 10% of eligible first- and second-year students. In total, within class years, this equates to 24% of M1s, 16% of M2s, 4% of M3s, and 0% of M4s.

2.3 Learning environment: Kids' Tech University (KTU)

KTU is an annual program that caters to middle school learners and is hosted by Virginia Tech University on its Blacksburg, Virginia campus. The KTU program focuses on learners ages 9 through 12. Approximately 160 kids attended the day-long festivities in 2024, which are comprised of a morning lecture from a scientist, followed by 20–30 interactive stations on Science, Technology, Engineer, and Mathematics (STEM) subjects in the afternoon.

Medical students from VTCSOM have actively participated in the KTU program since 2011. The data presented here were obtained during the 2024 outreach program. Medical students are setting up stations featuring hands-on activities and plastic anatomical models. These stations focused on educating learners about taste, olfaction, and the auditory and visual senses. The curriculum also offered a dramatization where each learner personified a red blood cell transporting gases in the blood circulation in the cardiovascular system. Lastly, the curriculum also includes discussions on nutrition, featuring simulations that illustrate the appropriate proportions of food on a plate.

2.4 Learning environment: MedDOCs

MedDOCs is a weekly after-school enrichment program designed to span six weeks. It is tailored for high school students living in underserved neighborhoods in Roanoke Valley, Virginia and who are demographically underrepresented in medicine. There were 25 high school students during this session, resulting in groups of five. Medical student volunteers worked in pairs (one M1 and one M2) and oversaw a group of high school learners interested in science and medicine. The curriculum, curated by medical students, featured interactive lectures and hands-on activities that immersed learners in anatomy, physiology, and pathology while providing volunteers opportunities to hone their teaching and communication skills. For this study, each pair of medical students set up a station focused on one of the special

senses. Each station involved a brief lecture followed by a hands-on activity specifically tailored to mirror the special senses activities of KTU.

2.5 Learning objectives for community learners

Although not assessed in the current study, the overall learning objective for learners (middle and high school students) participating in the outreach programs was to expose them to and improve their understanding of science and health literacy, as described in the literature (Vollbrecht et al., 2019). Our program activities focused on the physiology of the special senses (taste, smell, vision, hearing, and touch) and the circulatory system. By engaging with these concepts through interactive, hands-on experiences, the authors aimed to foster a deeper appreciation of the health sciences in the learners (Restini et al., 2024). In addition to building foundational knowledge, the study sought to inspire learners by exposing them to a diverse group of medical students, illustrating that careers in science and medicine are accessible to anyone, regardless of background.

2.6 Learning objectives for medical students

As the objective of this study, these outreach programs were designed for medical students to contribute to the community and enhance their engagement during teaching activities. The authors assessed medical students' self-reported engagement levels using a simplified survey instrument (Schaufeli et al., 2006). The focus was on comparing engagement between studying and teaching activities, with particular attention to energy levels, happiness, immersion, and flow experience (Table 1). By providing medical students with opportunities to teach in community settings, the program aimed to create a more engaging learning environment that could potentially translate to improved communication skills, as described in the literature (Restini et al., 2024).

3 Data collection and analysis

The authors simplified the Utrecht Work Engagement Survey (Schaufeli et al., 2006) (UWES) to assess medical students'

TABLE 1 Medical students responses regarding engagement during studying versus teaching.

Engagement scale (7 points scale)	Studying	Teaching	W-value	P-value
When I am doing my work as a student/teacher, I feel bursting with energy	4.33 (±0.5)	5.78 (±0.67)	3.0.	$p = 0.008$
I feel happy when I am studying/teaching	4.44 (±1.24)	6.00 (±0.5)	2.5	$P = 0.008$
I am immersed in my studies/teaching	4.56 (±1.42)	5.78 (±0.44)	13.0	$p = 0.078$
I get carried away when I am studying/teaching	4.33 (±1.12)	5.56 (±0.88)	5.0	$p = 0.016$

Scores for individual questions from the engagement scale (7-point Likert), comparing the same medical students' self-perceived engagement while studying versus teaching. Data is reported as mean ± standard deviation for descriptive purposes. Statistical comparisons were performed using the Wilcoxon signed-rank test, appropriate for paired ordinal responses. Each item was tested independently ($n = 9$ pairs).

engagement, comparing their perception of teaching versus studying activities. The original UWES contains 17 items. For this pilot study, the authors selected four questions derived from the original scale that were most relevant to the comparison between studying and teaching contexts (Table 1). The questions were adapted to specifically reference either teaching or studying activities, maintaining the same structure and format while adjusting context. An additional free-text question was included, asking students to “share any thoughts reflecting on your time participating in these activities.” We applied thematic analysis to the free-text question, obtaining insight into the medical students’ perception of their role in the outreach programs (Table 2). The thematic analysis was supported by Microsoft Copilot, a generative AI tool based on OpenAI’s GPT-4 model, integrated by Microsoft to assist with qualitative data interpretation and theme development.

The survey was anonymous and administered via the QuestionPro platform at the end of the outreach program, with access through a link and QR code. All thirty medical students who volunteered for KTU and MedDOCs outreach programs began responding to the engagement survey, and nine completed it.

3.1 Statistical analysis

Data was presented as means and standard deviations, and test results are reported with degree of freedom, *t* statistic, and *p*-value. To assess the effect of the teaching activity on student engagement, we compared responses between studying and teaching situations. Engagement was measured using a four-item questionnaire, with each item rated on a 7-point Likert scale.

For each student, an average engagement score was calculated by taking the mean of their responses to the four items, providing an average measure for each phase (“studying” and “teaching”). To analyze the change in engagement, a paired sample *t*-test was conducted comparing the mean engagement scores. For each individual question, the Wilcoxon signed-rank test was used to compare paired responses for studying and teaching, as this nonparametric test is appropriate for ordinal data. Statistical significance was set at *p* < 0.05. All analyses were performed using Python (pandas, scipy, matplotlib).

4 Results

The medical students responded about their overall engagement during studying compared to their teaching engagement (Figure 1). They reported higher engagement scores when teaching compared with studying: 5.8 ± 0.1 and 4.4 ± 0.1 , respectively [mean $\pm$ SD, *p* < 0.05, *t*(8)-3.93] on a seven-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neutral, 5 = Slightly Agree, 6 = Agree, 7 = Strongly Agree). The average score for each question is presented in Table 1.

TABLE 2 Medical student reflections on time spent during outreach activities.

1	“Wanting to come up with more engaging activities! I think having a stethoscope and allowing the kids to listen to hearts would be exciting and also have an ultrasound and letting the kids see organs in person.”
2	“Outreach was valuable to me because I felt as though I was truly doing something valuable for the community.”
3	“I had opportunities to get involved as a school aged child myself, and leading these activities now was incredibly meaningful to me.”
4	“I ‘missed’ a few extra hours of studying, but the positive impact that I made on the kids was so much more meaningful than sitting in the library. Spending the afternoon demonstrating science and engaging with the participants truly reminded me of what it means to be connected to a community, and why outreach and local engagement is so important.”
5	““It felt really good breaking down those complex physiological processes, like vision or smell, for kids in ways that really clicked for them. Also, getting parents involved, curious, and asking questions about how their own bodies work was pretty fun too!”

4.1 Comments from medical student

Table 2 displays medical students’ responses to the optional free-text question. The thematic analysis of their reflection on participation in the outreach programs were divided into themes.

4.2 Theme 1: Community engagement and social responsibility

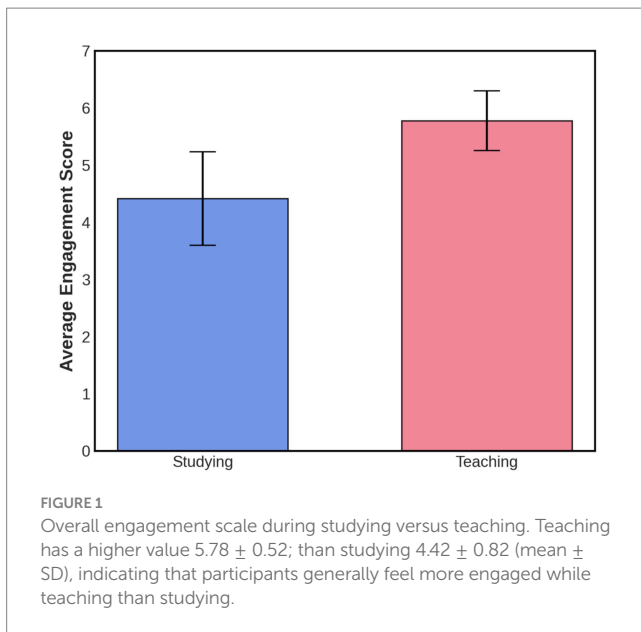
This theme reflects a growing awareness among students of their roles not just as future healthcare providers, but as active community members. Many students expressed a deep sense of fulfillment from contributing to their communities. They highlighted the importance of giving back and the meaningfulness of their involvement.

- “Outreach was valuable to me because I felt as though I was truly doing something valuable for the community.”
- “Spending the afternoon demonstrating science and engaging with the participants truly reminded me of what it means to be connected to a community.”

4.3 Theme 2: Personal and professional growth

This suggests that outreach programs can serve as powerful reminders of students’ core values and aspirations. Students noted that the outreach experience contributed to their personal development and reinforced their motivation for pursuing a career in medicine.

- “I had opportunities to get involved as a school-aged child myself, and leading these activities now was incredibly meaningful to me.”
- “The positive impact that I made on the kids was so much more meaningful than sitting in the library.”



4.4 Theme 3: Educational creativity and communication skills

This theme highlights the development of communication and pedagogical skills, which are essential for effective patient education in clinical practice. Participants emphasized the challenge and satisfaction of translating complex scientific concepts into engaging, age-appropriate content.

- “It felt really good breaking down those complex physiological processes, like vision or smell, for kids in ways that really clicked for them.”
- “Wanting to come up with more engaging activities! I think having a stethoscope and allowing the kids to listen to hearts would be exciting...”

4.5 Theme 4: Inspiration and role modeling

This underscores the cyclical nature of outreach—today’s learners becoming tomorrow’s leaders and educators. Some students reflected on the importance of being a role model and inspiring the next generation, especially those from backgrounds similar to their own.

- “I had opportunities to get involved as a school-aged child myself...”

The students’ comments aligned with findings from other studies where medical students gained valuable health and science communication skills through similar outreach programs. The comments, while limited, provide some qualitative context to the quantitative findings on engagement. They suggest these volunteer experiences may have value beyond the classroom setting.

5 Discussion

Experience with community outreach programs, such as KTU and MedDOCs, at VTCSOM offer valuable lessons for medical education. This manuscript presents preliminary data indicating that medical students who volunteer in an outreach program show increased engagement in teaching compared with studying. Medical students’ self-reported happiness and energy bursts underscore the effectiveness of moving beyond traditional classroom learning.

Furthermore, the act of translating complex physiological concepts into accessible formats, exemplified by KTU’s dramatizations of cardiovascular processes, reinforces learning (Carvalho and West, 2011). This experience offers a dual benefit for medical students: a better grasp of science alongside the crucial skill of clear communication that is essential for future patient interactions. As one student noted, the challenge of explaining concepts like vision or smell in a way that ‘really clicked’ with younger learners provides direct practice in this skill.

The authors advocate that elements of community-based teaching could be more formally integrated into the curriculum as required training modules prior to starting clerkships or for elective credits aimed at fulfilling specific communication or health advocacy learning objectives.

While the current study did not directly measure changes in communication skills or mentorship abilities, qualitative feedback from participants suggests that these outreach experiences may provide opportunities for practicing these skills in real-world settings. A recent publication (Restini et al., 2024) advocates for the early involvement of medical students in community outreach to strengthen individual and community health literacy.

5.1 Impact

The findings from this pilot study underscore the potential of community outreach programs to enhance student engagement while simultaneously building essential clinical communication skills. To enhance benefits, medical education institutions could consider several key strategies: actively promoting outreach opportunities as recognized avenues for personal and professional growth, ensuring acknowledgment of program and student time and efforts, and nurturing strong, reciprocal relationships with community partners (Restini et al., 2024).

Incorporating creative teaching methods, including arts-based approaches like dramatization (Dowlati et al., 2016; Connor and Carvalho, 2019; Halpin and Gopalan, 2021) as a pedagogical method and hands-on manipulatives (Li and Carvalho, 2016; Giffen and Carvalho, 2015; Jagzape et al., 2021) represent a promising direction for medical education. These approaches can provide a crucial outlet from intense academic pressures. This aligns with other research suggesting that humanities integration within medical curricula can help mitigate burnout and enhance well-being among medical students (Volpe et al., 2022; Mangione et al., 2018).

Navigating the challenges inherent in these real-world teaching environments, such as adapting content on the fly or managing group dynamics, may potentially help build resilience and practical

problem-solving skills that could be beneficial for future clinical roles. Similarly, the challenges observed when volunteers work with kids require creativity, adaptability, and communication (Butterfield et al., 2024). Though further research would be needed to substantiate these potential benefits, our preliminary findings suggest that community outreach programs could serve as complementary activities to traditional medical education, contributing to personal and professional development.

Integrating community outreach opportunities into the medical education curriculum cannot be overstated. These programs provide students with hands-on teaching experiences that enrich their academic and professional development while potentially contributing to their personal growth and well-being. As medical schools prioritize holistic training approaches, incorporating outreach initiatives can nurture well-rounded, empathetic physicians capable of addressing diverse community needs. Also, participation in KTU and MedDoc created opportunities for some volunteer students to develop and present posters (Prabhakar et al., 2024) and talks (Prabhakar and Carvalho, 2025).

In summary, this pilot study suggests that community outreach programs serve as more than just opportunities for medical students to give back to society; they serve as catalysts for personal and professional development. Active participation in such initiatives enriches students' educational experiences and cultivates essential skills and values that will benefit them throughout their medical careers.

5.2 Challenges, limitations, and future directions

The small sample size is a limitation of the study. With only thirty participants representing approximately 15% of the eligible student population, the findings may not fully represent the experiences and perspectives of all VTCSOM medical students. This limited representativeness affects the generalizability of the results and underscores the preliminary design and results of this pilot study. The authors intend to address this by continuing data collection over the next four years and tracking the engagement of this group of medical students' volunteers in their teaching roles as they progress from preclinical to clinical years, years one through four.

This study is also constrained by the preliminary nature of its self-reported and simplified data collection methods. While the adapted questionnaire provides valuable insights, future iterations could benefit from more comprehensive data collection methods. The authors recognize the need to explore potential confounding factors in the study design, especially given the varied engagement levels observed among students who participated in different outreach activities and interacted with middle versus high school students, as certain things could be influenced by audience maturity.

Ongoing outreach efforts will focus on identifying alternative assessment tools that offer more comprehensive evaluations of the impacts of community outreach programs on medical students' communication skills. Future research can include longitudinal studies comparing participant and non-participant outcomes throughout their medical school journey. Through rigorous evaluation of the impact of community teaching initiatives, the authors aim to adapt and enhance our programs to serve better both medical students and the communities in which they engage.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Virginia Tech Carilion School of Medicine IRB. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SP: Writing – original draft, Resources, Investigation, Formal analysis, Data curation, Conceptualization, Writing – review & editing, Methodology. BC: Conceptualization, Methodology, Formal analysis, Writing – review & editing, Writing – original draft, Investigation. KR: Conceptualization, Writing – review & editing, Investigation. HC: Conceptualization, Writing – review & editing, Investigation, Supervision, Writing – original draft, Data curation, Resources, Formal analysis, Methodology.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcomm.2025.1613259/full#supplementary-material>

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