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Promoting equitable access to infection prevention for people with different vulnerabilities: a scoping review

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Abstract

Background Educational health interventions play a crucial role in the prevention of respiratory infections, particularly among people with vulnerabilities, who bear a disproportionate burden, which can lead to severe complications such as increased morbidity and mortality. Tailored educational approaches, including digital interventions, are essential to engage and empower these groups, promote self-care behaviors, and reduce health inequities. Despite their significance, evidence on educational interventions, particularly those leveraging digital platforms, has yet to be systematically mapped. To identify and analyze existing educational interventions designed to foster self-care behaviors and prevent respiratory infections among people with vulnerabilities in community settings was the intent of this study.

Methods The PRISMA-ScR checklist was followed to conduct this scoping review. Systematic searches were performed in PubMed, CINAHL, Cochrane, and Scopus, supplemented by grey literature and reference screening. Studies involving educational interventions for people with vulnerabilities in community settings were included, with no publication date restrictions. The review protocol was registered in the Open Science Framework on February 21, 2024. Data extracted were narratively synthesized, focusing on interventions characteristics, different populations included, and outcomes.

Results Twelve studies were included, reporting in-person education, tailored materials, e-health, telehealth, digital and computer-based educational interventions. Older adults, children, individuals with chronic conditions, and groups with socioeconomic vulnerabilities were involved. Interventions have triggered significant improvements in knowledge, attitudes, and preventive behaviors. Digital approaches enhanced outreach and engagement but revealed barriers such as technological disparities due to limited digital literacy among people with vulnerabilities. In-person and culturally tailored interventions proved effective in promoting behavior change, particularly when aligned with community needs.

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Conclusions Tailored, community-based and hybrid approaches that combine face-to-face and digital components are recommended to close knowledge and behavioral gaps regarding preventive measures against respiratory infections in people with different vulnerabilities. However, there are challenges such as inequality in digital access and variability in intervention outcomes that suggest hybrid models and culturally sensitive approaches. Further research is needed to assess the long-term impact of these strategies on reducing respiratory infections and improving health equity.

Clinical trial number Not applicable.

Keywords Educational interventions, Digital education, People with vulnerabilities, Respiratory infections, Scoping review, Self-care behaviors

Background

The public health aim is to promote healthy behaviors to maintain health [1] and to prevent diseases at the individual and at the community levels [2]. Self-care in disease prevention, encompassing health-promoting behaviors, empowers individuals to take proactive measures to maintain their health, manage risks, and improve health outcomes reducing healthcare costs [3]. For its impact, implementing population-level strategies to prevent the growing burden of diseases (e.g., cardiovascular, diabetes, and respiratory conditions) is largely recommended [4].

Preventing respiratory infections is a priority given that they may lead to severe complications, including pneumonia and respiratory failure [5], increasing morbidity and mortality especially among people who experience vulnerable conditions, such as older adults and those living in low-income communities [6]. When simple preventive strategies are not followed, respiratory infections can rapidly spread, as occurred during the Coronavirus-19 (COVID-19) pandemic [7]. People with some vulnerabilities may have a particularly susceptible conditions to respiratory infections for example because of the potential presence of other health conditions or of social issues [8, 9], suggesting that they should be prioritised in the policies aimed at preventing respiratory infections.

The concept of vulnerability has recently been defined by Gordon [10] as the situation, condition or characteristic that places a person at greater risk of harm. Within this framework, vulnerability has been categorised into six different types, as follows:

- *cognitive or communicative*, including people who lack capacity, e.g., adults with cognitive impairment; who are living situations that do not allow them to exercise their capacities effectively, e.g., a person unconscious in danger for their life; and who cannot effectively communicate, e.g., who is not native language and cannot express his/her choice,
- *institutional*, including people who are under the formal authority of others who might have different values, goals, and priorities, e.g., people who are incarcerated,

- *deferential*, including people who are under the informal authority of others, e.g., in the context of doctor-patient relationship,
- *medical*, including those who have serious health conditions for which no satisfactory standard treatment options are available,
- *economic*, concerning individuals who are disadvantaged in the distribution of social goods and services, e.g., people without housing, and,
- *social* including people who belong to undervalued social groups, e.g., gypsy population) [10].

According to their vulnerability, persons may express a wide array of needs requiring individualized interventions to address their unique circumstances and obstacles [11, 12]. Consequently, preventive interventions may vary across people with different vulnerabilities [13]; furthermore, as they have been shown to be at high risk of serious illness and complications from respiratory infections, including secondary bacterial infections, hospitalization and mortality [14], the development of tailored educational measures should be a priority.

The range of barriers faced by people with vulnerabilities, from physical disabilities such as hearing or visual impairments to cognitive, psychological and age-related difficulties - emphasizes the importance of specific and tailored education, defined as interventions that provide relevant information to improve self-care skills by taking into account the unique needs of the person being cared for [13]. For example, people who are deaf may benefit from visual aids, sign language and written materials such as subtitles or sign language videos, emphasizing sign language interpretation and visual aids to improve comprehension [15]. Differently, individuals with visual impairments might require auditory resources or braille formats to understand health information effectively [16]. Similarly, older adults with cognitive decline or lack familiarity with digital tools, requiring simplified, in-person communication or assistance with technology for accessing health resources [17]. Additionally, epidemiological and behavioral factors influencing the transmission and the severity of respiratory infections among

people with vulnerabilities, such as their socioeconomic status, poor living conditions, and comorbidities, should be considered when tailoring educational interventions for mitigating the impact of respiratory infections and reducing the disproportionate burden they place [18, 19]. The COVID-19 pandemic has revealed the community's inability to effectively adapt preventive strategies [20], exposing significant weaknesses in healthcare systems' contingency response measures [21]. Furthermore, the COVID-19 pandemic has highlighted the need to investigate strategies to prevent respiratory infections, especially among people with vulnerabilities that have been disproportionately affected [22].

The digitalization of health education has demonstrated significant advantages, particularly during the COVID-19 pandemic, when physical distancing and lockdowns limited traditional methods of communication and care [23]. Digital education platforms are indispensable tools, enabling the continuity of health education, fostering preventive behaviors, and maintaining vital the networks and contacts with people with vulnerabilities [24]. By bridging geographic and overcoming physical barriers, these technologies may ensure access to relevant health information and services, underscoring their role as a resilient solution in times of crisis. However, the pandemic also has highlighted the importance of addressing disparities in digital access to fully achieve these benefits [25].

From this perspective, promoting healthy behaviors and preventive measures, whether using digital tools or not, among people with vulnerabilities is crucial for mitigating the impact of respiratory infections and reducing the burden on healthcare systems [26]. Helping them to adapt protective hygiene behaviors and manage health proactively may prevent the transmission of infections, particularly in community settings [27]. Additionally, educational interventions digitally delivered to promote the adoption of self-protection strategies may improve their health and that of their community [28]. However, no evidence has been mapped to date regarding educational interventions, whether digitally delivered or not, aimed at preventing respiratory infections among people with vulnerabilities. Providing a map of studies in this area can (a) inform researchers about the gaps that need to be filled in the future, (b) inform policy makers about the public health strategies to be promoted, and (c) inform public health workers about the interventions to be ensured. Thus, the aim of this study was to provide a comprehensive map of studies on educational interventions to promote self-care behaviors to prevent respiratory infections in people with vulnerabilities living in the community.

Methods

Design

A scoping review, following the Joanna Briggs Institute scoping review methodology [29], based on the earlier works of Arksey and O'Malley [30] and further enhanced by Levac and colleagues [31], was performed and here reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) checklist [32] (see Additional file 1).

The research protocol was developed by the Protecting You & Others (PRO Y&O) program, an international project involving partners from five countries (Italy, Poland, Slovenia, Spain, and Türkiye) (<https://proyouandothers.umlub.pl>) aimed at promoting preventive respiratory infections behaviors among people with vulnerabilities. A Steering Committee composed of representatives from the PRO Y&O consortium discussed and approved the research protocol that was preliminarily registered in the Open Science Framework database (registration on February 21, 2024, <https://doi.org/10.17605/OSF.IO/GQYSJ>).

Step 1: Identifying the research question

The research question was developed using the Participants, Intervention and Outcome (PIO) framework and defined as follows: (P) people with vulnerabilities were identified as the target population according to Gordon's classification [10]; (I) the interventions consisted of the educational activities delivered (or not) via digital platforms aimed at promoting self-care behaviors related to the prevention of respiratory infection; (O) the primary outcome was any changes in participants' self-care behaviours to reduce the incidence/spread of respiratory infections.

The research question was as follows: "What educational interventions delivered through digital platforms and aimed at promoting self-care behaviors for the prevention of respiratory infections among people with vulnerabilities have been investigated to date?"

Step 2: Identifying relevant studies

Comprehensive searches across multiple databases, including PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Database of Systematic Reviews, and Scopus, were conducted. Additionally, the reference lists of the included articles were screened to retrieve other relevant sources. The research team also reviewed the grey literature, guidelines, and related documents from relevant associations as, for example, the Association for Professionals in Infection Control and Epidemiology (APIC) and the World Health Organization (WHO).

The search strategy applied the Medical Subject Headings (MeSH) terms in PubMed's MeSH library and the MeSH descriptors in Cochrane; moreover, keywords, such as “community”, “underserved population”, “educational intervention” and “preventive behaviour”, combined with Boolean operators, were also applied in the databases (see Additional files 2, 3, 4, and 5).

Step 3: Selecting studies to be included in the review

Included were (a) quantitative and qualitative studies or reviews and evidence-based guidelines; (b) educational interventions implemented (or not) with digital devices for the prevention of respiratory infections in people with vulnerabilities living in community settings [10]; and (c) published in English, Polish, Slovenian, Spanish, Turkish or Italian. To ensure a comprehensive approach, no restrictions were placed on the date of publication. Commentaries, editorials, letters, books or book chapters, and studies focusing on hospital patients were excluded.

The records generated from each database were imported into web-based citation management software (<https://Rayyan.ai>). The software identified duplicate entries, whereupon a researcher from each country reviewed and agreed on the removal of these duplicates. The screening process involved independent assessments

involving the same researchers for each country, with an initial screening based on titles and abstracts, followed by a full-text screening of eligible articles. Discrepancies were resolved through discussion meetings involving all researchers (see authors).

The search strategy produced 1294 articles from databases and 16 from other sources. After the removal of duplicates and the screening process, a total of 12 articles were included as reported in the PRISMA 2020 flow diagram (Fig. 1) [33].

Steps 4 and 5: Charting the data and collecting, summarizing and reporting the results

Data from the selected documents were extracted independently by two researchers for each country (see authors) using a Microsoft Excel grid, collecting relevant information as: study author(s), title, year of publication, country, journal; aim of the study and design; population included in the study and description of those participating; main features of the intervention; outcomes measured, and main findings reported. No other tool or software were used in this process, and the data were extracted manually.

Numerical data was recorded in tables or charts (e.g., number of participants); a narrative synthesis was then

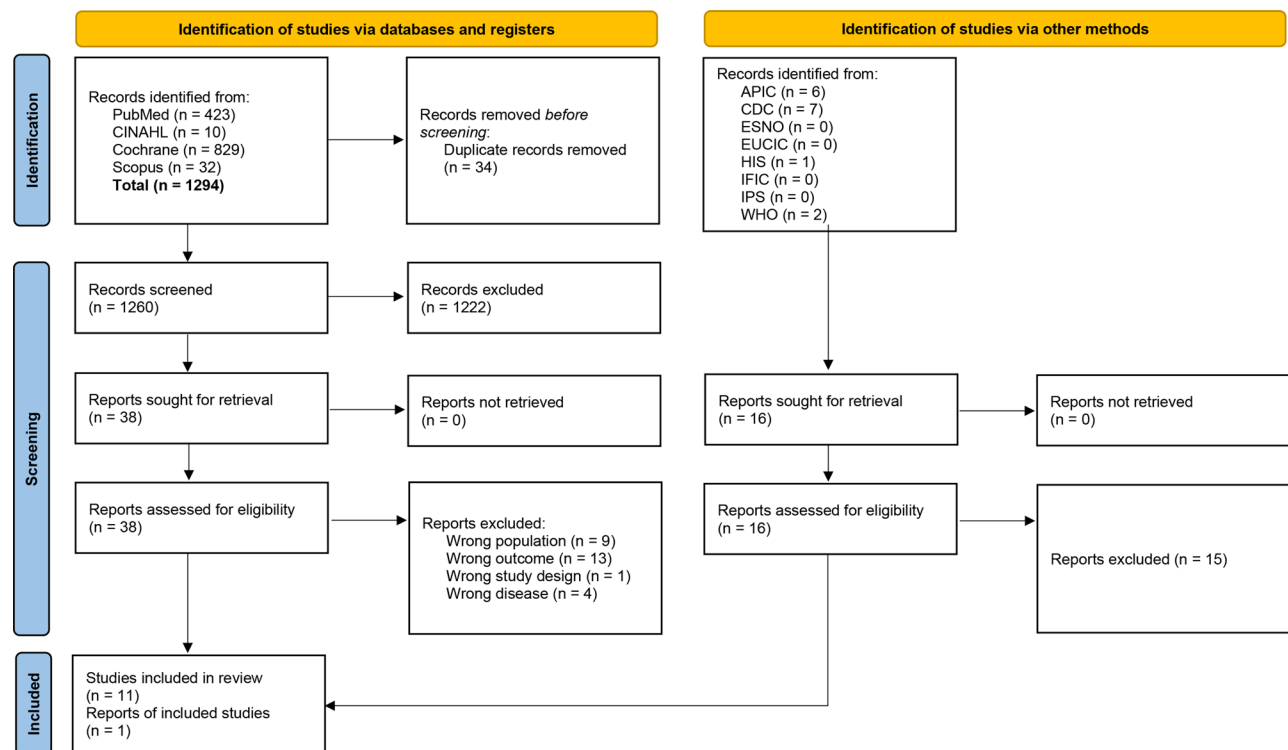


Fig. 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses flow diagram for new systematic reviews which included searches of databases, registers and other sources [33]. APIC Association for Professionals in Infection Control and Epidemiology; CDC Centers for Disease Control and Prevention; CINAHL Cumulative Index to Nursing and Allied Health Literature; ESN European Specialist Nurses Organization; EUCIC European Committee on Infection Control; HIS Healthcare Infection Society; IFIC International Federation of Infection Control; IPS Infection Prevention Society; WHO World Health Organization

produced to (a) present the characteristics of the studies, including their design and participating populations, and the types and characteristics of the educational interventions studied. Specifically, according with an inductive approach based on included studies, interventions were categorized into five main types based on their delivery modalities and focus on vulnerability, as in-to-face education, tailored education, e-health or telehealth education, and digital or computer-based education; and (b) the effectiveness of these interventions in promoting self-care behaviors and preventing respiratory infections.

To ensure accuracy, consistency and compliance to the established criteria, a calibration exercise [34] between independent researchers at the country level and then at the intercountry level was conducted, resulting in a complete agreement among the team.

Step 6: Consulting stakeholders

Stakeholders in the communities play an important role in research processes when directly involved in facilitating the inclusion of individuals with diverse perspectives [35] or in the discussion of findings when these stimulate principles, including those ethically motivated, such as autonomy, dignity, equity, inclusiveness, partnership, and participation [36]. Given their importance, and according

to the study design, two stakeholders from each country involved in the infection prevention and control strategies or policies have been identified (Table 1). They were then involved throughout the entire scoping review process, from its initial stages to the discussion of findings, by sharing with them the data extracted with tables; and in interpreting the findings to develop implications for practice and dissemination, given also their involvement in the Steering Committee of the Project PRO Y&O. The participants were asked to debate the findings emerged and to provide views, experiences and practices of people with vulnerabilities in relation to their respiratory infection prevention behaviors. Their input, based both on their professional experiences and on those lived in the association represented, was highly valuable to the researchers: the insights were then incorporated into various phases of the review and mostly in the discussion phase, which was organized according to the Patterns, Advances, Gaps, Evidence, and Recommendations methodology for Scoping Reviews framework [37].

Results
Characteristics of the studies

The included studies were published between 2007 and 2024, with the majority (10 out of 12) being published

Table 1 Stakeholders involved

Associations	Mission
Associazione Nazionale Infermieri Prevenzione Infezioni Ospedaliere (ANIPIO) https://www.rischioinfezitivo.it/home	To share knowledge and experiences to fight against the healthcare-associated infections
Association For Developing Voluntary Work Novo Mesto https://www.alda-europe.eu	A non-governmental and humanitarian organization (NGO) working in the public interest and promoting the values of human dignity, solidarity, volunteering, intercultural dialogue and active citizenship with programmes in the fields of social welfare, intercultural dialogue, youth work and support to NGOs
Bractwo Miłosierdzia im. św. Brata Alberta https://www.albert.lublin.pl	To help people in crisis of poverty and homelessness, specifically to offer free hot meals, offer shelters to homeless men, and help refugees. Provide material assistance (clothing, hygiene products, everyday essentials), co-payment assistance for prescriptions, and free social worker support for those, who are in need
Cultura tretze https://culturatretze.org	To promote the process of integration into the new social reality of those people who have recently arrived in Catalonia, especially from Morocco. Cultura Tretze redesigns and opens new possibilities for social intervention in the territory, working on the empowerment and participation of people as key elements of social transformation, integration and social and labor inclusion
European Network to Promote Infection Prevention for Patient Safety (EUNETIP) https://www.eunetips.eu/	To promote better cooperation among nations, to share experiences, to promote and support initiatives in infection prevention for patient safety particularly at a European level, recognizing and making the most of all single member societies
Karadeniz Technical University Farabi Hospital https://ktufarabihospital.com	To put into practice preventive behavior, education and improvements against respiratory diseases infections, to raise community awareness about preventive behaviors and to provide community training
Primary Healthcare Team Poble Sec from Barcelona (CAP Les Hortes) https://capleshortes.cat	Basic healthcare unit made up of family medicine, nursing and citizen care staff (the so-called UBA3) to provide a transversal service, distributing tasks in order to be able to provide the best response in an individualized manner according to demands. The application of the UBA3 allows citizens to know their reference team, improving accessibility to their center and streamlining the entire healthcare process
The Novo Mesto Elderly Care Facility https://www.vdc-nm.si/	To provide users with various forms of social welfare services, from institutional care to home care assistance. The mission is to create a positive environment where residents, their relatives and all employees feel valued, to provide proper care for the elderly and ensure their dignified aging
The World of the Deaf Foundation https://wfdeaf.org	Works to enhance access to services, information, and public spaces for individuals with special needs. Provides a variety of accessibility solutions for businesses, public administration, and cultural institutions; translating to and from Polish Sign Language and International Sign Language

in the last five years. Their geographical distribution was wide, with studies conducted in America (Canada, Costa Rica, Mexico and United States, $n=6$), Europe (Italy and Belgium, $n=2$), and Asia (China and India, $n=2$) (Table 2). Regarding their design, four were systematic reviews [38–41], two randomized trials [42, 43], two quasi-experimental studies [44, 45], two mixed-method [46, 47], and two cross-sectional studies [48, 49].

They were aimed at assessing the effectiveness of various educational interventions, including digital ones, in promoting healthy behaviors reducing the transmission of respiratory infections, especially for COVID-19 generic respiratory infections ($n=4$) [39–41, 45] or tuberculosis ($n=1$) [42]. The studies particularly focused on culturally tailored interventions, digital education tools, and community-based strategies to enhance public health efforts. These interventions were delivered in a variety of settings, including schools ($n=1$) [46], health-care settings ($n=4$) [39, 40, 42, 48], homes and digital platforms ($n=4$) [38, 44, 47, 49].

Populations included

Studies included individuals with cognitive or communicative, institutional, deferential, medical, economic and social vulnerability. In particular, included were children from kindergarten or primary schools (deferential vulnerability, $n=2$) [38, 46], children with autism spectrum disorders (medical vulnerability, $n=1$) [49], older adults (medical vulnerability, $n=3$) [39–41], people with chronic disorders (medical vulnerability, $n=2$) [40, 42] or with a disadvantage social conditions (social vulnerability, $n=7$) [43–45, 47, 48]. The range of the participants varied from six [49] to 1,055,337 [41].

Educational interventions

A wide array of educational interventions specifically tailored to address the needs of people with vulnerabilities was applied. These interventions were: in-person education [39, 42, 46], tailored education [40, 41, 45], e-health or telehealth education [38, 40, 43, 47, 49], and digital or computer-based education [44, 48]. In the Fig. 2, an infographic summarizing the main educational interventions emerged in the studies is provided.

In-person educational traditional interventions

Face-to-face educational interventions are considered a pillar of public health strategies, especially within school and community settings. In Italy, an intervention was implemented in primary schools where hygiene kits, along with educational materials to improve hygiene behaviors through a structured educational framework supported by teachers who guided the students, were provided [46]. The proposed educational intervention resulted in an increase of more than 20% in the

knowledge and correct hand-washing behavior of the students. Additionally, the incidence of COVID-19 was lower in the schools that participated in the program than in the regional averages, indicating the effectiveness of the intervention in reducing the spread of the infection [46]. In addition, group sessions, through direct engagement and psychological support, were found to be effective in improving knowledge and key health behavior. For example, a multicomponent intervention engaging patients with tuberculosis in China [42] and a social cognitive theory-based education program involving rural communities [39] were found to be effective, with significant increases in knowledge, awareness and adoption of preventive behaviors for respiratory infections. In particular, the multicomponent intervention [42] focused on three main educational areas: health education, psychotherapy and self-management intervention, whereas the social cognitive theory-based intervention [39] mainly focused on hand hygiene, coughing etiquette, wearing masks, oral hygiene and improving community exercise.

Overall, the results show that face-to-face education interventions, particularly when delivered through structured, multi-component programmes, appear to be effective in increasing knowledge, reinforcing health-related beliefs and practices, and ultimately reducing the incidence of respiratory infections in both schools and the community.

Tailored materials for educational interventions

The development of educational materials, alone or in combination with multicomponent interventions, has also been investigated. In a systematic review [40], educational leaflets on the importance of influenza vaccination were shared with older adults in a family clinic, leading to a significant increase in knowledge (33%; $p<0.001$) after adopting this strategy. Moreover, Tutt and colleagues [45] focused on the needs of Navajo residents and Diné public health students, examining the existing community health materials and adapting it to the cultural perspectives and attitudes towards the COVID-19 vaccine. The results revealed significant changes in attitudes, perceived behavioral control and the intention to get vaccinated after this educational intervention.

Finally, a series of tailored interventions for older adults living in a community setting, such as reminder letters followed by phone calls, educational interventions or meetings for specific targets, resulted in a small but significant increase in influenza vaccination rates [Odds Ratio (OR)=1.11, 95% Interval Confidence (IC) 1.07–1.15] [41].

Overall, these results suggest that tailored educational interventions, whether through culturally appropriate materials, structured information sources or reminder systems, can improve knowledge, positively influence

Table 2 Data extraction from the studies included in the scoping review (n = 12)

Authors Title Year Country Journal	Aim of the study Study design	Target population Sample size Age Vulnerability	Intervention Description Duration Dose Who has applied it	Outcomes measured	Main findings
Bricchi et al. [46] Impact of the educational program "Igiene Insieme" in 1,991 Italian primary schools: student behavior and incidence of SARS-CoV-2 2023 Italy Acta Biomedica	To evaluate the impact of the health educational program "Igiene Insieme 2021/2022" on Italian primary school children's knowledge, attitudes and practice of hygiene and sanitation To compare incidence of SARS-CoV-2 in schools participating the project with regional data of Lombardy and Apulia Mixed-methods: - Phase 1: educational intervention (Igiene Insieme kit); - Phase 2: Comparison be- tween data from educated school to the others	Primary schools N= 16,988 students were moni- tored from the survey N= 143,352 students have received the kit N= 520 teachers Range for students: 6–10 years Differential and institutional vulnerability	Educational intervention with nudge approach: to encourage positive hygiene behaviors in stu- dents through simple reminders, visual indications, and engaging activities. A hygiene kit containing educational material for teach- ers and sanitizing products for students The educational material was used for one month The evaluation questionnaires were administered before the start of the project and after one month The intervention was imple- mented by the teachers of the participating schools	<i>Students' Knowledge and Behavior Regarding Hygiene:</i> - importance of handwashing - how to correctly wash hands - awareness of alternative solution - knowledge of key moments - proper handwashing behavior - behavioral observation by teachers - complex communication needs SARS-CoV-2 Incidence - Lombardy - Apulia	Rate of students who understood the importance of handwashing to pre- vent diseases: pre-intervention 74.0%, post-intervention 91.3% (+ 17.3%) Rate of students who knew how to wash their hands correctly: pre- intervention 60.1%, post-intervention 83.3% (+ 23.2%) Rate of students who knew about alternative solutions: pre-intervention 74.8%, post-intervention 93.3% (+ 18.5%) Rate of students who knew when handwashing was required: pre- intervention 65.3%, post-intervention 87.9% (+ 22.6%) Rate of students who reported washing their hands correctly: pre- intervention 66.9%, post-intervention 89.5% (+ 22.6%) Rate of students observed washing their hands correctly: pre-intervention 65.3%, post-intervention 87.9% (+ 22.6%) Number of students with complex communication needs who knew how to wash their hands correctly: pre-intervention 650, post-interven- tion 878 (+ 35.1%) Incidence SARS-CoV-2 in project schools 9.6%, in non-participating schools 15.4%, Regional average 14.8%, $p < 0.001$ Incidence SARS-CoV-2 in project schools 10.7%, in non-participating schools 12.3%, Regional average 12.0%, $p < 0.001$

Table 2 continued

Authors Title Year Country Journal	Aim of the study Study design	Target population Sample size Age Vulnerability	Intervention Description Duration Dose Who has applied it	Outcomes measured	Main findings
Chen et al. [42] Effects of a HAPA-based multicomponent intervention to improve self-management precursors of older adults with tuberculosis: A community-based randomised controlled trial 2020 China Patient Education and Counselling	To evaluate the effectiveness of a multicomponent intervention based on the HAPA model in improving self-management precursors among older adults with TB Cluster randomized controlled trial	Local residents with TB N= 244 Mean: 71 years Medical vulnerability	<i>Multicomponent intervention with 3 key components:</i> - health education: group sections on TB health education through reading, role plays and panel discussions - psychotherapy: implementation of Morita therapy - self-management intervention: individual sessions, home visits, peer support Every component of intervention lasted approximately 30 min Participants received the intervention at three specific time points: at the start of TB treatment, at one month, and again at six months Health education: trained community health workers Psychotherapy: psychologists Self-management: trained community health workers, community administrators	Self-management precursors, assessed using a Self-Management Assessment Scale (Behavior Beliefs subscale, Behavior plan subscale, Self-Efficacy subscale)	Patient in the intervention group scored better than those in the control group; health education can improve behavior beliefs (Intervention group = 0.35, $p < 0.001$), behavior plan (Intervention group = 0.72, $p < 0.001$) and self-efficacy of patient with TB (Intervention group = 1.85, $p < 0.001$) Patients with higher level of education were more likely to have strong behavior beliefs ($\beta = 0.18$, $p < 0.05$) One of the main barriers to improve patients' self-efficacy is the perceived lack of social support The HAPA-based multicomponent intervention was significantly more effective than single health education in improving self-management among older adults with TB (Intervention group = 2.92, $p < 0.001$) Patients with chronic comorbidities were less likely to have well-developed behavior plans ($\beta = -0.26$, $p < 0.05$)
Gold et al. [38] Effectiveness of digital interventions to improve household and community infection prevention and control behaviours and to reduce incidence of respiratory and/or gastro-intestinal infections: a rapid systematic review 2021 NR BioMed Central Public Health	To evaluate the effectiveness of digital interventions in improving household and community infection prevention and control behaviours, as well as in reducing the incidence of respiratory and gastrointestinal infections Rapid systematic review	Children from kindergartens and parents N= 60 children N= 60 parents NR Deferral and institutional vulnerability	WeChat education group (platform similar to WhatsApp in which health care workers could upload health educational materials and participants could ask them questions) and usual care (health education delivered face to face) WeChat intervention lasted for 3 months NR The intervention was delivered by healthcare workers	Incidence of HFMD Proportion of children who mastered the correct way of washing hand Proportion of children who formed good habits of washing hands	The incidence of HFMD was 13.3% in the control group and 0% in the intervention group that received the digital intervention 96.67% of children in the intervention group mastered the correct handwashing technique, compared to 76.67% in the control group ($p < 0.05$) 96.67% of children in the intervention group formed good handwashing habits, compared to 66.67% in the control group ($p < 0.05$)

Table 2 continued

Authors Title Year Country Journal	Aim of the study Study design	Target population Sample size Age Vulnerability	Intervention Description Duration Dose Who has applied it	Outcomes measured	Main findings
Han et al. [39] A Systematic Review for Effective Preventive Public Education of Respiratory Infection 2021 NR International Journal of Environmental Research and Public Health	To find the best available evidence on the efficacy of non-pharmaceutical interventions for preven- tion of transmission of respiratory infections that have been used in the community Systematic review	Older of rural community N= 37 for intervention N= 32 for control Mean: • Intervention group: 76.6 years • Control group: 74.4 years Economic, medical and social vulnerability	Respiratory infection preventive education program based on so- cial cognitive theory (emphasizing the interaction between personal, behavioural, and environmental factors in shaping behaviour) 50 min per session on hand hygiene, coughing etiquette, wearing a mask, oral hygiene, improving immunity exercise 4 sessions, one per week, and one session for reinforcement The sessions were conducted by trained healthcare workers and public health educators	KAP Social Capital Incidence of ARI	Post-intervention, there was a statisti- cally significant increase in scores in these areas, indicating improved awareness and adoption of preventive behaviours for respiratory infections ($p < 0.001$) The study found a significant improve- ment in social capital scores post- intervention ($p < 0.001$) The intervention group showed a statistically significant reduction in ARI episodes ($p < 0.05$)
Harris et al. [47] Leveraging mHealth to Mitigate the Impact of COVID-19 in Black American Communities: Qualitative Analysis 2023 United States of America Journal of Medical Internet Research Human Factors	To explore COVID-19 infor- mation behaviour among black Americans, identify preferences for COVID-19 education via mHealth, examine barriers and facilitators to COVID-19 education and care Mixed-methods and qualitative study	Stakeholders across 3 three dis- tinct geographic areas (St. Louis, Cincinnati, Statesboro) N= 54 Mean: 50.24 years Medical and social vulnerability	The intervention was designed based on feedback from 7 focus groups, then the mHealth app mobile app was developed NR NR The intervention content was created and facilitated by a team of researchers and healthcare pro- fessionals using community-based participatory research principles	Preferences for COVID-19 education via mHealth Barriers and facilitators to COVID-19 education and diagnostic testing Identification of key content for inclusion in the mHealth app	Participants preferred content that was visually appealing, user-friendly, and provided community-specific information Major barriers included health literacy, technology access, and trust issues The inclusion of Black healthcare providers and community-specific messaging was identified as critical for building trust and credibility in health interventions
Leeman-Castillo et al. [48] Acceptability of a Bilingual Interactive Computer- ized Educational Module in a Poor, Medically Underserved Patient Population 2007 United States of America Journal of Health Communication	To evaluate the accept- ability and impact of an audiovisual, bilingual, interactive computer module relating to ap- propriate antibiotic use among patients seeking care for acute respiratory infections in an urban, underserved clinic setting Cross sectional study	Spanish- or English-speaking adults uninsured N= 296 Age: 18 years and older Communicative, economic and social vulnerability	An interactive computer module with an audio-visual, bilingual (English and Spanish) survey, de- signed to be accessible to patients with low literacy and those with limited computer experience 4 months Single session participants (me- dian time of 17.4 min) to complete the interactive module The intervention was facilitated by clinic staff at the Denver Health Medical Center, who assisted patients in using the computer module as needed	Knowledge of new informa- tion and trusting of informa- tion by the computer Learning something new: whether participants felt they learned new informa- tion about colds and flu Ease of use: how easy participants found the module to use, particularly for those with little computer experience	Participant's report to have learned something new (OR 5.0, 2.0-12.4) and to trust the information (OR 2.5, 1.0-6.0) Spanish-language participants were more likely to report learning some- thing new (OR 5.0, 95% IC 2.0-12.4) and trusting the information (OR 2.5, 95% IC 1.0-6.0) compared to English- speaking participants Those with less computer experience and limited literacy benefited most from the intervention, indicating the potential of such educational tools in reducing health disparities

Table 2 continued

Authors Title Year Country Journal	Aim of the study Study design	Target population Sample size Age Vulnerability	Intervention Description Duration Dose Who has applied it	Outcomes measured	Main findings
Linhares et al. [40] Effectiveness of educational interventions in knowledge, attitude, and practice for preventing respiratory infections: a systematic review and meta-analysis 2022 NR Revista Brasileira de Enfermagem	To demonstrate the effectiveness of educational interventions in knowledge, attitude and practice for preventing respiratory infections in adults and older adults Systematic review	Adults and older adults (family clinic patients) N=40 Range: 18–100 years Adults and older adults registered in a social service N=118 Mean (years): 55 years Patients undergoing hematopoietic stem cell transplantation, their families and friends NR NR Medical, social vulnerability	Pre-test, educational leaflets on importance of vaccination against influenza, post test 90 days NR Pre-test, telephone health education, post test 7 days NR Pre-test, education session through structured guidance (lectures) and printed materials, post test 60 days 5-minute for session NR	Knowledge, focusing on participants' understanding of respiratory infection prevention Attitude, capturing beliefs and perceptions related to the effectiveness and importance of preventive measures Practice, measuring actual preventive behaviors adopted by participants	Knowledge changing: 6/7 studies reported a significant improvement in knowledge; 1/7 reported a non-significant improvement in knowledge; overall OR 2.82 (1.70, 4.69), χ^2 19.68 ($p < 0.0001$) Attitude changing: 1/4 study reported a statistical significance ($p < 0.01$) Practice changing: 3/4 studies showed statistical significance ($p < 0.01$); 1/4 study showed non statistical significance
Newman et al. [44] Effectiveness of an eHealth intervention for reducing psychological distress and increasing COVID-19 knowledge and protective behaviors among racialized sexual and gender minority adults: A quasi-experimental study (#SafeHandsSafeHearts) 2024 Canada PloS one	To increase COVID-19 knowledge and protective behaviors To evaluate the effectiveness of an eHealth intervention (#SafeHandsSafeHearts) tailored to support racialized LGBTQ+ individuals in reducing psychological distress (depression and anxiety) Quasi experimental, single group pre-post test	Racialized LGBT+ people N=202 enrolled N=96 completed the follow up NR Social vulnerability	3-sessions delivered on line: - focused on building relationship, goal identification and psycho-education, adding content on knowledge about COVID-19 - focused on understanding and practicing COVID-19 protective behaviors - focused on understanding psychosocial issues, promoting awareness and improving mental health 60 min per modules Once a week for 3 weeks Trained peer counsellors	Depression symptoms Anxiety symptoms COVID-19 knowledge COVID-19 protective behaviors Sessions' satisfaction	Significant reductions in the prevalence of depressive symptoms by one-fourth (25.4%) from baseline to postintervention (IRR 0.746; 95% IC 0.612–0.911, $p < 0.01$) Significant reductions in anxiety symptoms, with the prevalence reduced by 16.6% from baseline to postintervention (IRR 0.834; 95% IC 0.710–0.970, $p < 0.05$) No statistically significant increase in Covid-19 knowledge scores over time Significant increase in Covid-19 protective behavior scores over time (increase 4.9%, IRR 1.049; 95% IC 1.002–1.099, $p < 0.05$), and to 2-month follow-up (increase 8.6%, IRR 1.086; 95% IC 1.036–1.138, $p < 0.0001$) "Very satisfied" with evaluation of sessions 84%; "very satisfied" with the duration of the session 79%; "very helpful" in improving emotional well-being or mental health 86%

Table 2 continued

Authors Title Year Country Journal	Aim of the study Study design	Target population Sample size Age Vulnerability	Intervention Description Duration Dose Who has applied it	Outcomes measured	Main findings
Sivaraman et al. [49] Telehealth mask wearing training for children with autism during the COVID-19 pandemic 2021 Belgium, India, Mexico, Costa Rica Journal of Applied Behavior Analysis	To evaluate the effectiveness of coaching caregivers via telehealth to implement graduated exposure and shaping to teach mask-wearing to children with autism spectrum disorder To evaluate the effectiveness of telehealth coaching to teach mask-wearing to children with Autism Spectrum Disorder during the COVID-19 pandemic Cross-sectional	Children with autism spectrum disorder and their families and/or therapists from different countries N=6 NR Cognitive, communicative and deferential vulnerability	Telehealth mask wearing training program. Caregivers were coached to apply graduated exposure, shaping, and positive reinforcement. The caregivers followed a series of steps to gradually increase mask-wearing duration and manage problem behaviors associated with wearing a mask 1.3–2.2 min per session 27–47 intervention sessions The intervention was implemented by caregivers (parents or therapists) who were coached by the researchers via telehealth	Number of graduated exposure steps completed Duration of mask-wearing in seconds per session Frequency of problem behaviors Oxygen saturation levels	All participants completed the exposure steps All participants wore a face mask for a period of 10 min All participants wore a face mask without exhibiting challenging behavior No evidence of low oxygen saturation due to mask wearing
Thomas & Lorenzetti [41] Interventions to increase influenza vaccination rates of those 60 years and older in the community (Review) 2018 NR Cochrane Library	To assess access, provider, system and societal intervention to increase the uptake of influenza vaccination in people aged 60 years and older living in the community Systematic review	Older living in the community N= 1,055,337 Range: over 60 years Medical vulnerability	<i>Interventions to increase community demand</i> - Increasing perceptions among people - Increasing beliefs that vaccination is effective - Decreasing concern about side effects - Reminder letters followed by phone calls <i>Interventions to enhance access</i> - Providing more clinics - Bettering clinic hours - Offering vaccination during existing home visits - Arranging home visits to provide vaccination - Decreasing economic barriers <i>Provider- or system-based interventions</i> - Recommendation from healthcare workers - Educational campaigns <i>Societal interventions</i> - Government policies and mandated programs - Meeting for specific targets NR NR Healthcare workers, policy makers and organization	Increasing Community Demand Enhancing Access to Vaccination Provider or System-Based Interventions	The educational interventions to increase influenza vaccination uptake in older adults were found to be effective through several strategies Client reminders (Letters + Leaflets or Postcards): Meta-analysis showed a small but significant increase in vaccination rates, with an OR 1.11 (95% IC 1.07–1.15) based on 3 studies involving 64,200 participants Telephone outreach by retired teachers: highly effective, with an OR 3.33 (95% IC 1.79–6.22), increasing vaccination rates from 231 per 1000 to 500 per 1000 Invitations by clinic receptionists: significant effect, with an OR 2.72 (95% IC 1.55–4.76), increasing vaccination rates from 220 per 1000 to 433 per 1000 Nurses or pharmacists educating patients and administering vaccines: high impact, with an OR 152.95 (95% IC 9.39–2490.67), though this was based on a single study Multiple recall questionnaires: modest but significant impact with an OR 1.13 (95% IC 1.03–1.24), based on 13,809 participants

Table 2 continued

Authors Title Year Country Journal	Aim of the study Study design	Target population Sample size Age Vulnerability	Intervention Description Duration Dose Who has applied it	Outcomes measured	Main findings
Torres et al. [43] Effect of Physician-Delivered COVID-19 Public Health Messages and Messages Acknowledging Racial Inequity on Black and White Adults' Knowledge, Beliefs, and Practices Related to COVID-19: A Randomized Clinical Trial 2021 United States of America JAMA Network Open	To determine whether messages delivered by physicians improve COVID-19 knowledge and preventive behaviours for white and black individuals Randomized Clinical Trial	White and Black adults with less than a college education N = 20,460 Range: over 18 years Social vulnerability	Intervention group: videos messages on COVID-19; covering COVID-19 symptoms, case numbers, and CDC social distancing guidelines Control group: placebo videos with the generic health topics (fitness guidelines, recommended sugar intake, and the importance of adequate sleep NR 3 videos per each participant, both for intervention and control group Several physicians of varied age, gender, and race	Knowledge Improvement Information-Seeking Behavior Willingness to Pay for Masks Safety Behavior	In the control group, 8.4% of participants had no gap in COVID-19 knowledge, compared to 13.0% in the intervention group. The intervention significantly reduced knowledge gaps (IRR 0.89, 95% CI 0.87–0.91, $p < 0.001$) Participants in the intervention group showed higher information-seeking behavior (IRR 1.05, 95% CI 1.01–1.11, $p = 0.03$), compared to the control group Participants in the intervention group were willing to pay \$0.50 more for masks than those in the control group (difference, \$14.58 vs. \$14.07; 95% CI \$0.15–\$0.85, $p = 0.005$) Self-reported safety behavior (e.g., mask-wearing, handwashing) improved slightly in the intervention group, but the difference was not statistically significant (IRR 0.96, 95% CI 0.92–1.01, $p = 0.08$)
Tutt et al. [45] Diné teachings and public health students informing peers and relatives about vaccine education: Providing Diné (Navajo)-centered COVID-19 education materials using student health messengers 2022 United States of America Frontiers in Public Health	To analyse the development of materials and the outcome of COVID-19 vaccine safety education sessions developed for Navajo Nation residents Quasi-experimental study using a consensus panel approach	Navajo Nation community health representatives and Diné public health students N = 46 for the community population N = 13 students NR Social vulnerability	The research team engaged in a consensus-based, decision-making method to review and modify health messengers with community health representatives (Four Traditional Knowledge Holders) and student NR The research team, community health representatives, and Diné public health students applied the intervention	Changes in attitudes Perceived behavioural control and subjective norms Intent to receive the vaccine The single perceived-behavioural-control and three subjective norm questions were approached but they did not attain significance ($p > 0.05$) Statistically significant changes occurred with increases in the number of participants who believed that getting the COVID-19 vaccine was a good idea (56.5%), that the vaccine would prevent COVID-19 (66.3%), and that the vaccines would protect the community (53.3%) ($p < 0.05$)	Four of the nine attitude questions and two of the three intent questions demonstrated a statistically significant change ($p < 0.05$) The single perceived-behavioural-control and three subjective norm questions were approached but they did not attain significance ($p > 0.05$) Statistically significant changes occurred with increases in the number of participants who believed that getting the COVID-19 vaccine was a good idea (56.5%), that the vaccine would prevent COVID-19 (66.3%), and that the vaccines would protect the community (53.3%) ($p < 0.05$)

ARI, Acute Respiratory Infections; COVID-19, Coronavirus-19; HAPA, Health Action Process Approach; HFMD, hand foot mouth disease; IC, interval of confidence; IRR, incidence rate ratios; KAP, Knowledge, Attitude, and Practice; LGBTQ+, lesbian, gay, bisexual, transgender, and queer (or questioning), plus other sexual and gender identities; N, number; NR, not reported; OR, odds ratio; TB, tuberculosis

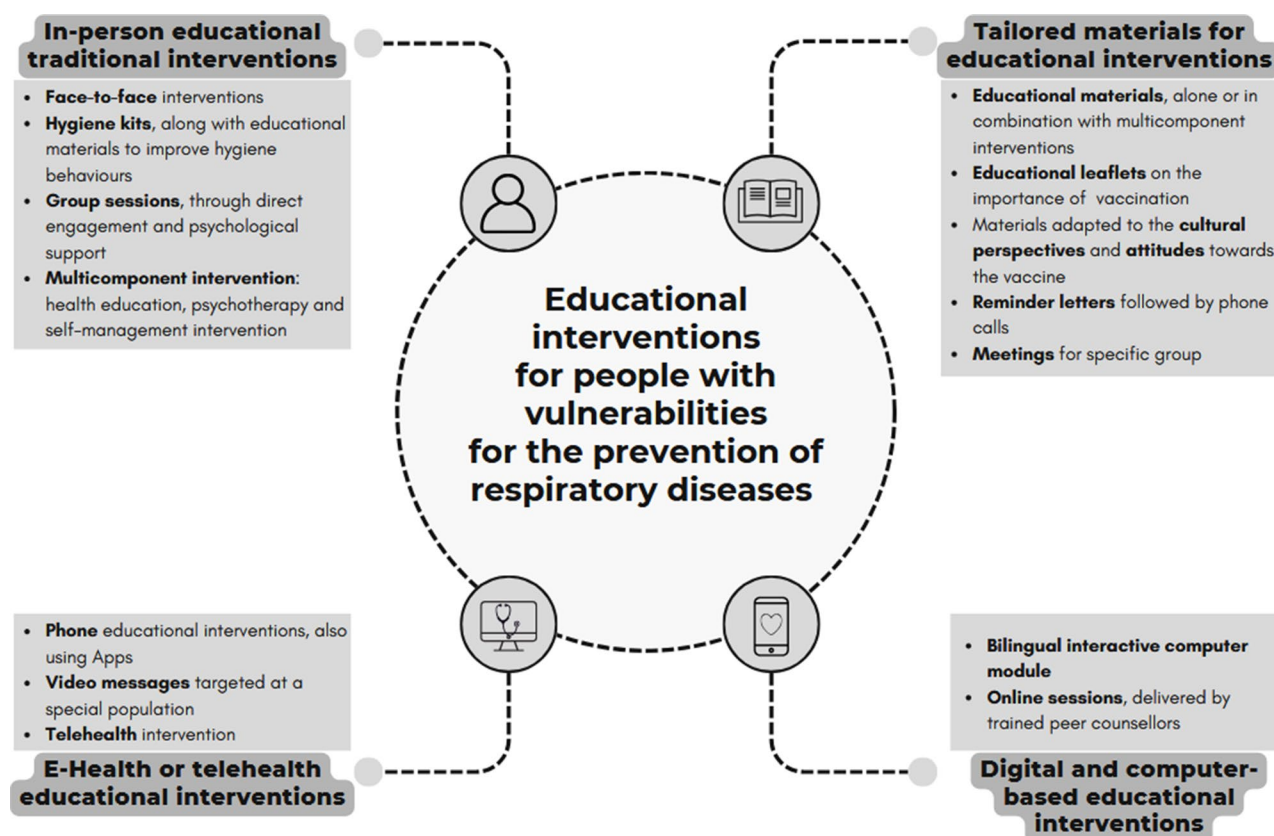


Fig. 2 Infographic of the Scoping Review results

attitudes and vaccination intention, and increase measurable preventive behaviors such as influenza vaccination uptake among older adults.

E-health or telehealth educational interventions

Phone educational interventions, also using Apps, have been used for people with vulnerabilities. For example, in China, the WeChat platform, a widely used social messaging application, was employed to provide educational materials and to maintain ongoing engagement with participants, answering questions and ensuring that educational content was understood and applied [38]. With this intervention, the incidence of the hand foot mouth disease decreased from 13.3 to 0%, owing also to the newly-formed good handwashing habits (96.67% of children in the intervention group, compared with 66.67% in the control group, $p < 0.05$). Similarly, in the United States, the development of a mobile health (mHealth) app with the inclusion of black healthcare providers and community-specific messaging was identified as critical for building trust and credibility in health interventions [47]; users expressed a strong preference for information that was visually engaging, easy to navigate, and specific to their community. Another example was a phone-based educational intervention for older adults

registered in a social service, which however did not significantly improve their knowledge of severe acute respiratory syndrome (SARS) transmission [40]; in contrast, the intervention was found to significantly improve the participants' practices after the educational component ($p < 0.01$).

Moreover, video messages targeted at white and black adults with less than a college education, focusing on specific COVID-19 symptoms, case numbers and social distancing guidelines, were also used in the study by Torres and colleagues [43]; in this case, knowledge gaps were significantly reduced (Incidence Rate Ratio, IRR, 0.89), information-seeking behavior increased (IRR, 1.05), and willingness to pay for masks rose by \$0.50 after the educational intervention, though improvements in self-protective behaviors were not statistically significant [43].

Finally, one study considered a telehealth intervention for a people with vulnerabilities, implementing an educational intervention for children with autism spectrum disorders during the COVID-19 pandemic, coaching their caregivers on how to gradually teach children to wear masks using behavioral techniques, such as positive reinforcement [49]. After the intervention, all participants wore a face mask for a period of 10 min without

displaying challenging behavior and without evidence of low oxygen saturation due to mask wearing.

These findings suggest that e-health and telehealth education interventions, when culturally tailored and delivered through accessible digital platforms, could effectively improve knowledge, promote healthier behaviors and, in some cases, reduce the incidence of infection in vulnerable populations, while providing innovative solutions to overcome barriers to accessibility and engagement in preventive health education.

Digital and computer-based educational interventions

Multimedia interactive computer-based interventions have proven effective in engaging participants who may have limited health literacy or technological skills in a study conducted in the United States, where a bilingual interactive computer module was introduced in underserved clinical settings to educate patients on the appropriate use of antibiotics [48]. This module was designed to be accessible to individuals with low literacy levels, utilizing both audio-visual elements and user-friendly interfaces to ensure comprehension. Participants with less computer experience and limited literacy benefited the most from the intervention: Spanish-speaking users were 5 times more likely to report learning something new ($OR=5.0$, $p<0.001$) and 2.5 times more likely to trust the information provided ($OR=2.5$, $p<0.05$) compared with English-speaking users. Moreover, online sessions, delivered by trained peer counsellors, were tailored to support racialized lesbian, gay, bisexual, transgender, and queer (LGBTQ+) individuals to increase COVID-19 knowledge and protective behaviors [44]. This intervention was based mainly on building relationships, psychoeducation, understanding protective behaviors and promoting awareness and mental health. The study has revealed a significant increase in protective behavior scores over time (increase of 4.9%, $p<0.05$) and at the 2 months follow-up (increase of 8.6%, $p<0.001$); however, there was no statistically significant increase in participants' knowledge scores over time.

Overall, these findings suggest that digital and computer-based educational interventions, particularly when designed to be linguistically and culturally responsive, should be effective in enhancing trust, fostering protective behaviors, and supporting vulnerable populations, although their impact on knowledge acquisition may be less consistent.

Discussion

This scoping review mapped studies on educational interventions, including digitally delivered, to promote healthy self-care behaviors preventing respiratory infections in people with vulnerabilities. Overall, our scoping review underlines that educational interventions tailored

to specific population needs are effective in improving knowledge, attitudes, and preventive behaviors related to respiratory infections [40, 41]. Tailored and contextualized educational public health strategies may address the needs of people with vulnerabilities while overcoming common barriers such as resource intensity, limited scalability, and technological disparities to ensure equitable access and effectiveness.

Characteristics of the studies and populations included

Most of the included studies were published in recent years, reflecting increased research interest following the COVID-19 pandemic, which highlights the urgent need for effective public health strategies to mitigate the spread of respiratory infections, especially among populations with some vulnerabilities. Regarding vulnerability as a concept [10], studies reveal a significant focus on social vulnerability, suggesting a growing global interest in safeguarding this dimension. This attention reflects the global need to improve social conditions, as essential to promote equity and sustainable development, protecting the most exposed populations [50]. At the same time, medical vulnerability has been extensively investigated, mirroring a growing concern driven by global ageing trends [51]. The increasing prevalence of chronic conditions, advanced age, and health risks underscore the need for innovative health interventions to address medical vulnerability in older adults and other people with vulnerabilities [52].

In contrast, economic vulnerability has received comparatively less attention in this field, with fewer studies [39, 48] explicitly investigating the impact of financial barriers on health outcomes and access to care. Several studies demonstrate that financial barriers and socioeconomic inequities exacerbate healthcare disparities, e.g. in a restrict access to essential maternal care in resource-constrained environments [53] and limit access to health insurance [54]. This narrow focus highlights a significant gap in understanding how economic disparities impact the effectiveness of preventive strategies and health education programs, particularly in resource-limited settings. Addressing economic disparities requires context-specific interventions, including financial assistance programs, infrastructure improvements, and innovative healthcare solutions tailored to low-resource settings. Such efforts are crucial for achieving equitable healthcare delivery and enhancing the effectiveness of preventive strategies globally [55].

Patterns of educational interventions across vulnerabilities

The interventions show promising results in improving knowledge and behaviors; however, the vulnerabilities identified express diverse needs shaping the accessibility and the effectiveness of educational initiatives [10].

Tailored approaches are essential for effectively addressing these differences [56], but when barriers such as technological disparities, institutional gaps, or socio-cultural exclusion are not addressed, inequities in intervention outcomes can be exacerbated [25].

Children with cognitive or communicative vulnerabilities, such as those faced by children with autism spectrum disorders, benefit significantly from telehealth programs that offer behavioral reinforcement and real-time feedback [49]. However, these interventions often remain inaccessible to low-income families due to limited technological resources and digital literacy, highlighting the persistent digital divide [57]. Conversely, economically tailored strategies, such as mobile health (mHealth) platforms [47], aim to overcome some of these barriers, but are hindered by the fact that a significant proportion of low-income households still lack access to essential devices or internet connectivity [23].

People with institutional vulnerabilities, particularly in structured settings such as schools, provide an opportunity to leverage existing frameworks for effective educational interventions. School-based hygiene programs have been shown to significantly improve infection prevention knowledge and behaviors [46]. However, these approaches often exclude populations lacking access to formal education, such as refugees or individuals in informal settlements. Community-based organizations can serve as alternative delivery platforms, expanding outreach to these underserved groups [20].

People with deferential vulnerabilities, which are seen in children and adolescents reliant on caregivers, require culturally sensitive interventions that engage both participants and their families. Programs that focus on mask-wearing and hygiene practices in schools have proven effective when aligned with the socio-cultural context of the community [58]. Culturally adapted initiatives in Navajo communities, for example, have promoted trust and adherence by integrating local values, although their resource-intensive nature makes scalability difficult [45, 59].

People with a social vulnerability, including LGBTQ+ communities [44] and American Indian and Alaska Native communities [45], face unique barriers related to stigma, discrimination, and exclusion, which can limit access to health education initiatives, addressing social marginalization by providing tailored, stigma-free educational content. While these approaches have been shown to be effective in improving protective behaviors, they also highlight the resource-intensive nature of developing culturally and contextually relevant materials, posing challenges for widespread implementation [44].

Older adults with medical vulnerabilities often benefit from community-based, in-person educational opportunities, but their participation decreases with the shift

to digital formats due to their lower digital literacy and challenges in accessing digital media [60]. Hybrid models that combine in-person and digital components have shown promise in overcoming these limitations by ensuring flexibility and inclusivity [61].

However, the effectiveness of educational interventions in reducing actual disease incidence or improving health outcomes remains unclear, as few studies have examined these outcome measures [62]. Moreover, the effectiveness of these educational interventions may be influenced by various contextual factors, such as the severity of the respiratory infection, the existing health literacy and behaviors of the target population, and the broader social determinants of health that shape access to resources and opportunities. These contextual factors significantly influence the reach and impact of educational initiatives, highlighting the need for a more comprehensive, systemic approach to promote healthy behaviors and prevent respiratory infections in populations experiencing vulnerability [63].

Educational interventions advancements and gaps across vulnerabilities

Traditional face-to-face educational interventions, such as structured education programs in schools [46] and community settings [42] remain a cornerstone of effective health education, providing personalized engagement and immediate feedback. In-person classes and counselling sessions continue to play a pivotal role in delivering comprehensive health education [58]. These in-person strategies facilitate direct engagement and interaction between educators and participants, allowing for the clarification of doubts and the creation of customized educational experiences. The ability to provide personalized, immediate feedback, allows educators to adapt their teaching methods to participants' responses, which enhances learning retention and engagement [64]. When designed and delivered in a culturally competent manner, these interventions can effectively improve knowledge, attitudes, and preventive behaviors related to respiratory infections. Communication-related behavior change techniques integrated into these interventions, such as role-playing and active discussions, have been proven to significantly influence attitudes and behaviors [65]. Interventions based on social cognitive theory emphasize the importance of observing and imitating behavior in a social context, and educational that incorporates observational learning and guided practice increases self-efficacy [39]. The effectiveness of in-person sessions depends on the educators' skills and their adherence to curriculum standards. However, variability in educational intervention or delivery methods can lead to inconsistent outcomes, even within the same program [39]. Moreover, sustainability remains a challenge,

as noted in interventions where the initial increase in knowledge could not always be translated into lasting behavior changes without continued support and reinforcement [44].

In addition, tailored educational interventions are recommended: there is a need to move beyond stand-alone educational programs to adopt a more comprehensive, community-engaged approach. Interventions engaging the community may achieve additional outcomes by leveraging trust and relevance within focused populations in reaching and engaging people with vulnerability [59]. Similarly, tailored interventions to the specific cultural beliefs, literacy levels, and technological access of the engaged population tend to be more effective [66]. Therefore, in this context, the tailored approach is not only individually directed but also community based.

The educational materials targeting the needs of people with vulnerabilities [38, 40, 45, 46] have been documented to increase knowledge, awareness and changes in habits. Multi-faceted approach to health education should consider the specific needs and barriers faced by people with vulnerabilities; culturally competent approaches considering the unique beliefs, values, and barriers faced by these populations may also affect the success of education interventions [40, 43, 47].

An in-depth analysis of the interventions has shown that, on the one hand, phone-based educational interventions [40, 41, 47], such as interactive voice response systems and mobile apps with tailored messaging, have significant potential to address the need for health education needs among populations with low socioeconomic status. These tools offer a versatile approach that can deliver personalized health messages and facilitate continuous learning in a format accessible to users with limited resources or those located in remote areas; mobile technology is widely available, which makes it an effective channel for public health outreach, especially in communities that might lack traditional educational infrastructure [40]. A key limitation is the digital divide, which affects access according to socioeconomic status, age, and geographic location. Individuals from lower-income backgrounds and older adults may have limited access to smartphones or stable internet connection, potentially hindering the inclusivity and effectiveness of these interventions [61].

On the other hand, telehealth educational interventions [43, 49] delivered via video or audio platforms can overcome logistical barriers (e.g., transportation, work schedules) that often prevent people with vulnerabilities from attending in-person education. Customized content and real-time feedback mechanisms on digital platforms promote participant engagement and learning retention [67]. By offering flexible scheduling and remote

access, telehealth solutions allow participants to learn from home or preferred locations [68] also when other in-person strategies are limited [49]. Nevertheless, maintaining participant engagement in virtual formats can be challenging, as attention spans may wane more rapidly if compared with in-person sessions [69]. A hybrid model integrating both in-person and virtual components may optimize the impact.

Educational interventions recommendation in the field of vulnerabilities

According to the findings, digital educational interventions should be designed with the end-user in mind, incorporating community-specific messaging, visual elements, and user-friendly interfaces to maximize engagement and comprehension. Digital or computer-based educational interventions [38, 48] may play a role in delivering also health education. Digital tools, such as mobile apps, social media, and interactive computer modules, have shown promise in engaging hard-to-reach populations and overcoming barriers related to health literacy and access to traditional educational resources [66]. However, designing multicomponent, including digital, and community-based interventions integrating education, psychosocial support, and culturally relevant approaches into public health strategies is recommended to people with vulnerabilities at high risk of respiratory infection. Despite the promising outcomes of digital educational interventions, the persistent digital divide underscores the need for hybrid models that cater to participants without reliable internet access or technological proficiency [70–72].

Limitations

This scoping review has several limitations. The broad inclusion of studies with different designs and focusing on populations with different vulnerabilities should comprehensively reflect the available research. However, given the increasing number of studies in this area, a subgroup analysis categorizing the findings by specific vulnerability domains is recommended. Although the established review protocol was developed and strictly followed, given the amount of data managed by the research team, studies may have been overlooked. In addition, only studies published in the selected languages were included, which could lead to language bias and limit the inclusion of potentially relevant findings from non-English or non-included language sources, leading to selection bias. Finally, while this review summarized general evidence of the effectiveness of the included interventions, it did not provide a detailed analysis of their comparative impact: it is suggested that this gap in the literature be filled by future studies.

Conclusions

Our scoping review highlighted that a range of educational interventions, including in-person, digital, and multicomponent strategies, can improve knowledge and encourage respiratory infection preventive behaviors among people with vulnerabilities. The success of these interventions largely depends on their approach tailored to the specific needs of individuals with vulnerabilities. Interventions capable of incorporating culturally sensitive and context-specific approaches have a stronger impact, emphasizing the importance of customizing educational content and delivery methods to meet specific needs and match the literacy levels, the technological access, and the cultural values of the target populations.

The effectiveness of these strategies in translating improved knowledge and behavior into an actual reduction in the incidence of respiratory infections is less conclusive, highlighting the need for further empirical research. To advance the field, future research should focus on the development of comprehensive, community-based education strategies that are based on a participatory process and involve partnerships between researchers, healthcare providers and local community organizations.

Overcoming barriers related to access, literacy and technological inequalities is critical to making these interventions equitable and effective. By prioritizing these issues and encouraging community engagement, researchers and public health professionals can develop robust, adaptable strategies that improve self-care practices and effectively reduce the burden of respiratory infections in individuals with vulnerabilities.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12912-025-03773-8>.

Supplementary Material 1: Additional file 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist [32]

Supplementary Material 2: Additional file 2. Search strings in PUBMED (6th March 2024)

Supplementary Material 3: Additional file 3. Search string in CINAHL (6th March 2024)

Supplementary Material 4: Additional file 4. Search string in SCOPUS (6th March 2024)

Supplementary Material 5: Additional file 5. Search string in COCHRANE (6th March 2024)

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Author contributions

BD, NKV, MMS-P, AO and AP conceived the topic; BD, AP, SC designed the work; CM, PO, MS, MŠ, GL, SK AER, ME, AB, SC completed the acquisition and analysis; CM, BD, NKV, MMS-P, AO, AP, SC have interpreted the data; CM, BD, NKV, MMS-P, AO, AP, SC drafted the work and revised the work. All authors have approved the submitted version and have agreed both to be personally accountable for the author's own contributions.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. European Centre for Disease Prevention and Control. Acute respiratory infections in the EU/EEA: epidemiological update and current public health recommendations. [Internet]. 2023. Available from: <https://www.ecdc.europa.eu/en/news-events/acute-respiratory-infections-eueea-epidemiological-update-and-current-public-health>
2. Caron RM, Noel K, Reed RN, Sibel J, Smith HJ. Health promotion, health protection, and disease prevention: challenges and opportunities in a dynamic landscape. *AJPM Focus*. 2024;3(1):100167.
3. Stearns SC, Bernard SL, Fasick SB, Schwartz R, Konrad TR, Ory MG, et al. The economic implications of self-care: the effect of lifestyle, functional adaptations, and medical self-care among a national sample of Medicare beneficiaries. *Am J Public Health*. 2000;90(10):1608–12.
4. Mozaffarian D, Afshin A, Benowitz NL, Bittner V, Daniels SR, Franch HA, et al. Population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. *Circulation*. 2012;126(12):1514–63.
5. Kimberlin D, Barnett E, Lynfield R, Sawyer M. Red book 2021–2024 report of the committee on infectious diseases 32nd edition. 32nd ed. Itasca: American Academy of Pediatrics; 2021.
6. CDC COVID-19 Response Team, CDC COVID-19 Response Team, Chow N, Fleming-Dutra K, Gierke R, Hall A, et al. Preliminary estimates of the prevalence of selected underlying health conditions among patients with coronavirus disease 2019 — United States, February 12–March 28, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(13):382–6.

7. Villena J, Kitazawa H. The modulation of mucosal antiviral immunity by immunobiotics: could they offer any benefit in the SARS-CoV-2 pandemic? *Front Physiol.* 2020;11:699.
8. Akhtar A, Hassali MAA, Zainal H, Ali I, Iqbal MS, Khan AH. Respiratory-tract infections among geriatrics: prevalence and factors associated with the treatment outcomes. *Ther Adv Respir Dis.* 2021;15:1753466620971141.
9. Andeweg SP, Schepp RM, Van De Kasstele J, Mollema L, Berbers GAM, Van Boven M. Population-based serology reveals risk factors for RSV infection in children younger than 5 years. *Sci Rep.* 2021;11(1):8953.
10. Gordon BG. Vulnerability in research: basic ethical concepts and general approach to review. *Ochsner J.* 2020;20(1):34–8.
11. Blount MA, Douglas MD, Li C, Walston DT, Nelms PL, Hughes CL, et al. Opportunities and challenges to advance health equity using digital health tools in underserved communities in Southeast US: a mixed methods study. *J Prim Care Community Health.* 2023;14:21501319231184789.
12. Prior J, Harfield S. Health, well-being and vulnerable populations. In: *International Encyclopedia of Housing and Home* [Internet]. Elsevier; 2012 [cited 2024 Oct 18]. pp. 355–61. Available from: <https://linkinghub.elsevier.com/retrieve/pii/B9780080471631000369>
13. Richards KC, Enderlin CA, Beck C, McSweeney JC, Jones TC, Roberson PK. Tailored biobehavioral interventions: A literature review and synthesis. *Res Theory Nurs Pract.* 2007;21(4):271–85.
14. Arbefeville S, Ferrieri P. Epidemiologic analysis of respiratory viral infections mainly in hospitalized children and adults in a Midwest university medical center after the implementation of a 14-virus multiplex nucleic acid amplification test. *Am J Clin Pathol.* 2016;aqw185.
15. Shrivastava R, Gupta A, Nishant null, Sharda S, Das D, Goyal A. Visual learning strategies for oral health promotion and treatment interventions in children and adolescents with hearing impairment - A systematic review. *Spec Care Dent Off Publ Am Assoc Hosp Dent Acad Dent Handicap Am Soc Geriatr Dent.* 2023;43(5):597–610.
16. Hamadah K, Velagapudi M, Navarro JJ, Pirotte A, Obersteadt C. Best practices for treating blind and visually impaired patients in the emergency department: A scoping review. *West J Emerg Med.* 2024;25(3):350–7.
17. Bertolazzi A, Quaglia V, Bongelli R. Barriers and facilitators to health technology adoption by older adults with chronic diseases: an integrative systematic review. *BMC Public Health.* 2024;24(1):506.
18. Burton DC, Flannery B, Bennett NM, Farley MM, Gershman K, Harrison LH, et al. Socioeconomic and racial/ethnic disparities in the incidence of bacteremic pneumonia among US adults. *Am J Public Health.* 2010;100(10):1904–11.
19. Wiemers E, Abrahams S, Alfakhri M, Hotz VJ, Schoeni R, Seltzer J. Disparities in vulnerability to severe complications from COVID-19 in the United States [Internet]. Cambridge, MA: National Bureau of Economic Research; 2020 Jun [cited 2024 Oct 16] p. w27294. Report No.: w27294. Available from: <http://www.nber.org/papers/w27294.pdf>
20. Clark H, Cárdenas M, Dybul M, Kazatchkine M, Liu J, Miliband D, et al. Transforming or tinkering: the world remains unprepared for the next pandemic threat. *Lancet.* 2022;399(10340):1995–9.
21. Deana C, Rovida S, Orso D, Bove T, Bassi F, De Monte A, et al. Learning from the Italian experience during COVID-19 pandemic waves: be prepared and Mind some crucial aspects. *Acta Biomed Atenei Parm.* 2021;92(2):e2021097.
22. Morawska L, Milton DK. It is time to address airborne transmission of coronavirus disease 2019 (COVID-19). *Clin Infect Dis.* 2020;ciaa939.
23. Kaihlanen AM, Virtanen L, Buchert U, Safarov N, Valkonen P, Hietapakka L, et al. Towards digital health equity - a qualitative study of the challenges experienced by vulnerable groups in using digital health services in the COVID-19 era. *BMC Health Serv Res.* 2022;22(1):188.
24. Monaghesh E, Hajizadeh A. The role of telehealth during COVID-19 outbreak: a systematic review based on current evidence. *BMC Public Health.* 2020;20(1):1193.
25. Eruchalu CN, Pichardo MS, Bharadwaj M, Rodriguez CB, Rodriguez JA, Bergmark RW, et al. The expanding digital divide: digital health access inequities during the COVID-19 pandemic in new York City. *J Urban Health.* 2021;98(2):183–6.
26. McLaughlin JM, McGinnis JJ, Tan L, Mercatante A, Fortuna J. Estimated human and economic burden of four major adult vaccine-preventable diseases in the United States, 2013. *J Prim Prev.* 2015;36(4):259–73.
27. Park YH, Lee SH, Yi YM, Lee CY, Lee MH. Compliance with respiratory infection preventive behaviors and its related factors in older adults using a senior center. *J Korean Acad Community Health Nurs.* 2018;29(3):322.
28. Eid J, Desgrées du loû A. Empowerment-based support program for vulnerable populations living with diabetes, obesity or high blood pressure: a scoping review. *BMC Public Health.* 2022;22(1):2051.
29. Peters MD, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil H. Scoping reviews. In: Aromataris E, Lockwood C, Porritt K, Pilla B, Jordan Z, editors. *JBI Manual for Evidence Synthesis* [Internet]. JBI; 2024 [cited 2024 Aug 18]. Available from: <https://jbi-global-wiki.refined.site/space/MANUAL/355862497/10.+Scoping+reviews>
30. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol.* 2005;8(1):19–32.
31. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci.* 2010;5(1):69.
32. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* 2018;169(7):467–73.
33. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 2021;n71.
34. Dahabreh IJ, Chan JA, Earley A, Moorthy D, Avendano EE, Trikalinos TA, et al. A Review of validation and calibration methods for health care modeling and simulation. In: *Modeling and Simulation in the Context of Health Technology Assessment: Review of Existing Guidance, Future Research Needs, and Validity Assessment* [Internet]. Agency for Healthcare Research and Quality (US); 2017 [cited 2024 Dec 15]. Available from: <https://www.ncbi.nlm.nih.gov/sites/books/NBK424022/>
35. Maurer M, Mangrum R, Hilliard-Boone T, Amolegbe A, Carman KL, Forsythe L, et al. Understanding the influence and impact of stakeholder engagement in patient-centered outcomes research: a qualitative study. *J Gen Intern Med.* 2022;37(5):6–13.
36. Concannon TW, Grant S, Welch V, Petkovic J, Selby J, Crowe S, et al. Practical guidance for involving stakeholders in health research. *J Gen Intern Med.* 2019;34(3):458–63.
37. Bradbury-Jones C, Aveyard H, Herber OR, Isham L, Taylor J, O'Malley L. Scoping reviews: the PAGER framework for improving the quality of reporting. *Int J Soc Res Methodol.* 2022;25(4):457–70.
38. Gold N, Hu XY, Denford S, Xia RY, Towler L, Groot J, et al. Effectiveness of digital interventions to improve household and community infection prevention and control behaviours and to reduce incidence of respiratory and/or gastro-intestinal infections: a rapid systematic review. *BMC Public Health.* 2021;21(1):1180.
39. Han W, Yu JS, Park S, Kwon MS. A systematic review for effective preventive public education of respiratory infection. *Int J Environ Res Public Health.* 2021;18(8):3927.
40. Linhares FMP, Abreu WJCD, Melo PDOC, Mendes RCMG, Silva TAD, Gusmão TLAD, et al. Effectiveness of educational interventions in knowledge, attitude, and practice for preventing respiratory infections: a systematic review and meta-analysis. *Rev Bras Enferm.* 2022;75(4):e20210522.
41. Thomas RE, Lorenzetti DL. Interventions to increase influenza vaccination rates of those 60 years and older in the community. *Cochrane Database Syst Rev.* 2018;5(5):CD005188.
42. Chen Y, Tan D, Xu Y, Wang B, Li X, Cai X, et al. Effects of a HAPA-based multi-component intervention to improve self-management precursors of older adults with tuberculosis: A community-based randomised controlled trial. *Patient Educ Couns.* 2020;103(2):328–35.
43. Torres C, Ogbu-Nwobodo L, Alsam M, Stanford FC, Banerjee A, Breza E, et al. Effect of physician-delivered COVID-19 public health messages and messages acknowledging racial inequity on black and white adults' knowledge, beliefs, and practices related to COVID-19: a randomized clinical trial. *JAMA Netw Open.* 2021;4(7):e2117115.
44. Newman PA, Chakrapani V, Massaquoi N, Williams CC, Tharao W, Tepjan S, et al. Effectiveness of an eHealth intervention for reducing psychological distress and increasing COVID-19 knowledge and protective behaviors among racialized sexual and gender minority adults: a quasi-experimental study (#SafeHandsSafeHearts). Wong CL, editor. *PLoS One.* 2024;19(5):e0280710.
45. Tutt M, Begay C, George S, Dickerson C, Kahn C, Bauer M, et al. Diné teachings and public health students informing peers and relatives about vaccine education: providing diné (Navajo)-centered COVID-19 education materials using student health messengers. *Front Public Health.* 2022;10:1046634.
46. Bricchi L, Signorelli C, Odone A, Cereda D, Bisceglia L, Lopalco PL. Impact of the educational program igiene insieme in 1,991 Italian primary schools: student behavior and incidence of SARS-CoV-2. *Acta Biomed Atenei Parm.* 2023;94(53):e2023184.

47. Harris KM, Mayo Gamble T, Yoo MG, Spell LA, Minor TN, Jones H, et al. Leveraging mHealth to mitigate the impact of COVID-19 in black American communities: qualitative analysis. *JMIR Hum Factors*. 2023;10:e47294.
48. Leeman-Castillo BA, Corbett KK, Aagaard EM, Maselli JH, Gonzales R, MacKenzie TD. Acceptability of a bilingual interactive computerized educational module in a poor, medically underserved patient population. *J Health Commun*. 2007;12(1):77–94.
49. Sivaraman M, Virues-Ortega J, Roeyers H. Telehealth mask wearing training for children with autism during the COVID -19 pandemic. *J Appl Behav Anal*. 2021;54(1):70–86.
50. Rami F, Searight HR, Morrissey MB, Charvonia A, Indart M, Brown LM. Health inequities and social determinants of health in refugee and immigrant communities. *Am Psychol*. 2023;78(2):160–72.
51. Halonen P, Raitanen J, Jämsen E, Enroth L, Jylhä M. Chronic conditions and Multimorbidity in population aged 90 years and over: associations with mortality and long-term care admission. *Age Ageing*. 2019;48(4):564–70.
52. Rawther F, Bondje S, Rahman A, Duku A, Gooneratne S, Beck M, et al. Community immersion project to enhance medical students Understanding of the health needs of the most vulnerable in the community. *BMJ Lead*. 2022;6(1):60–3.
53. Alberta JN. The impact of Socio-Economic factors on maternal health in rural Africa. *INOSR Appl Sci*. 2024;12(3):29–35.
54. Artignan J, Bellanger M. Does community-based health insurance improve access to care in sub-Saharan africa? A rapid review. *Health Policy Plan*. 2021;36(4):572–84.
55. Crabtree-Ide C, Sevdalis N, Bellohusen P, Constone LS, Fleming F, Holub D, et al. Strategies for improving access to cancer services in rural communities: A Pre-implementation study. *Front Health Serv*. 2022;2:818519.
56. Daniels SI, Cheng H, Gray C, Kim B, Stave CD, Midboe AM. A scoping review of implementation of health-focused interventions in vulnerable populations. *Transl Behav Med*. 2022;12(9):935–44.
57. Hamiduzzaman M, Gaffney HJ, Jindal S, Patra M, Gudur R, Pit S, et al. Virtual healthcare for older adults with preventable chronic conditions: a meta-synthesis of quality aspects. *J Appl Gerontol*. 2024;07334648241296791.
58. Carter MW, Tregear ML, Moskosky SB. Community education for family planning in the U.S. *Am J Prev Med*. 2015;49(2):S107–15.
59. Goodman MS, Sanders Thompson VL. The science of stakeholder engagement in research: classification, implementation, and evaluation. *Transl Behav Med*. 2017;7(3):486–91.
60. Jiang X, Wang L, Leng Y, Xie R, Li C, Nie Z, et al. The level of electronic health literacy among older adults: a systematic review and meta-analysis. *Arch Public Health*. 2024;82(1):204.
61. Lu SY, Yoon S, Yee WQ, Heng Wen Ngiam N, Ng KYY, Low LL. Experiences of a Community-Based digital intervention among older people living in a Low-Income neighborhood: qualitative study. *JMIR Aging*. 2024;7:e52292.
62. Ishihara W, Sum K, Lee J, Nathan-Roberts D, Flunking. COVID-19 out of schools: A systematic review of Non-Pharmaceutical interventions to minimize novel Coronavirus-2 in educational settings. *Int J Public Adm*. 2021;44(11–12):1018–27.
63. Darlington EJ, Violon N, Jourdan D. Implementation of health promotion programmes in schools: an approach to understand the influence of contextual factors on the process? *BMC Public Health*. 2018;18(1):163.
64. Du Plooy E, Casteleijn D, Franzsen D. Personalized adaptive learning in higher education: A scoping review of key characteristics and impact on academic performance and engagement. *Heliyon*. 2024;10(21):e39630.
65. Noordman J, Van Der Weijden T, Van Dulmen S. Communication-related behavior change techniques used in face-to-face lifestyle interventions in primary care: A systematic review of the literature. *Patient Educ Couns*. 2012;89(2):227–44.
66. Kessy SJ, Gon G, Alimi Y, Bakare WA, Gallagher K, Hornsey E, et al. Training a continent: A process evaluation of virtual training on infection prevention and control in Africa during COVID-19. *Glob Health Sci Pract*. 2023;11(2):e2200051.
67. Sharma V, Feldman M, Sharma R. Telehealth technologies in diabetes Self-management and education. *J Diabetes Sci Technol*. 2024;18(1):148–58.
68. Centers for disease control and prevention. Ten essential public health services. [Internet]. 2024. Available from: <https://www.cdc.gov/publichealthgateway/publichealthservices/essentialhealthservices.html>
69. Hayat AA, Keshavarzi MH, Zare S, Bazrafcan L, Rezaee R, Faghihi SA, et al. Challenges and opportunities from the COVID-19 pandemic in medical education: a qualitative study. *BMC Med Educ*. 2021;21(1):247.
70. cura della Redazione A. Indicatori ed Esiti associati Alla qualità dell'assistenza: come Usarli e come interpretare i risultati. *Assist Inferm Ric*. 2024;43(1):44–5.
71. Ellison-Barnes A, Moran A, Linton S, Chaubal M, Missler M, Evan Pollack C. Limited technology access among residents of affordable senior housing during the COVID-19 pandemic. *J Appl Gerontol*. 2021;40(9):958–62.
72. Gallo HB, Marshall LW, Levy-Storms L, Wilber KH, Loukaitou-Sideris A. Voices of experience: what do low-income older adults tell us about mobility, technology, and social participation? *J Appl Gerontol*. 2022;41(2):571–80.

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