



Review Article

Theory of Planned Behavior and Vaccine Confidence Among Underserved Populations

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Abstract

Objectives: The World Health Organization defines vaccine hesitancy as “a delay in acceptance or refusal of safe vaccines despite the availability of vaccination services” [1]. To evaluate vaccine hesitancy and increase vaccine uptake, especially in underserved communities, the Theory of Planned Behavior was utilized specifically to observe and analyze vaccine intention. This rapid review examines the influence of the three constructs of the Theory of Planned Behavior and applies them to the context of Buffalo, New York. The goal of this review is to observe the importance of enhancing vaccine education, addressing mistrust, and ultimately increasing vaccine uptake over time with the development of a Mobile Health Literacy application and Health Literacy Toolkit distribution in its underserved communities. **Methods:** All databases were searched in June and July of 2025, using specific terms related to this rapid review. All sources were within 15 years of this review to ensure relevancy. **Results:** All three constructs of the Theory of Planned Behavior: attitude, subjective norms, and perceived behavioral control, were all significant predictors of vaccine hesitancy in all studies that used the Theory of Planned Behavior in this rapid review. However, the construct with the most influential factor was attitude. With this, this rapid review observes attitude shifts in the context of Buffalo, NY, as an outcome measure of the development and establishment of the Mobile Health Literacy application and Health Literacy Toolkit distribution in its underserved communities. **Conclusions:** The Theory of Planned Behavior was proven to have an impact on behavioral intention towards receiving vaccinations. There is clear support for this theory to be utilized in interventions stated in this rapid review, such as the Mobile Health Literacy application and Health Literacy Toolkit distribution in the underserved communities of Buffalo, NY.

This rapid review hypothesizes that educational interventions grounded in the Theory of Planned Behavior, with the support of biomedical informatics tools, are effective in increasing vaccine confidence and uptake among underserved populations. Specifically, by targeting the key TPB ideas, attitudes toward vaccination, subjective norms, and perceived behavioral control, and by leveraging informatics strategies such as the utilization of a mobile health literacy app, such interventions can reduce vaccine hesitancy and address prevalent safety concerns, mistrust in health systems, and structural barriers. The integration of biomedical informatics tools, such as natural language processing, specifically Sentiment Analysis, to monitor vaccine-related discourse and predictive analytics trends to identify hesitancy, can contribute

to creating culturally tailored, accessible educational toolkits informed by the Theory of Planned Behavior and facilitate positive shifts in vaccine-related beliefs and behaviors within these underserved communities.

Introduction

Health Literacy is defined by the United States Department of Health and Human Services as both personal and organizational health literacy [2]. Personal health literacy is an individual’s capability to be able to find, comprehend, and use health-related information, as well as services, to contribute to making well-informed health-related decisions [3]. Organizational health literacy refers to an organization’s ability to provide and enable individuals and

communities to locate, comprehend, and use information to make well-informed health-related decisions that may affect their health. 3. Health literacy is crucial, especially during times of public health emergencies like outbreaks, pandemics, epidemics, and endemics [4]. Communities must be enabled and provided the resources to seek, locate, and comprehend health information and resources to improve their own health and well-being.

There is a substantial correlation between health literacy and vaccine hesitancy. Vaccine hesitancy poses a barrier for one to achieve immunization that is widespread [5], and this is quite prominent in underserved communities, which have experienced significant and persistent structural inequities, with a majority of such communities being Black, rural, and of low-income groups [6]. For example, in a majority of Black communities, vaccine hesitancy is rooted in mistrust due to a history of unethical medical experiments. This mistrust persists today due to ongoing experiences of racism, discrimination, mistreatment, and overall health inequalities [7].

Similarly, rural populations in states like Alaska and Idaho have reported that their citizens' vaccine hesitancy statistics have been driven by the fear of side effects, low perceived risks, and barriers related to access, availability, and misinformation [8]. These hesitancy patterns are magnified by low health literacy, which limits individuals' ability to be successful in accessing, understanding, and acting upon public health information [9]. Therefore, educational interventions that improve health literacy are essential in addressing vaccine hesitancy. Herein, we set out to create this rapid review to examine the effectiveness of educational interventions, guided by the constructs of the Theory of Planned Behavior and supported by biomedical informatics tools, in improving vaccine confidence and uptake among underserved populations by addressing health literacy and structural barriers.

The Theory of Planned Behavior (TPB) is a cognitive theory that assists an individual's decision-making to engage in a specific behavior [10]. It is also used as a behavioral framework to understand and influence health-related decision-making. TPB asserts that intentions to perform a behavior are shaped by three core constructs: attitudes, subjective norms, and perceived behavioral control [11]. Attitude refers to an individual's overall evaluation of a specific behavior, whether they view it as positive or negative; subjective norms is influenced by normative belief and refers to the perception of social pressure to perform that behavior; and perceived behavioral control refers to the belief of having the abilities to perform that behavior, or in other words, the belief about whether one can control their performance of a behavior [12,13]. Many studies in this rapid review have validated TPB's behavioral framework for vaccine uptake. In addition, studies have affirmed that TPB-based interventions can successfully target behavioral

correlates of vaccine hesitancy [18,21,23,31], especially when the interventions are tailored to the community context and identity.

To enhance education-based interventions for toolkit development, biomedical informatics tools were included to offer data strategies for tracking and scaling across the population and addressing vaccine hesitancy. Tools such as Natural Language Processing (NLP) and geospatial sentiment analysis of social media platforms will allow researchers to monitor the public's attitude toward vaccination in real time [14]. Natural language processors, which deal with how computers comprehend, analyze, and manipulate human languages [15], will be the main type of biomedical informatics technology utilized in this toolkit. NLP involves understanding the significance of the meaning of the language, translating between languages, and recognizing patterns in how people communicate with each other [15]. In addition, machine learning tools trained on interpreting Electronic Medical Records (EMRs) and socioeconomic data will be used to identify patients at high risk of vaccine hesitancy. Furthermore, by prioritizing the inclusion of a mobile health literacy app containing interactive FAQs and push notifications for vaccination reminders, the Health Literacy Toolkit will be able to deliver tailored educational content that contributes to fostering informed decision-making and reinforcing trust in vaccines.

This rapid review intends to synthesize already existing research on education interventions grounded in the Theory of Planned Behavior to reduce vaccine hesitancy in underserved communities. The goal is to achieve vaccine uptake by informing the development of a toolkit that is culturally relevant and tailored for communities in Buffalo, New York, and hopefully, the nation.

Methods

Inclusion and Exclusion Criteria

The inclusion criteria for this rapid review involved peer-reviewed studies that were both quantitative and qualitative, with all having relevance to the application of the Theory of Planned Behavior to investigate vaccine hesitancy, intentions, or change in behaviors related to vaccination. Studies that involved underrepresented populations and communities, including both United States-Based and international populations that had comparable structural inequities, social or trust-related barriers to vaccinations (such as rural or low-resource environments), were included. Studies that examined factors such as mistrust, misinformation, social norms, and perceived behavioral control were all included, regardless of geographic location, as long as findings could inform the Health Literacy Toolkit development for underserved communities in Buffalo, New York. Due to the focus of including biomedical informatics in enhancing vaccine confidence, studies that utilized digital technologies, such as natural language processing,

sentiment analysis, predictive analysis, or geospatial modeling, were used to evaluate vaccine-related discourse to further analyze the significance of public trust and behavior trends on vaccine intention. Articles written in English and published within the past 15 years were included to ensure all ideas and evaluations were relevant to the public health advancements and context of our modern day. Studies were excluded if they lacked a TPB framework, did not address vaccine-related attitudes or behaviors, were not peer-reviewed, or were not available in any English translation. These inclusion and exclusion criteria allowed for the inclusion of diverse perspectives and methods while clearly focusing on behavioral influences relevant to vaccine confidence and uptake.

Selection of Sources

This rapid review followed the PRISMA-ScR guidelines to ensure clarity, reproducibility, and comprehensiveness in identifying literature relevant to this review. The goal was to capture peer-reviewed studies on vaccine hesitancy, behavioral interventions grounded in the Theory of Planned Behavior (TPB), health literacy, and the use of biomedical informatics tools to inform the development of an educational toolkit aimed at improving vaccine confidence in underserved communities in Buffalo, NY.

Data Extraction

The databases searched included: Science Direct, Oxford Academic, PubMed, Sage Journals, *Advances in Medicine*, *Psychology and Public Health*, National Library of Medicine, *Frontiers in Public Health*, *Humanities and Social Sciences Communications*, all of which were found using Google Scholar to identify open-access peer-reviewed content. In addition to peer-reviewed academic sources, grey literature from public health organizations, including the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO), was used. Only peer-reviewed and credible articles published in English and based on human subjects were included. No geographic location restriction was applied, but priority was given to studies with findings relevant to underserved populations.

Databases and Search Strategy

All databases were searched in June and July of 2025, using key specific terms and concepts relevant to this rapid review, which included: “vaccine hesitancy”, “vaccination uptake”, “vaccine confidence”, “vaccine refusal”, “Theory of Planned Behavior”, “TPB”, “underserved populations”, “health disparities”, “rural health”, “low-income communities”, “health literacy”, “health communication”, “biomedical informatics”, “natural language processing”, “NLP”, “social media analysis”, “digital health interventions”, “real-time surveillance”.

Assessment of Study Quality

To assess the quality of the studies included in this rapid review, the Joanna Briggs Institute Critical Appraisal Checklist for Systematic Reviews and Research Syntheses was used based on the design of each study. This checklist helped to evaluate whether the studies used had clear research questions, whether appropriate methods were used, and whether results were accurate and reported clearly. For qualitative studies, they were evaluated based on whether the study design matched the outcome and goals of the study, how data were collected and analyzed, and whether there were limitations and biases that were not mentioned. For both quantitative and survey-based studies, they were evaluated based on how participants were selected, whether the measures were reliable, and whether the results were correctly analyzed. Biomedical informatics studies were reviewed based on how clearly their data sources, analysis methods, and tools related to real-world vaccine hesitancy were explained. Only studies that met the Joanna Briggs Institute Critical Appraisal Checklist for Systematic Reviews and Research Syntheses quality standards were included in this rapid review.

Synthesis of Results

Findings and results were summarized using a thematic approach, identifying themes around the Theory of Planned Behavior constructs: attitude, subjective norms, and perceived behavioral control. To add, the findings also highlighted the importance of the role of utilizing biomedical informatics tools in supporting vaccine education and uptake. The results of this rapid review aided in informing the development of the proposed Health Literacy Toolkit, designed to increase vaccine confidence in underserved communities in Buffalo, NY.

Discussion

When referring to the three constructs of the Theory of Planned Behavior: attitude, subjective norms, and perceived behavioral control, all three constructs influenced increasing vaccine uptake across all studies analyzed. Although all three constructs played a role in vaccine uptake, the construct with the highest influential factor was attitude. In all the studies in this rapid review, study participants who had negative attitudes toward the intervention or the vaccine itself demonstrated higher levels of hesitancy as compared to the influence of subjective norms or perceived behavioral control. This pattern across the diverse and underserved populations in this review shows the central role that attitude may play in vaccine hesitancy.

Subjective norm played a meaningful role in influencing vaccine uptake, though to a lesser extent than attitudes. Social influences such as religion, peers, and familial expectations shaped

individuals' willingness to get vaccinated.

One common influence that played a role in vaccine hesitancy was religious beliefs [16]. For instance, only 52.9% of college males and females aged 13 to 17 in rural Alabama in 2013 were up-to-date (i.e., 2- or 3-dose series completion) with the HPV vaccine compared to 58.6% nationally [17,18]. In 2021, students who were not vaccinated were more likely to report that religion influenced their health beliefs [18]. Religiosity had negatively impacted Human papillomavirus vaccine uptake, especially among women and college students who had regularly practiced an organized religion, and this population of individuals tended to have less knowledge of HPV or the HPV vaccine, and were less likely to have initiated or completed the HPV vaccine series [18-20]. Similarly, in Bangladesh, a strong religious belief was found among the respondents who showed unwillingness to be vaccinated [21]. Some people mistakenly believe that the vaccine contains "haram" (religiously forbidden) ingredients like pig-derived products that influence their decision on vaccine acceptance [21].

Beyond religion, community leaders, family, and friends were key drivers of vaccine acceptance. For example, in one study, the relationship between subjective norms and COVID-19 vaccine uptake intention was found to be positive and significant, as strong subjective norms from friends and relatives drove people to get the COVID-19 vaccine [22]. In addition, vaccine hesitancy tended to decrease as familial support in favor of vaccination increased, with one study finding that a one-unit increase in familial support in favor of getting the COVID-19 vaccine reduced vaccine hesitancy by 0.31 units [23]. In a study using TPB to predict mothers' intentions to vaccinate their daughters against HPV, subjective norms were measured with questions involving how much mothers agreed with each statement; "Most people who are important to me think that I should vaccinate my daughter," "It is expected of me that I will vaccinate my daughter against HPV," and "The people in my life whose opinions I value would want me to vaccinate my daughter." [24]. These measures were combined to form a total measure of subjective norms [24]. The results of the linear regression indicated that those with subjective norms that were in support of the vaccine were more likely to intend to vaccinate [24].

These findings suggest that when individuals are socially pressured and perceive expectations from individuals they consider to be influential, their vaccine-related decision can be impacted. This emphasized the importance of community engagement, trusted messengers, and culturally tailored outreach in future interventions to increase vaccine uptake.

Perceived behavioral control refers to an individual's belief in their ability to access, understand, and complete a behavior, which in this review is getting vaccinated [13]. Perceived behavioral

control influences whether individuals feel able to follow through with vaccination. For example, during the COVID-19 pandemic, individuals from underserved communities often struggled to identify which centers had vaccine availability or how to schedule appointments, which were all challenges that decreased their likelihood of getting vaccinated, even if they had favorable attitudes or supportive social networks [25-27].

In one study among Bangladeshi adults, it was analyzed that in terms of perceived behavioral control, respondents who mentioned registering for COVID-19 vaccination were within their control were less vaccine-hesitant [23]. This resulted in $\beta = -0.05$, which translates to a one-unit increase in perceived benefits of getting the COVID-19 vaccine, leading to a reduction of vaccine hesitancy by 0.05 units [23]. However, in a study on HPV vaccination, perceived behavioral control remained under addressed. That is, mothers in this study perceived HPV vaccination as in their control, indicating that vaccinating their daughters was "possible" and "easy." [24]. Cost was not perceived as a barrier in this study due to all of the daughters in the sample having health insurance, and the vaccine is covered by health insurance in this state [24], but since only 3% of the children in the state were without health insurance, cost would have minimal impact on the study results [24]. Therefore, it can be inferred that lack of health insurance is a possible barrier to vaccination [28-30]. For example, a 2018 cross-sectional study of 18,089 individuals reported that lack of access to affordable vaccines for some PLWH (People Living with HIV) contributed to low vaccine uptake [28]. Similarly, in a rapid review predicting vaccination intention against COVID-19 using the Theory of Planned Behavior, it was found that in two studies focusing on parents' intention to vaccinate their children, parents' intention was stronger if they had higher levels of positive attitudes towards vaccinating their children and if they reported stronger subjective norms [61]. But, perceived behavioral control was not a significant predictor of vaccination intention [31].

Similarly, in one study looking at factors influencing the intention and uptake of COVID-19 vaccines on the African continent, in African countries such as Ghana and South Africa, vaccine accessibility is a huge barrier to getting vaccinated [32]. For example, in one qualitative study going over the facilitators and barriers to COVID-19 vaccine uptake among women in two regions of Ghana, one of the three major barriers to receiving vaccination was due to their tight work schedule, hindering their participation in the COVID-19 vaccination routine [33]. They revealed that they go to work early and close late, and hence, they are unable to go to the vaccination centers for the vaccine [33]. In addition, perceived behavioral control was found to be a key factor influencing vaccination intention in Africa [31], and this is a result of the shortage of vaccines. In a study done

in 2022, it was found that inadequate vaccine supply at hospitals, health centers, or vaccination centers prevented women from receiving the COVID-19 vaccines [33]. This study implies that making COVID-19 vaccines available and accessible to women would encourage COVID-19 vaccination [33]. In addition to the shortage of vaccinations in the Ghanaian regions of study, an additional barrier to vaccination was the distance between their place of residence and health facilities or vaccination centers [33]. We must ensure that transportation doesn't remain a barrier for all individuals seeking vaccinations for various health ailments, especially for underserved populations who face transportation barriers at higher rates [34,35].

In summary, although perceived behavioral control may be an unexplored factor as compared to the other constructs of the Theory of Planned Behavior, it is still very important in influencing vaccine uptake. Barriers such as cost, access, time constraints, and transportation can undermine individuals' sense of control and reduce vaccine uptake, especially within underserved and vulnerable populations.

Attitude is the last construct in the Theory of Planned Behavior, and it refers to an individual's overall evaluation of whether a behavior is positive or negative [36]. This is influenced by their beliefs about the consequences of the behavior and how they value those consequences [36].

In one study among Bangladeshi adults predicting COVID-19 vaccine hesitancy, although all four components of the Theory of Planned Behavior were significant predictors of vaccine hesitancy, respondents who had a more negative attitude toward the COVID-19 vaccine were more vaccine-hesitant [23]. Similarly, in another study predicting intention to receive the COVID-19 vaccine, participants were more likely to be willing to get vaccinated if they reported higher levels of perceived benefits of the COVID-19 vaccine [62]. In other words, when someone perceives strong benefits from getting the COVID-19 vaccine, they are more likely to form a favorable attitude toward vaccination, which in turn increases their intention to get vaccinated.

According to the 5th Edition of *Health Behavior: Theory, Research, and Practice* by Editors Karen Glanz, Barbara K. Rimer, and K. Viswanath [37], it is indicated that changing the beliefs linked to every predictor in the Theory of Planned Behavior is not always practical or achievable [37,38], so we must address the construct with the strongest predictor [38,63], which is attitude [38].

In a systematic and meta-analysis study, it was found that attitude was the strongest predictor of vaccination intention, followed by subjective norms and perceived behavioral control [31]. Upon analysis of all constructs using the IBM SPSS Statistics [27] and Comprehensive Meta-Analysis 4.0, attitude had the strongest

association with vaccination intention, yielding an average correlation of 0.487 (95% CI: 0.368-0.590) [31], but this did vary according to geographic location [31] with attitude toward COVID-19 vaccine was a statistically significant predictor of vaccine acceptance in all eighteen studies in a Western context, but only 87% of the studies reported attitude as a significant determinant in a non-Western context [31]. This stresses that attitude is a major factor in vaccination intention everywhere, but geographic location and study population play a role in the extent to which attitude can affect vaccine intention.

In addition, in one study assessing COVID-19 vaccine acceptance among urban slum people in Bangladesh [21], overall, 18% of respondents refused or were unsure about receiving the COVID-19 vaccination, with 46.58% fearing unknown future consequences, 45.21% having religious beliefs, and 41.10% having vaccine allergy, high blood pressure, or diabetes; these were the top reasons for vaccine hesitancy [21]. Fear of unknown consequences, being the highest hesitancy reasoning, reflects anticipated negative outcomes, which contribute to a negative attitude toward the behavior of getting vaccinated. But, one study predicting mothers' intentions to vaccinate their daughters against HPV showed that intent to vaccinate was influenced by mothers' positive attitudes about the vaccine in such a way that more positive attitudes increased the likelihood of vaccinating ($\beta = .61, p < .001$) [24].

Concerning two different populations, attitudes played different roles among the White and Black populations. White individuals tended to have stronger attitudes towards the COVID-19 vaccine as trust in health institutions was linked the highest to their compliance; however, attitudes had the weakest role among the Black population [64]. This may indicate that the weaker impact among Black individuals suggests that improving compliance with vaccination may require addressing deeper systemic issues, such as discrimination and mistrust in health systems, not just risk awareness at the individual level.

To conclude, as seen in the various evidence presented to support the attitude construct in the Theory of Planned Behavior, attitude consistently emerges as the strongest predictor of vaccination intention among various populations. Although its impact can vary by geography, Meta-analytic findings reinforce that attitude has the strongest correlation with vaccination intention. In addition, being that there are numerous differences in vaccine attitudes between many racial groups, contributes to why there should be a highlighted need to consider broader social determinants of health, such as historical mistrust and systemic inequities that have continuously disadvantaged minority groups. Changing every belief underlying the Theory of Planned Behavior may be difficult to achieve in a time that is limited; therefore, we must focus interventions on shaping positive mindsets and attitudes through

educating the public by addressing misinformation, emphasizing the benefits of vaccination, and acknowledging concerns that are community-specific. Putting these interventions into action can improve vaccine acceptance.

Focusing on the Theory of Planned Behavior, which highlights attitude, subjective norms, and perceived behavioral control as key predictors of health behaviors, it is important to consider each of the three constructs when addressing vaccine hesitancy, specifically when applying it to Buffalo, New York. While attitude has continually shown to be the strongest influence, subjective norms and perceived behavioral control also play an equally important role in shaping vaccine intentions. To effectively design interventions that address these three constructs, we must first understand all factors that shape them, especially health literacy, which has proven to significantly affect how individuals interpret vaccine-related information, perceive social expectations, and assess their ability to act on health decisions.

With the toolkit centered on Buffalo, New York, it is very important to assess the literacy rates in the population. In Erie County, approximately 150,000 adults struggle to read and write English [65]. When someone struggles to read English, they will struggle to grasp medical instructions, prescription information, the Public Health Department of Health's safety messages and measures, and other health-related decision-making materials [65]. If someone struggles to read English, they may feel less capable of understanding or acting on health information, including vaccine guidance, safety messages, or appointment logistics [39]. This lowers their perceived behavioral control over engaging in the health behavior, in this case, getting vaccinated. As a result, literacy must be viewed as a skill needed to survive in order to make educated health decisions for one's own health and well-being [40].

Poverty, public assistance, and vaccine mistrust are among the socioeconomic determinants of health that contribute to low literacy. In Buffalo, New York, 43% of adults with the lowest literacy skills live in poverty, 50% of the unemployed are functionally illiterate, and welfare recipients with the lowest literacy skills stay on welfare the longest [41,42]. Despite efforts to increase COVID-19 testing and immunizations in Black and Brown areas, particularly on Buffalo's East Side, vaccination rates remained low. This was mostly due to the discrepancy in income and location [66]. People in poorer communities, whether urban or rural, are less likely to be vaccinated [66]. According to county data, 6.7% of people in the 14211-zip code on Buffalo's east side received one dose of vaccination in 2021 [66].

According to a systematic review that analyzed trust and vaccine hesitancy, in Black communities, vaccine hesitancy is rooted in an

extended history of unethical and inhumane medical experiments and persists today due to how this targeted population still experiences mistreatment, racism, and overall health inequalities [43]. Black communities are frequently affected by low income and low literacy levels, which are both determinants that have previously strained access to important COVID-19 information, which further impacted their vaccination rates [44].

Increasing preventative education in marginalized and low-income populations is an important strategy to promote health literacy. Increased education leads to less vaccine reluctance [45]. When compared to no intervention, vaccine education was shown to increase vaccine rates in older individuals [45]. Interactive interventions improved vaccination rates more than non-interactive interventions [45]. A single additional year of schooling has proven to reduce vaccination reluctance by around 16 percentage points [67]. We must prioritize and focus on developing education awareness, especially in schools with low literacy rates, to ensure that all populations and communities benefit from healthy lifestyles and well-being equally.

To construct a toolkit, we must first seek out previous toolkit initiatives and compare existing ones in similar areas. In Virginia, the Department of Health collaborated with ImmunizeVA to combat vaccine reluctance by developing a Vaccine Literacy Toolkit for libraries in various neighborhoods and their communities. The toolkit has numerous resources that are easily attainable and available, such as fact sheets and discussion guides. The toolkit involved trusted local voices to provide information to the community [68]. When communities hosted events, culturally appropriate literature was distributed to encourage health-informed conversation. Overall, this toolkit included a curated reading list of engaging, age-appropriate vaccine resources, clear, evidence-based vaccine information without the need for experts, fact sheets, FAQs, conversation guides, and programming ideas tailored to the needs of librarians and community leaders [68]. Due to this toolkit specifically tailoring its information to meet the needs of the population through using trusted voices, adapting its language to age and literacy levels, as well as simplifying language, it has greatly engaged and helped the public understand the importance of vaccination.

This relationship between the Department of Health, ImmunizeVA, and the communities the toolkit reached has caused an increased vaccination trust and outreach in underprivileged populations [68]. This finding suggests that we use our resources to improve the health literacy in underserved settings and systems in order to attain health equity and vaccine confidence [69].

Through partnering with trusted local stakeholders such as faith-based organizations [46], community groups, and libraries, we will

be able to seek out the effects of the subjective norm construct of the Theory of Planned Behavior [47]. These institutions are historical; they hold influence within their communities and can help shape positive social expectations around vaccination [48,49]. When individuals see respected community figures that they cherish and look up to, who endorse and support vaccination, they are more likely to perceive vaccination as a socially approved and expected behavior, thereby increasing their intention to get vaccinated [47,48].

Literacy Buffalo Niagara has previously attempted to increase health literacy in Buffalo by hosting a free “Digi-Skills” training. Their entire curriculum, called “Digi-Skills”, covered how to operate a computer, navigate the internet, attend and engage in telehealth appointments, start an online job search, create an email account, and more [70]. Such activities contribute to increasing basic knowledge in all sectors, including health, by ensuring that marginalized populations that may lack any or a stable internet connection, educational knowledge, or digital understanding, have access and training in order to access health information that can improve their health. When people feel capable and readily informed, they are more likely to view actions such as vaccination or healthcare that is routine, as beneficial and something they can effectively manage on their own [50,51]. In this way, improving health literacy plays an important role in creating and keeping positive attitudes towards health, as it allows individuals to have and sustain the capability of knowing and understanding all information pertaining to their health [52,53]. This supports the attitude construct of the Theory of Planned Behavior.

While initiatives like Digi-Skills by Literacy Buffalo Niagara are steps towards improving the health literacy of underrepresented populations, there are still many barriers that continue to hinder vaccine uptake and overall health engagement among marginalized populations. To design a toolkit that is inclusive and effective in such communities, it is important to acknowledge the importance that faith-based leaders have in underserved communities. It is also important to acknowledge barriers such as reading levels and difficulties navigating the health system due to age constraints or literacy, and increasing positive connotations to vaccinations. These all aid in shaping individuals’ experiences and perceptions of vaccination [54]. Not only analyzing, but understanding these will enable us to continue to utilize the Theory of Planned Behavior in efforts to integrate components that are evidence-informed in order to respond to real-world needs.

As it relates to public health and biomedical informatics, in addition to addressing structural and social barriers that underserved populations may face, integrating biomedical data and using behavioral analytics based on real-time data into the toolkit, this can aid in further enhancing the relevance and

effectiveness of the toolkit. Recent studies that have utilized Sentiment Analysis, natural language processing, and geospatial modeling have shown how public attitudes towards vaccines can vary based on time and location [14,55,56]. These three analytical tools allow us to observe and look into vaccine hesitancy trends, public trust in topics such as vaccination, and sentiments that have evolved, which are all insights that can be used to inform tailored communication strategies and intervention efforts [14]. By utilizing these biomedical and behavioral tools and data, they can help ensure that the toolkit remains relevant and responsive to the constantly changing perceptions of the public. This can contribute to seeking ways to support a greater vaccine acceptance and increased uptake.

In addition to utilizing natural language processing tools for sentiment analysis, developing a Mobile Health Literacy App is key to this toolkit. To reduce vaccine hesitancy and improve health outcomes in Buffalo, the mobile health literacy app and toolkit will include features designed to address key predictors of behavior identified in the Theory of Planned Behavior. These include vaccine education written in plain language, adapted to at least a third-grade reading level, a FAQ section that directly addresses common vaccine myths using trusted sources, community testimonials, and push notifications for vaccine reminders, each tailored to improve users’ attitudes, perceived control, and social norms around vaccination. This intervention will be provided to facilitate vaccination directly by leveraging, but not trying to change, what people think and feel [57].

Given the fact that internet access is a social determinant of health [58], the digital divide in underserved communities in Buffalo, NY, remains a priority. Our consideration is that for individuals who don’t have internet access, access to the multi-lingual Mobile Health Literacy application will be placed in areas like community-based centers and transportation, such as local libraries and community centers, or buses. These community-based centers will serve as sites for the Mobile Health Literacy application to distribute vaccine health education for vaccine uptake and health literacy for various public health efforts [59]. Engagement between the community and its centers will allow for increased vaccine uptake, as it will increase equitable access to vaccine information [[60]. Placing the application in community sites such as libraries, churches, or local community centers targets the subjective norm by embedding vaccine education within trusted and socially influential spaces [47]. For example, in one study expanding vaccination access in underserved communities across Maryland through a collaborative approach, education outreach from trusted messengers of pharmacists, pharmacy students, pharmacy technicians, community and public health workers, and primary care physicians to 105,785 individuals resulted in 23,521 (22%) administered vaccines, 11,405 (48%) of which occurred through

individualized scheduling of vaccines in community settings [60].

Our outcome measures include comprehension of the importance of vaccines, actual vaccine uptake, and community engagement in vaccination efforts. In addition, evaluation of attitudes towards vaccination will be observed to determine if there is a positive shift for vaccination through the Mobile Health Literacy application and toolkit distribution. The long-term outcome is sustained behavioral change, recognizing that such change may be immediately difficult to achieve.

Limitations

While this rapid review provides many strategies to reduce vaccine hesitancy, there are a few limitations noted. The Theory of Planned Behavior consists of three constructs: attitude, perceived behavioral control, and subjective norms. However, not all studies using the Theory of Planned Behavior addressed each construct comprehensively or equally as in some studies, some constructs were inconclusive. In these studies, this may limit the ability to fully compare the influence of each construct in shaping vaccine hesitancy and behavior. In addition, this toolkit is designed specifically for Buffalo, New York, with the intention of utilization around the nation, but due to the specificity, this draws only on socioeconomic and health literacy data for Buffalo, New York. The applicability of the toolkit may be limited outside of similar urban settings with comparable demographic and structural conditions, such as rural settings, since Buffalo is majority urban. To conclude, although the intervention is targeted towards addressing mistrust through education and trusted messengers such as healthcare workers, deeper issues related to systemic racism and healthcare inequities may persist and require a variety of healthcare systems that go beyond the scope of this review.

Conclusion

To conclude, by utilizing the Theory of Planned Behavior and its three constructs, which are attitude, subjective norms, and perceived behavioral control, we will be able to better understand and address the various factors that influence vaccine hesitancy. Through the development of a Mobile Health Literacy App and a comprehensive Health Literacy Toolkit, we will be able to offer a targeted, evidence-informed strategy to increase vaccine uptake in the underserved communities of Buffalo, New York. By ensuring that such strategies are accessible, culturally competent, and community-embedded in education, these interventions will aim to improve health literacy, foster positive attitudes towards vaccination, strengthen supportive social norms, and enhance individuals' confidence in their ability to make informed health decisions, such as getting vaccinated. All in all, these tools support the long-term goal of behavioral change by correlating positive attitudes to increase vaccine uptake.

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References

1. World Health Organization (2015) Vaccine hesitancy: A growing challenge for immunization programmes.
2. Office of Disease Prevention and Health Promotion (2020) Health Literacy in Healthy People 2030.
3. National Institutes of Health. Health Literacy.
4. Hange N, Agoli AM, Pormento MKL, Sharma A, Somagutta MR, et al. (2022) Impact of COVID-19 response on public health literacy and communication. *Health Promot Perspect* 12: 1-9.
5. Nwachukwu G, Rihan A, Nwachukwu E, Uduma N, Elliott KS, et al. (2024) Understanding COVID-19 Vaccine Hesitancy in the United States: A Systematic Review. *Vaccines* 12: 747.
6. Hussain B, Latif A, Timmons S, Nkhoma K, Nellums LB (2022) Overcoming COVID-19 Vaccine Hesitancy among Ethnic minorities: a Systematic Review of UK Studies. *Vaccine* 40: 3413-3432.
7. Savoia E, Masterson E, Olander DR, Anderson E, Farah AM, et al. (2024) Determinants of Vaccine Hesitancy among African American

- and Black Individuals in the United States of America: A Systematic Literature Review. *Vaccines* 12: 277.
8. Robinson R, Nguyen E, Wright M, Holmes J, Oliphant C, et al. (2022) Factors contributing to vaccine hesitancy and reduced vaccine confidence in rural underserved populations. *Humanities and Social Sciences Communications* 9: 416.
9. Zheng Y, Frew PM, Wang D, Eiden AL (2025) Factors associated with parental literacy and hesitancy toward pediatric vaccination. *BMC Public Health* 25: 2201.
10. Brookes E (2023) The Theory of Planned Behavior - Simply Psychology.
11. Asare M (2015) Using the Theory of Planned Behavior To Determine the Condom Use Behavior Among College Students. *Am J Health Stud* 30: 43-50.
12. Capasso M, Conner M, Caso D (2024) Testing an extended theory of planned behaviour in predicting Covid-19 vaccination intention over the course of the pandemic: A three-wave repeated cross-sectional study. *Heliyon* 10: e24826.
13. Wallston K (2015) Perceived Behavioral Control - An overview.
14. Ye J, Hai J, Wang Z, Wei C, Song J (2023) Leveraging natural language processing and geospatial time series model to analyze COVID-19 vaccination sentiment dynamics on Tweets. *JAMIA Open* 6: ooad023.
15. Natural Language Processing. NNLM.
16. Khayyam M, Chuanmin S, Salim MA, Nizami A, Ali J, et al. (2022) COVID-19 Vaccination Behavior Among Frontline Healthcare Workers in Pakistan: The Theory of Planned Behavior, Perceived Susceptibility, and Anticipated Regret. *Front Psychol* 13: 808338.
17. Bernat DH, Gerend MA, Chevallier K, Zimmerman MA, Bauermeister JA (2013) Characteristics Associated With Initiation of the Human Papillomavirus Vaccine Among a National Sample of Male and Female Young Adults. *J Adolesc Health* 53: 630-636.
18. Shah SFA, Ginossar T, Bentley JM, Zimet G, McGrail JP (2021) U Using the Theory of Planned behavior to identify correlates of HPV vaccination uptake among college students attending a rural university in Alabama. *Vaccine* 39: 7421-7428.
19. Thomas T, Blumling A, Delaney A (2015) The Influence of Religiosity and Spirituality on Rural Parents' Health Decision Making and Human Papillomavirus Vaccine Choices. *ANS Adv Nurs Sci* 38: E1-E12.
20. Hittson H, McAleer L, Saucedo L, Mahler L, Andino G, et al. (2023) Association between Religious Beliefs and HPV Vaccination Attitudes among College Students. *Vaccines* 11: 1623.
21. Patwary MM, Disha AS, Hasan M, Bardhan M, Hasan M, et al. (2023) Integrating health belief model and theory of planned behavior to assess COVID-19 vaccine acceptance among urban slum people in Bangladesh. *PLoS One* 18: e0290412.
22. Husain F, Shah Nawaz MG, Khan NH, Parveen H, Savani K (2021) Intention to get COVID-19 vaccines: Exploring the role of attitudes, subjective norms, perceived behavioral control, belief in COVID-19 misinformation, and vaccine confidence in Northern India. *Hum Vaccin Immunother* 17: 3941-3953.
23. Hossain MB, Alam MZ, Islam MS, Sultan S, Faysal MM, et al. (2021) Health Belief Model, Theory of Planned Behavior, or Psychological Antecedents: What Predicts COVID-19 Vaccine Hesitancy Better Among the Bangladeshi Adults? *Front Public Health* 9: 711066.
24. Askelson NM, Campo S, Lowe JB, Smith S, Dennis LK, et al. (2010) Using the Theory of Planned Behavior to Predict Mothers' Intentions to Vaccinate Their Daughters Against HPV. *J Sch Nurs* 26: 194-202.
25. Santangelo OE, Provenzano S, Di Martino G, Ferrara P (2024) COVID-19 Vaccination and Public Health: Addressing Global, Regional, and Within-Country Inequalities. *Vaccines* 12: 885.
26. Ekezie W, Awwad S, Krauchenberg A, Karara N, Łukasz Dembiński L, et al. (2022) Access to Vaccination among Disadvantaged, Isolated and Difficult-to-Reach Communities in the WHO European Region: A Systematic Review. *Vaccines* 10: 1038.
27. Essa-Hadad J, Gorelik Y, Vervoort J, Jansen D, Edelstein M (2024) Understanding the health system barriers and enablers to childhood MMR and HPV vaccination among disadvantaged, minority or underserved populations in middle- and high-income countries: a systematic review. *Eur J Public Health* 34: 368-374.
28. Kolobova I, Nyaku MK, Karakusevic A, Bridge D, Fotheringham I, et al. (2022) Vaccine uptake and barriers to vaccination among at-risk adult populations in the US. *Hum Vaccin Immunother* 18: 2055422.
29. CDC (2024) Ensuring Vaccine Access for All People. *Vaccines & Immunizations*.
30. Escobar ML, Griffin C, Paul R (2010) The Impact of Health Insurance in Low-and Middle-Income Countries.
31. Limbu YB, Gautam RK, Zhou W (2022) Predicting Vaccination Intention against COVID-19 Using Theory of Planned Behavior: A Systematic Review and Meta-Analysis. *Vaccines* 10: 2026.
32. Naidoo D, Meyer-Weitz A, Govender K (2023) Factors Influencing the Intention and Uptake of COVID-19 Vaccines on the African Continent: A Scoping Review. *Vaccines* 11: 873.
33. Afrifa-Anane GF, Larbi RT, Addo B, Agyekum MW, Kyei-Arthur F, et al. (2022) Facilitators and barriers to COVID-19 vaccine uptake among women in two regions of Ghana: A qualitative study. *PLoS One* 17: e0272876.
34. Wolfe MK, McDonald NC, Holmes GM (2020) Transportation Barriers to Health Care in the United States: Findings From the National Health Interview Survey, 1997-2017. *Am J Public Health* 110: 815-822.
35. Carroll JC, Herbert SMC, Nguyen TQ, Schork CJ, Kampas LN, et al. (2024) Vaccination equity and the role of community pharmacy in the United States: A qualitative study. *Vaccine* 42: 564-572.
36. Fossos N (2019) Theory of Planned Behavior - An overview.
37. Health Behavior. Google Books.
38. Xiao X, Wong RM (2000) Vaccine hesitancy and perceived behavioral control: A meta-analysis. *Vaccine* 38: 5131-5138.
39. American Academy of Pediatrics (2026) Addressing Low Health Literacy and Limited English Proficiency.
40. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, et al. (2012) Health literacy and public health: a systematic review and integration of definitions and models. *BMC Public Health* 12: 80.
41. About Us | Literacy New York. Literacynewyork.org.

42. Adult Literacy Rates Declining in New Study – LBN Calls On WNY Literacy.
43. Rabin Y, Kohler RE (2025) COVID-19 Vaccination Messengers, Communication Channels, and Messages Trusted Among Black Communities in the USA: a Review *J Racial Ethn Health Disparities* 12: 134-147.
44. Okoro O, Kennedy J, Simmons G, Vosen EC, Allen K, et al. (2022) Exploring the Scope and Dimensions of Vaccine Hesitancy and Resistance to Enhance COVID-19 Vaccination in Black Communities. *J Racial Ethn Health Disparities* 9: 2117-2130.
45. Chan YT, Chair SY, Gao RT, Ng MH, Lee VWY (2025) Effect of vaccine education intervention on vaccine uptake and vaccine knowledge among older adults: A systematic review with meta-analysis. *Vaccine* 56: 127182.
46. Prescott GM, Prescott WA (2021) Health information technology utilization and impact on COVID-19 vaccination. *J Am Pharm Assoc* (2003) 61: e230-e232.
47. Song MY, Blake-Hepburn D, Karbasi A, Fadel SA, Allin S, et al. (2024) Public health partnerships with faith-based organizations to support vaccination uptake among minoritized communities: A scoping review. *PLOS Glob Public Health* 4: e0002765.
48. Syed U, Kapera O, Chandrasekhar A, Baylor BT, Hassan A, et al. (2023) The Role of Faith-Based Organizations in Improving Vaccination Confidence & Addressing Vaccination Disparities to Help Improve Vaccine Uptake: A Systematic Review. *Vaccines* 11: 449.
49. Strengthening Local Health Departments: Building and Sustaining Faith-Based Partnerships for Vaccine Confidence and Access – NACCHO.
50. Lupu D, Tiganasu R (2024) Does education influence COVID-19 vaccination? A global view. *Heliyon* 10: e24709.
51. Hoffman E, Kahan T, Auerbach E, Brody H, Abramson NN, et al. (2024) Peer education as a strategy to promote vaccine acceptance: A randomized controlled trial within New York community healthcare practices. *Vaccine* 42: 126028.
52. Coughlin SS, Vernon M, Hatzigeorgiou C, George V (2020) Health literacy, Social Determinants of health, and Disease Prevention and Control. *J Environ Health Sci* 6: 3061.
53. Panahi S, Ghalavand H (2024) The mediating role of health literacy in the relationship between self-care and planned behavior against Covid-19. *BMC Infect Dis* 24: 608.
54. Manca TA, Aylsworth L, Driedger SM, MacDonald SE (2024) 'It's really embarrassing [...] to ask for help:' navigating invisible and intersecting inequities in barriers to getting vaccinated. *Journal of Risk Research* 27: 1133-1148.
55. Huang LC, Eiden AL, He L, Annan A, Wang S, et al. (2024) Vaccine sentiments and hesitancy on social media: a natural language processing-powered real-time monitoring system (Preprint). *JMIR Medical Informatics* 12: e57164.
56. Qorib M, Oladunni T, Denis M, Ososanya E, Cotae P (2022) Covid-19 vaccine hesitancy: Text mining, sentiment analysis and machine learning on COVID-19 vaccination twitter dataset. *Expert Syst Appl* 212: 118715.
57. Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A (2017) Increasing Vaccination: Putting Psychological Science into Action. *Psychol Sci Public Interest* 18: 149-207.
58. Sieck CJ, Sheon A, Ancker JS, Castek J, Callahan B, et al. (2021) Digital inclusion as a social determinant of health. *NPJ Digit Med* 4: 52.
59. Pavia G, Branda F, Ciccozzi A, Romano C, Locci C, et al. (2024) Integrating Digital Health Solutions with Immunization Strategies: Improving Immunization Coverage and Monitoring in the Post-COVID-19 Era. *Vaccines* 12: 847.
60. Brandt NJ, Hindman FM, Cherokee Layson-Wolf, Brandt S, Zarowitz BJ (2025) Expanding vaccination access in underserved communities across Maryland through a collaborative approach. *J Am Pharm Assoc* (2003) 65: 102389.
61. Li JB, Lau EYH, Chan DKC (2022) Why do Hong Kong parents have low intention to vaccinate their children against COVID-19? testing health belief model and theory of planned behavior in a large-scale survey. *Vaccine* 40: 2772-2780.
62. Shmueli L (2020) Predicting intention to receive COVID-19 vaccine among the general population using the Health Belief Model and the Theory of Planned Behavior Model. *medRxiv*.
63. Fishbein M, Cappella JN (2006) The Role of Theory in Developing Effective Health Communications. *Journal of Communication* 56: S1-S17.
64. Nkouaga F (2025) Addressing racial disparities in COVID-19 compliance: A community-driven approach using the theory of planned behaviour. *Adv Med Psychol Public Health. Original Article in Sociology of Health* 2: 166-182.
65. Erie County Department of Health. Health Literacy.
66. Preval J (2021) COVID-19 disparity: Buffalo's Black Rock, Riverside neighborhoods report low vaccination rate.
67. Kountouris Y, Remoundou K (2024) Education and vaccine hesitancy: Evidence from the Covid-19 pandemic. *Economics Letters* 240: 111768-111768.
68. Association of Immunization Managers (2025) Virginia: Building Vaccine Confidence Through Collaboration with a State Immunization Coalition.
69. Sentell T, Vamos S, Okan O (2020) Interdisciplinary Perspectives on Health Literacy Research Around the World: More Important Than Ever in a Time of COVID-19. *Int J Environ Res Public Health* 17: 3010.
70. Erie County Department of Health joins Literacy Buffalo Niagara, Buffalo Center for Health Equity, Buffalo & Erie County Public Library and Erie Niagara AHEC to promote Health Literacy Month | Erie County Department of Health.