VACÚNATE: Vaccine Access Through Communication, Understanding, and Tailored Interventions

by
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“Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.”

-Marie Curie

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Abstract

The COVID-19 pandemic has underscored the urgent need for equitable access to public health interventions, healthcare, and accurate health information. This dissertation aims to address health disparities and improve COVID-19 vaccine uptake through culturally tailored interventions and misinformation mitigation strategies.

Paper 1 focuses on identifying barriers and enablers to COVID-19 vaccine uptake among participants in the San Francisco Department of Public Health contact tracing program. Seventeen interviews were conducted, and data analysis employed the Capability, Opportunity, Motivation Behavior model (COM-B) and the Behavior Change Wheel framework. Barriers to vaccine uptake included an unprepared health system, fear of side effects, limited knowledge, and conflicting information. Interventions targeting education, enablement, and environmental restructuring were identified as effective strategies.

Paper 2 evaluates the impact of culturally and linguistically tailored informational videos delivered via social media campaigns on COVID-19 vaccine uptake in Indigenous Maya communities in Guatemala. Pre- and post-intervention surveys were collected from 1,572 participants, and logistic regression models were utilized. Results indicated that exposure to the intervention videos increased the odds of vaccination by 1.78 times compared to those who did not see the videos. Culturally sensitive information delivered through trusted sources on social media was found to positively influence vaccination uptake.

Paper 3 addresses health misinformation among Spanish-speaking communities in the San Francisco Bay Area. Through formative interviews and workshops, a co-created checklist was developed to identify and counter health misinformation. Misinformation surrounding vaccine safety, side effects, and government control were identified as concerns. The checklist empowers Spanish-speaking communities to verify information sources, assess trustworthiness, and engage with reliable content.

This dissertation highlights the importance of tailored interventions and misinformation mitigation strategies in addressing health disparities and increasing COVID-19 vaccine uptake. Culturally sensitive approaches, such as multilingual social media campaigns and community co-creation of tools, can effectively counter barriers and empower marginalized populations. By implementing these findings, public health departments can work towards achieving equitable access to healthcare and reducing health disparities during the COVID-19 pandemic and beyond.

TABLE OF CONTENTS

List of Figures

List of Tables

Introduction

The COVID-19 Pandemic

The COVID-19 pandemic has brought global health to the forefront of public attention, highlighting the need for equitable access to public health interventions, healthcare, and health information. COVID-19 is a leading cause of morbidity and mortality globally.[1, 2] As the pandemic disproportionately impacts marginalized communities, addressing health disparities through research and interventions is critical.[3-6] The doctoral research presented in this dissertation focuses on three projects related to COVID-19 vaccination: understanding barriers and enablers to vaccination in Spanish-speaking populations in San Francisco, evaluating a COVID-19 vaccine social media campaign for Indigenous communities in Guatemala, and the development of a tool to aid Spanish in California speakers identify online misinformation.

SARS-CoV-2 was first identified in China following the report of a cluster of pneumonia-like cases in December 2019.[7] The highly infectious virus rapidly spread, and by March 2020 the World Health Organization (WHO) declared it a global pandemic. The pandemic has had a significant impact on global health, economies, and social structures, and as of March 2023, the official global death toll caused by COVID-19 had reached 6.9 million.[8] However, estimates of excess deaths suggest that the actual death toll may be much higher, with some projecting the figure to be closer to 21 million - three times the reported number.[9] The Americas has been one of the hardest hit regions, accounting for 42% of all global deaths despite having 13% of the global populaiton, and within the region and globally.[8]

The COVID-19 pandemic has highlighted existing health inequities and disparities both globally and in the United States. Vulnerable populations, such as racial and ethnic minorities, people living in poverty, and those with preexisting health conditions, have been disproportionately affected by the pandemic.[10] The collateral effects of the pandemic due to a global economic crisis are unequally affecting lower-income populations, making them more vulnerable to other health risks.[11]

Indigenous communities across Latin America, including Guatemala, have faced longstanding and pervasive health disparities, which the COVID-19 pandemic has exacerbated. With under-resourced healthcare systems, limited access to healthcare services, and a lack of hospital beds and skilled healthcare workers, these communities have been disproportionately impacted by the pandemic.[11] Furthermore, indigenous peoples have historically experienced significant discrimination based on ethnicity, poverty, and language, which have resulted in profound barriers to healthcare access.[12] Indigenous populations have been especially vulnerable to the COVID-19 virus due to poor access to healthcare, higher rates of communicable and non-communicable diseases, and a lack of access to essential services and preventive measures such as clean water, sanitation and information.[13]

In the United States, the pandemic has also revealed striking racial and ethnic disparities.[14] Latinx individuals, particularly those who are immigrants, have experienced a higher risk of infections, hospitalizations, and deaths compared with non-Latinx White individuals.[15] Latinx individuals are also more likely to lack healthcare access, live in poverty, use public transportation, be employed in the essential workforce, and reside in high-density, multigenerational housing.[16] Structural racism continues to impede equal access to health for all, leading to communities of color experiencing a higher rate of death due to COVID-19 compared with their White counterparts.[17]

COVID-19 Prevention

COVID-19 can range from asymptomatic to severe, affecting people of all ages and backgrounds. While anyone can contract COVID-19, certain risk factors have been identified for developing severe disease. These include underlying health conditions like diabetes, obesity, and hypertension, as well as non-health related factors such as age, race, ethnicity, and occupation.[18]

To combat the spread of COVID-19, a range of public health interventions have been developed, including non-pharmaceutical interventions (NPI) and pharmaceutical interventions. NPIs like physical distancing, masking, contact tracing, isolation and quarantine, testing, and hygiene measures were initially adopted to prevent the spread of the virus. However, from the beginning, inequities in the adoption of these interventions were evident, with some populations less likely to adhere to them.[19] As pharmaceutical interventions like vaccines and therapies became available, additional barriers to disease prevention emerged, such as access to healthcare, insurance, and technology, widening the disparities in COVID-19 outcomes.[20]

COVID-19 Vaccines

In December 2020, a year after the first case of COVID-19 was reported, the first vaccines began to be administered to the public following the completion of all necessary scientific trials and approvals. This remarkable achievement was made possible by several factors, including previous vaccine research, advancements in vaccine manufacturing processes, and adequate funding. Unlike previous vaccines, which often took several decades to develop, highly effective and safe vaccines for COVID-19 were developed in just one year.[21]

COVID-19 vaccines have played a crucial role in reducing COVID morbidity and mortality worldwide since their rollout. Within the first year of their availability, the vaccines prevented an

estimated 14.4 million deaths globally. This number rose to nearly 20 million when estimated using excess mortality data.[22] In the United States alone, the vaccines prevented an estimated 3.25 million COVID-19 deaths between December 2020 and 2022.[23] However, the benefits of the vaccines could have been even more significant if they were distributed more equitably to meet the World Health Organization's 40% vaccination coverage target. Studies show that if this target had been achieved globally, an additional 599,300 deaths could have been prevented in just one year.[22] The unequal distribution of vaccines can lead to significant disparities in access and health outcomes, particularly for marginalized communities, not only between countries but also within them.

Vaccine distribution in the United States has been inequitable, with Black and Hispanic individuals less likely to be vaccinated. Although initial efforts to narrow these disparities were promising, recent data shows that these inequities have resurfaced with the introduction of new boosters, which only 25% of Latinos in California have received, compared to 46% of non-Hispanic Whites.[15] Similarly, in Guatemala, there are significant differences in the vaccination rates between various communities. Most COVID-19 vaccines have been given out in urban areas, resulting in a lack of access for many rural indigenous communities. Even though indigenous people make up more than 40% of the country's population, the areas where they mostly reside have the lowest vaccination rates. For example, 70% of people in Guatemala City have been fully vaccinated, compared to 29% of people in the department of Sololá, where almost all residents are Kaqchikel Mayan.[24]

Overall, remarkable progress has been made in reducing COVID-19 mortality. However, it is essential to identify the barriers and enablers specific populations face in accessing COVID-19 vaccines to ensure that the benefits of progress are equitably distributed. The purpose of this research is to identify the factors that prevent vaccine uptake, particularly in high-risk populations,

and to develop and evaluate interventions to facilitate uptake. By doing so, we can better understand how to overcome these obstacles and prepare for future public health emergencies.

Barriers to COVID-19 Vaccination

Research has shown that Spanish speakers in California face unique barriers to vaccine access, including language barriers, mistrust of the healthcare system, and misinformation. Addressing these barriers requires targeted interventions and communication strategies that are culturally sensitive and delivered in their language.[25] Barriers are multifaceted and can be categorized into several factors. Systemic racism and inequalities are among the most significant barriers.[11] These include a lack of access to healthcare, health insurance, immigration status, and safety nets, disproportionately affecting marginalized communities.[25, 26] System failures are also significant barriers, including unequal vaccine distribution, a shortage of vaccines, a lack of culturally and linguistically appropriate information, and vaccination site locations that are not easily accessible for some communities.[27] Individual-level barriers to vaccine uptake and access include low literacy, language barriers, and lack of trust in the healthcare system.[28] Addressing these individual-level barriers requires culturally competent approaches that are sensitive to the needs of different communities.

Indigenous communities, globally face additional barriers to getting vaccinated against COVID-19. Previous studies have identified a range of potential obstacles, including concerns about side effects, language barriers, historical health inequities, vaccine myths and misinformation, and inconsistent supply and availability.[29] Additionally, there are several system-level barriers to vaccination, such as inequitable vaccine distribution across municipalities, inadequate healthcare infrastructure and clinics in Indigenous communities, and a lack of culturally appropriate and linguistically relevant communication campaigns.[12] At the individual level, research has

highlighted several factors hindering vaccine uptake, including fear of side effects, vaccine misinformation, insufficient information, and certain religious beliefs.[29] These barriers are exacerbated by the historical distrust of government among indigenous communities due to years of human rights violations and marginalization, leading to structural racism.[30]

Strategies for Addressing Vaccine Hesitancy and Misinformation

Vaccine hesitancy and misinformation are major public health challenges that have been amplified during the COVID-19 pandemic.[31] Misinformation and disinformation involve spreading false information, but disinformation is characterized by its deliberate and malicious intent. To address this issue, strategies must be developed that promote vaccine confidence and counteract misinformation. One important step is to educate the public about the effectiveness and safety of vaccines, the reliability and competence of the health system, and how researchers and health policymakers decide on vaccine needs.[32]

Spanish speakers in the US are vulnerable to misinformation and are more likely to consume and share disinformation online than the general population.[33] Thus, creating efficient strategies and tools to assist Spanish and indigenous-language speakers in recognizing misinformation on the internet is critical. Strategies may include various techniques such as machine learning, health literacy guidelines, checklists, mythbusters, and fact-checkers. Developing and tailoring effective health communications and campaigns to counter vaccine misinformation is essential to ensure high uptake of vaccines to prevent and control disease outbreaks. Public health institutions should also target their communication to people with low education to reduce communication inequalities.[34] Future research should assess specific communication strategies for public health institutions to overcome vaccine hesitancy and misinformation during public health crises.

Community-engaged Implementation Science Methods for Public Health Interventions

Community-engaged implementation science methods have become increasingly important in designing public health interventions. The COVID-19 pandemic has highlighted the need for targeted behavioral approaches to successfully change behavior and increase adherence to public health measures, including vaccination. Implementation science involves promoting the systematic uptake of research findings and evidence-based practices into routine practice to improve the quality and effectiveness of health services.[35] To achieve this goal, community engagement is essential to incorporate unique perspectives from communities experiencing health inequities, which have historically been left out of the research process.

By engaging community stakeholders throughout the research process, community-engaged dissemination and implementation research can help improve health inequities through the development of tailored strategies that consider structural, systems, and socially based drivers of risk and inequity.[36] This approach is critical to accelerate and improve the implementation of evidence-based interventions to reduce health inequities. Meaningful community engagement is instrumental to the effective implementation and sustainment of equitable public health interventions. Engaging communities can help tailor interventions to the needs of the communities themselves and promote community health and research quality.[37]

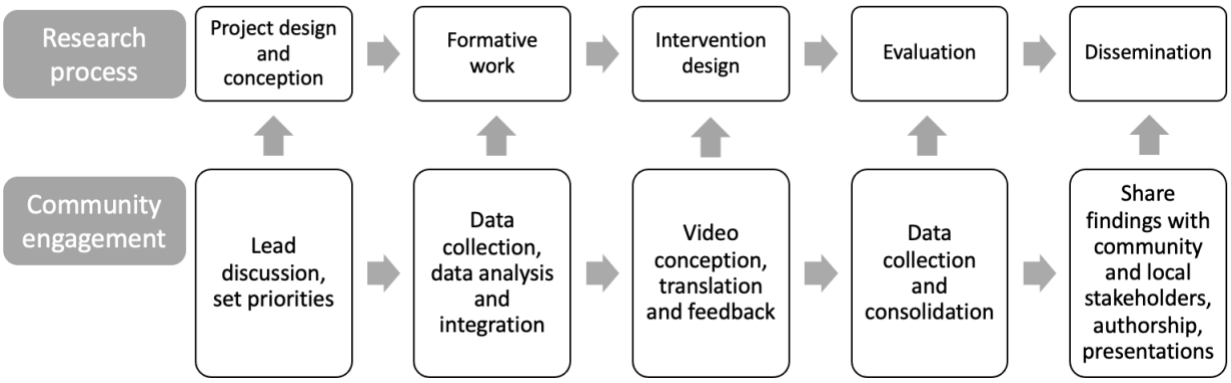

Figure 0.1. Example of community engagement in the development of a COVID-19 vaccine education campaign.

Research in this Dissertation

The first chapter of this work is a study that was embedded in the San Francisco Department of Public Health's contact tracing program. We were tasked to identify barriers and enablers to COVID-19 preventive measures, including vaccination in the city's Spanish speakers, who were the most affected group during the first year of the pandemic. We employed qualitative interviews to analyze the barriers and enablers to vaccine uptake using implementation science frameworks, specifically through a Capability, Opportunity, Motivation Behavior (COM-B) model and the Behavior Change Wheel framework, which links intervention functions and supporting policies to the identified barriers. We found that the barriers participants faced were an unprepared health system, fear of side effects, limited knowledge, and conflicting information. The intervention functions that would address barriers were education, enablement, and environmental restructuring. Finally, policies, including communication and marketing and environmental planning, could significantly increase vaccination. Public health departments should tailor interventions to high-risk populations by first understanding the specific barriers they face and highlighting the role of implementation science in achieving this goal.[25]

In the second chapter, we aimed to evaluate the impact of culturally and linguistically tailored informational videos on COVID-19 vaccine uptake in indigenous Maya communities in Guatemala. We utilized a pre-post intervention design where we collected in-person pre-intervention surveys from a sample of respondents in four rural municipalities in March 2022. Then, we delivered COVID-19 vaccine informational videos in Spanish, and two indigenous Mayan languages (Kaqchikel and Kiche) via social media campaigns for three weeks. We conducted post-intervention surveys by telephone among the same participants in April 2022. We used logistic regression models to estimate the odds ratio of COVID-19 vaccine uptake following exposure to the intervention videos. Our findings suggest that culturally and linguistically tailored videos addressing COVID-19 vaccine misinformation deployed over social media can increase vaccinations in a rural, indigenous population in Guatemala, indicating that social media content can influence vaccination uptake. [29, 38]

For the third and last chapter, we co-designed a tool to combat health misinformation among Spanish-speaking individuals in the San Francisco Bay Area. To achieve this, we partnered with Mujeres Activas y Unidas, a community-based organization in the Bay Area. We conducted workshops in Spanish via Zoom with 12 self-identified Hispanic or Latina women. The workshops focused on identifying practical steps to identify and challenge misinformation related to COVID-19, and the resulting tool outlined 10 steps in Spanish and English. The tool was refined with the input of community partners and directly informed by the data collected from the workshops. Through active discussions, participants shared strategies for identifying misinformation, such as evaluating the source, messenger, message, tone, and content of the information presented. The tool we developed can help Spanish speakers challenge misinformation and access reliable sources of health information, which can ultimately inform targeted interventions to promote health and increase COVID-19 vaccine uptake among this vulnerable population.

The goal of this doctoral work was to explore and evaluate interventions to increase COVID-19 vaccine uptake among vulnerable populations and contribute to developing effective strategies to promote health equity during public health emergencies. In the context of the COVID-19 pandemic, it highlights the importance of understanding the specific barriers faced by at-risk populations, tailoring interventions to address these barriers, and using implementation science frameworks to guide intervention development. These findings can inform interventions and policies to increase vaccination and promote health among vulnerable populations in future public health emergencies. Ultimately, this work aims to advance global health by promoting health equity and reducing health disparities

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Chapter 1: Barriers and Enablers to COVID-19 Vaccination in San Francisco's Spanish-Speaking Population

Abascal Miguel, L., Christian, C., Accurso, E.C. *et al.* Barriers and Enablers to COVID-19 Vaccination in San Francisco's Spanish-Speaking Population. *Glob Implement Res Appl* **3**, 56–66 (2023). https://doi.org/10.1007/s43477-023-00071-w

Abstract

Populations at high risk for COVID-19-- including Spanish speakers—may face additional barriers to obtaining COVID-19 vaccinations. By understanding their challenges, we can create more equitable vaccine interventions. This paper presents data from interviews focused on COVID-19 vaccine uptake that was part of a project to improve COVID-19 preventive behaviors in San Francisco. In this study, we used interviews to identify barriers and enablers to COVID-19 vaccine uptake among participants in the San Francisco Department of Public Health contact tracing program. Data analysis employed the Capability, Opportunity, Motivation Behavior model (COM-B) and the Behavior Change Wheel framework as guides to target barriers with interventions and supporting policies. We completed seventeen interviews between February and May 2021; six (35%) were completed in English and 11 (65%) in Spanish. Barriers to vaccine uptake included an unprepared health system, fear of side effects, limited knowledge, and conflicting information. Behavioral factors influencing vaccine uptake were mainly related to physical opportunity, automatic motivation, and psychological capability. Interventions that could address the most significant number of barriers included education, enablement, and environmental restructuring. Finally, communication and marketing policies that use diverse multi-lingual social media and environmental planning that includes accessible vaccine sites for people with disabilities, literacy barriers, and limited English proficiency could significantly increase vaccination. Public health departments should tailor interventions to high-risk populations by understanding the specific

barriers they face. This exploratory study suggests how implementation science can provide frameworks to achieve this.

Background

Despite widespread access to COVID-19 vaccines, the United States lags behind other high-income countries in vaccination coverage [1]. The vaccination gap has impacted the country's ability to fight the pandemic and new waves of infections due to arising new variants. Multiple barriers to vaccination have been described, including challenges with access, vaccine hesitancy, and lack of readiness. In the US, Black and Latinx people face more barriers than those who identify as White or Asian [2, 3]. Recent surveys have shown that Latinx and low-income participants are more likely to wait to get the vaccine and less likely to trust public health officials regarding COVID-19 [4].

As of December 2021, San Francisco, California, has had one of the lowest COVID-19 case and death counts of any metropolitan city in the United States [5]. Despite the overall success in mitigating the spread of COVID-19, the pandemic has highlighted striking disease disparities, disproportionally affecting racial and ethnic minorities. This is similar to what was observed in the rest of the country, where Black and Hispanic or Latinx persons and Native Americans had higher rates of infection and hospitalization than non-Hispanic White persons [6]. Factors including increased exposure, limited access to information, and limited and differential access to healthcare services, including COVID-19 diagnostics and care, are some of the challenges these communities have faced throughout the COVID-19 pandemic in the United States, including San Francisco [7, 8].

Hispanic or Latinx people comprise 15% of San Francisco's total population but account for 35% of all its COVID-19 cases [9]. The disparity in case rate was more significant in the first year of the

pandemic; from April to June 2020, when 70% of COVID-19 cases and their close contacts participating in the city's contact tracing program were Latinx and of these 85% reported Spanish as their primary language [10]. This project was initiated in response to the San Francisco Department of Public Health's (SFDPH) need to understand adherence to Public Health recommendations within their contact tracing program among Spanish speakers, who were overrepresented in their cases and contacts [10]. The City of San Francisco partnered with UCSF implementation scientists to understand the specific barriers this group faced to prevent infection and later, as vaccines became available, increase vaccine uptake within this group.

There is strong evidence that a targeted behavioral approach is needed to design strategies to successfully change behavior and increase adherence to public health measures [11, 12]. This need has been even more apparent with the COVID-19 pandemic, which has required individuals and communities to act and navigate various behaviors, including vaccination. We must first understand the barriers and enablers driving such behavior in specific communities to design better vaccine interventions. Vaccination strategies that consider human behavior must focus on structural, systems, and socially based drivers of risk and inequity.

We applied a theory-informed assessment to aid the selection of evidence-based intervention strategies to improve uptake of approaches to increase vaccination among the primarily Latinx population in San Francisco, focusing on individual and contextual factors. For this, we used the Capability, Opportunity, and Motivation Behavior (COM-B) Model and related Behavior Change Wheel (BCW) framework to identify specific barriers and enablers in this population and guide the selection of interventions and policies to address them [13]. This paper illustrates one approach for how public health departments can use implementation science frameworks, such as the COM-B model, within their programs to better inform their design by considering the needs of high-risk populations. The objective of the study was to aid the SFPHD in identifying barriers and enablers

contact traced participants were facing in 'real-time' as the pandemic unfolded (shelter in place, masking, vaccination). To build on understanding these barriers, the project also focused on identifying intervention functions and policies to address them. Additionally, this paper seeks to illustrate how implementation science models and frameworks, specifically the COM-B model and BCW framework, can be applied in real-time in public health programs to identify problems and find solutions.

Methods

Setting and Study Design

We conducted a prospective observational qualitative study within the contact tracing (CT) Program in San Francisco, administered by the San Francisco City and County Department of Public Health (SFDPH). The study was iterative and designed to adapt to evolving priorities set by the SFDPH. Initially, the one-year study focused on identifying barriers to behaviors around self-isolation, quarantine, and testing. As vaccines became available, the study pivoted to better understand barriers and enablers to COVID-19 vaccination. This paper includes the subsample of interviews done after COVID-19 vaccines became available. The study was a collaboration between SFDPH and the University of California, San Francisco (UCSF) researchers.

We recruited participants from the San Francisco Department of Public Health's Contact Tracing Program (SFDPH CT) between February and May 2021. We used purposive real-time sampling to find people that recently participated in contact tracing activities using bi-weekly random sampling among COVID-19 contacts, oversampling Spanish speakers to achieve a 2:1 ratio to reflect the demographics of San Francisco's COVID-19 case burden at the time. Eligibility included people over 18 who had been exposed in the last week to COVID-19, were still in quarantine and spoke Spanish or English. We included one participant per household or cluster to increase diversity of the sample and reduce the risk of duplication of findings.

After the SFDPH CT team completed an initial contact tracing call, which reached over 80% of reported COVID-19 exposures, those sampled received a follow-up call from a language-concordant research team member [10]. The interviewer described the study and asked for consent to participate in a one-hour in-depth interview. Interviews were conducted by phone, recorded, transcribed, and translated (for interviews conducted in Spanish). The study team also prepared interview memos following each call. The SFDPH research review committee and the UCSF Committee on Human Research (IRB# 20-31634) approved all study procedures.

Theoretical Approach

We applied the Capability, Opportunity, and Motivation Behavior (COM-B) Model and related Behavior Change Wheel (BCW) as the guiding framework to help us better understand the population and individual behaviors relevant to COVID-19 prevention within each person's specific context. The COM-B model and BCW were developed as a synthesis of nineteen behavior change frameworks identified through a systematic review [14]. The BCW framework uses the COM-B model at its center to identify barriers and enablers to targeted behavior, such as getting vaccinated, in context. COM-B specifies that to change behavior, individuals need to be able to change or have the environment around them support change. Specifically, the framework helps identify whether Capability, Opportunity, and Motivation-related factors drive a specific behavior. For any given behavior, a person needs the 'capability' to perform it, including skills, knowledge, and physical strength; the 'opportunity' in terms of the physical and social environment, affordability, accessibility, and social support; and lastly, they must be 'motivated' to complete such behavior. Once we identify barriers and enablers, the next steps of the BCW provide guidance to identify intervention functions and their supporting policies to address the behavioral barriers and leverage enablers identified through COM-B, thus creating a 'road map' for intervention designs. The BCW framework provides a basis for translating stakeholder input

into interventions that change the desired behavior [15, 16]. For this project, we used COM-B to (1) develop the interview guide and survey; (2) code transcripts and conduct thematic analysis; and (3) prioritize modifiable barriers and enablers for intervention targeting. We then used the BCW to identify a list of intervention functions and supporting policies mapped to the identified barriers and enablers.

Interviews

Using COM-B conceptual model, we developed an in-depth semi-structured interview guide that incorporated findings from an initial assessment of barriers based on previous results [7]. The iterative guide initially asked about COVID-19 prevention barriers and enablers, focusing on behaviors recommended by the CT program and the socio-economic context that contacts were facing (shelter in place, masking, return to work) as they attempted to adhere to recommendations and shifted to ask about vaccines as they became available. This paper reports on those who were included in the vaccine-specific interviews, including behaviors and intervention components that could encourage COVID-19 vaccine uptake. The study sample reflects the composition of the contact tracing program participants at the time of the study. The interviews included questions about motivational barriers, such as beliefs and fear of the vaccine; capability barriers, such as skills related to scheduling and navigating the vaccination process; and opportunity barriers, such as asking about social norms and the influence of peers on their decision to get or not vaccinated against COVID-19.

Additionally, we also asked participants to provide personal recommendations on what would improve vaccine access in their communities, their perceptions of the SFDPH COVID-19-related programs, and the role of community-based organizations (CBOs). The structured part of the survey was completed in REDCap by the interviewer; interviews were recorded with prior consent,

transcribed, and translated to English if conducted in Spanish. Participants received a $25 e-gift card for their participation.

Data Analysis

We analyzed transcripts concurrently with data collection to have a real-time feedback mechanism that included sharing results with the SFDPH CT program in reports and presentations. All transcripts were analyzed to identify perceived and experienced vaccine-related barriers and enablers. We based data analysis on applied qualitative inquiry [17]. A priori codes were determined using the COM-B model, and all transcripts and memos were coded by two independent reviewers using Dedoose version 7.0.23. The coding team had high inter-rater reliability (>80%), as calculated by Dedoose after the coding of 5 initial transcripts through the program's "Training Center," in the analysis planning team meetings. A study team comprised of the primary investigator and three co-investigators met weekly and reviewed findings.

Once we identified what needed to change to increase vaccine uptake through our COM-B behavioral analysis, we used the BCW framework as a guide to identify intervention functions and supporting policies that would be effective against the identified barriers. We used an alluvial chart to graphically depict how barriers link to intervention functions and their supporting policy categories. Our depiction is similar to the wheel the BCW framework uses to show what intervention function and policy categories can be used to address specific COM-B categories[15].

Results

Participants

We completed 17 interviews specific to COVID-19 vaccine uptake barriers and enablers between February and May 2021. Eleven (65%) of the interviews (Table 1) were done in Spanish and 6 (35%) in English. Three participants who completed the interview in English were also Spanish

speaking but preferred English. Overall, most participants identified as female (X%); male and female participation in the English interviews was equally split, while 72% of the Spanish interviews were among females. The mean age for participants was higher for Spanish interviews than for English (41 vs. 36 years, p <.001). Fifteen (88%) of our participants identified as Hispanic or Latino, and 2 (12%) identified as White. All the Spanish-speaking participants lived in zip codes that belong to the first (n=5) and second quartiles (n=6) of median household income in San Francisco. Of the participants that qualified for the vaccine (n=13), ten had received at least one dose of the vaccine. We did not follow up to ask about vaccination status at a later point in time.

Table 1.1 Sociodemographic Characteristics of Participants

Participant Characteristic		By the language of the interview	
	Total n (%)	Spanish n (%)	English n (%)
Completed interviews	17	11 (65%)	6 (35%)[1]
Gender			
Male	6 (35%)	3 (18%)	3 (18%)
Female	11 (65%)	8 (47%)	3 (18%)
Age (mean, range, SD)	39 (24-67, 13.32)	41 (26-65, 12.02)	36 (24-67, 16.13)
Race and Ethnicity			
White	2 (12%)	0	2 (12%)
Hispanic or Latino	15 (88%)	11 (65%)	4 (24%)
High risk for severe COVID-19[2]	6 (35%)	4 (24%)	2 (12%)
Number of people in the household (mean, SD)	4.5 (3)	4.6 (3.8)	4.3 (2.4)
Zip code by median income			
First quartile	6 (35%)	6 (35%)	0
Second quartile	0	5 (29%)	3 (18%)
Third quartile	2 (12%)	0	2 (12%)
Fourth quartile	1 (6%)	0	1 (6%)

Note: Median income quartiles were based on the most recent census data. Zip codes in San Francisco were ordered by median income based on the most recent US census data and divided into quartiles.
[1]Three were bilingual but preferred to be interviewed in English
[2]Patients 65 or over or with a preexisting condition that increases the risk of COVID-19 hospitalization or death

COM-B Barriers and Enabler Themes

We categorized key themes from the analysis using the COM-B model (Table 2). We identified (1) perceived system-level barriers, including poor systems preparedness and a lack of coordination between system players; and (2) individual-level barriers that reflected a wide range of beliefs and experiences, from confusion and lack of clarity about vaccine eligibility to fears of

side effects or government control. Systems barriers fell into the COM-B category of *opportunity* barriers and were reported more frequently in the early phases of vaccine roll-out. Participants mentioned the system was unprepared to provide vaccines, for example, by having strict eligibility criteria that confused who qualified and when, and perceived a lack of communication and coordination between vaccine providers. On the individual level, the main *capability* barriers were knowledge about the safety and side effects related to the vaccine and limited skills to gain such information.

In many cases, participants referred to social media/networks to fill in gaps rather than health systems providers. Many participants did not know how the vaccines work, how they were produced, and how the government regulated the approval process. Some participants lacked the skills to seek information or schedule an appointment online due to low general and tech literacy. A consistent theme was the role of social media as a source of information and misinformation. Health concerns that reduced *motivation* for vaccination included fear of immediate and long-term side effects and worry that the vaccine would not protect against new variants. Some participants cited media stories about side effects such as blood clots and myocarditis. Legitimacy concerns included the speed at which the vaccines were produced and approved (too fast) and the potentially disingenuous role the government might have played.
Contrary to widespread views that hesitancy was the main barrier among the unvaccinated, we found that perceived structural barriers around access played a more prominent role in our sample. However, two participants mentioned opposing getting vaccinated.

We also identified several themes related to facilitators that enabled participants to get vaccinated, which again focused on vaccine access and social support to motivate them to get vaccinated. More than half of the participants referred to the encouraging, enabling, and supportive roles of specific community-based organizations (CBOs) and individual community

leaders (such as church leaders and neighbors involved in non-profits). Participants who had connections to a community group reported more straightforward navigation to get the vaccine because of the relationship. Other enablers included outreach from clinics, language and cultural concordance of information, and vaccine sites.

Table 1.2 Main Barriers and Enablers for COVID-19 Vaccination by COM-B Category

COM-B Category	Barrier and enabler themes (N)	Example Quote
Capability Barriers	Poor or limited understanding of the safety and effectiveness of the vaccine makes people hesitant. (N= 9)	"I don't even really trust the vaccine just because how could you have a vaccine for something that you don't know… that you don't know where it came from? But you don't have a vaccine for HIV, AIDS, you don't have a vaccine for cancer, lupus, none of vaccines for none of these other things but you have a vaccine for COVID-19. And then it's like, what's the purpose of the vaccine if you can still catch COVID? So basically, I'm injecting some foreign object inside me because I don't know what it is, you are injecting something inside of me because you feel like it's the vaccine for COVID. But if you don't know where COVID is from, how can you make a vaccine for it? You can't."
	Conflicting information from different sources creates confusion and hinders the ability to decide on the vaccine. (N= 6)	"Things that I hear in the news about the vaccine are confusing. They say one thing and then another. Honestly, I don't know what to think."
Capability Enablers	Community-based organizations play a vital role in encouraging and facilitating vaccination. (N= 9)	"I went to 18th and Shotwell; one of my friends gave me this info. He works in a CBO. I was looking for an appointment close to me, but there weren't any. I was worried because they weren't any appointments for this year. It was saturated. So, I went to where the CBO told me, so I just walked there, and everybody was super nice. I didn't even have to wait. It didn't even hurt. I waited there for 15 minutes, and everything went great. People were amazing. I was expecting a more complicated experience with longer lines."
	A more nuanced understanding of the vaccine increases confidence in vaccination decision-making. (N= 17)	"I think that the way it goes, that it's about not getting COVID. I might still get it, but it won't kill me. So that's what I understand from the vaccine. I don't think it makes me like immune to it, that I'll never get COVID, I think there is a very good a chance I could still get it, but especially if I go out and not everyone is vaccinated, but because of that, it won't kill me."
Opportunity Barriers	The lack of clear communication between health systems, providers, and patients created confusion around vaccine eligibility, appointments, and roll-out. (N= 6)	"The hardest thing is trying to find out about the vaccines. You know, I mean, in SF it's so chaotic. No one knows what they're doing. You can't get an answer. They kind of blew me off. Said that I needed to wait and pay attention to the news."
	A lack of coordination within the system complicates navigation and access. (N= 17)	"Most of the time people are going to be working 8-12 hour shifts and hard to go through loopholes and going to inconvenient places and deal with people if they're rude."

COM-B Category	Barrier and enabler themes (N)	Example Quote
Opportunity Enablers	Identifying as part of a group or religion that is pro-vaccine makes people confident and vocal about others being vaccinated. (N= 8)	“I was able to do it through the organization "Excelsior Strong." It makes a big difference to have organizations help. I belong to an Aztec dance group, and a member was able to schedule all the Elders of the group to get vaccinated. Around 10 of us went.”
	Vaccine outreach from CBOs, clinics, or health departments increases the completion of vaccination. (N= 6)	“When my parents were eligible for the vaccine they got notified via text, which made things easier. I would like that as well.”
Motivation Barriers	People are afraid of long-term side effects and permanent changes to the body. (N= 14)	“I plan on getting it in two years. I gave it two years to see how people's bodies react, because you know people are saying on the second shot, they are getting a little cold maybe, they have a little cough, a headache, or a little fever maybe, but that's only because they only get that after that second shot. But what's going to happen after 2 years? How is the shot going to affect your body then? I would rather just give it a time period, so I see how it’s going affect people's bodies. I know more than 20 people who have it, so I'm going to see this how going to affect their bodies.”
	Legitimacy Concerns: Vaccine is new and not well tested yet, mistrust in government. (N= 9)	“I feel like the roll-out of the vaccine was rushed, I just don’t how effective it would have been if we could have waited a little longer or put more time into making the vaccine. For example, the J&J was recalled; they had to recall a certain lot for Moderna, etc. I know that they had to rush it because of the severity of the pandemic, but I always wonder if they had more time or did things a little more different.” “I’m hesitant and scared of the agenda behind the vaccine and why it's being pushed. I don’t understand why it has to be something that everyone has to get. Why does it have to be mandated?”
Motivation Enablers	A trusted person and community setting are motivating for vaccination (N= 12)	“The Priest in the church I go to is very involved and has talked a lot about the virus, they've used the church for testing.”
	Fear of getting COVID inspires vaccination (N= 7)	“I'm concerned about getting covid. Once I get vaccinated, the side effects are worth it. I had family members in Los Angeles who passed away due to COVID or got really ill, which made me really want to get it.”
	Getting the vaccine is a positive commitment to friends, family, community (N= 13)	“It's important to protect the most vulnerable community.”

Note. N= number of participants that identified each barrier

Linking Barriers to Intervention Functions and Policy Categories

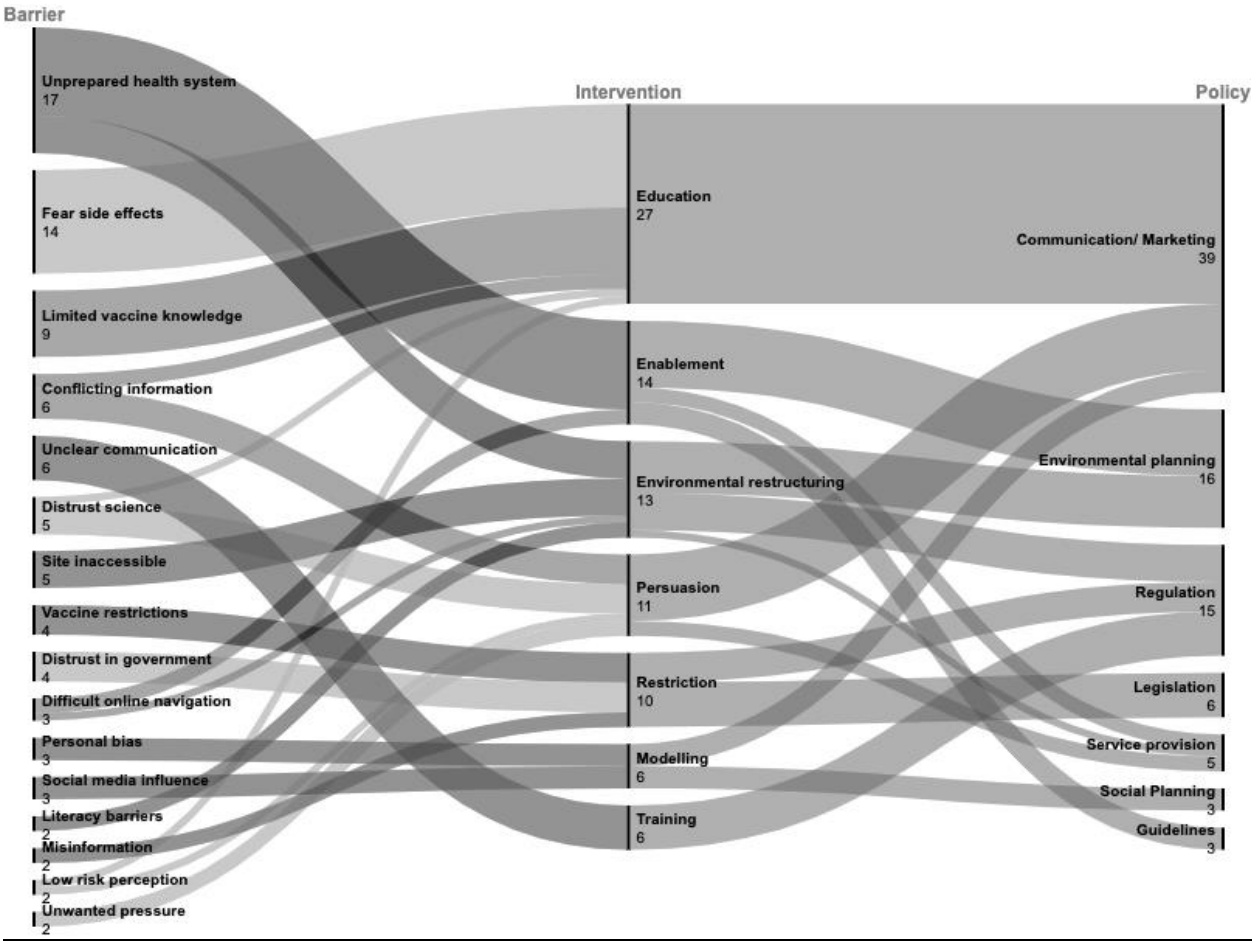

Figure 1.1 Alluvial chart of barriers, intervention functions and policies.

Figure 1.1 maps how the barriers identified through our interviews and described in table 2 link to intervention functions and policies. The alluvial chart shows the identified barriers color-coded by their COM-B category. Each barrier flows to its corresponding intervention function, and each intervention function to a policy category. The distilled data set was imported to RAWGraphs, an open-access data visualization application to create an alluvial chart. An alluvial chart is a flow chart that helps identify patterns and trends, data categories, and rankings. Variables are assigned to nodes in the parallel columns. Each node represents values ordered in descending order based on their frequency; it shows observations with a stream flowing through the nodes. Alluvial charts are read from left to right, and the size of the vertical nodes (black line) and the

stream's width are proportional to the frequency, also shown numerically. The chart shows, from left to right, the identified vaccine uptake barriers, the potential intervention functions and the policies to consider to address the barriers. Barriers in the first column are the same as those discussed in table 2. The barrier colors represent their COM-B categories, red for capability, green for opportunity, and yellow for motivation. Barriers were only counted once for each participant, even if they came up more times during the interviews.

For example, looking at the first barrier, "unprepared health system," we can see that all participants (N=17) mentioned it; this is green given that it is an opportunity barrier under COM-B. The stream then flows to the intervention functions, identified through the BCW, that would be adequate for this barrier, in this case, enablement and environmental restructuring; lastly, the stream flows to different policy categories that would support the delivery of these interventions, including environmental planning, service provision, and guidelines.

The main barriers (column 1) that participants faced the most to access a COVID-19 vaccine were an unprepared health system (n=17), fear of side effects (n=14), limited vaccine knowledge (n=9), and conflicting information (n=6). The COM-B category to which the most barriers belonged was physical opportunity which refers to the opportunity afforded by the environment to get vaccinated; unprepared health system, unclear communication, inaccessible vaccine sites, and literacy barriers were all part of this category. Automatic motivation and psychological capability barriers were also important categories. Fear of side effects was the most significant contributor to automatic motivation, while limited vaccine knowledge and conflicting information made up psychological capability. The intervention functions (column 2) to which the most barriers were linked were education, followed by enablement and environmental restructuring. Lastly, the most relevant policy considerations (column 3) included communication and marketing, environmental planning, and regulation.

Discussion

The COVID -19 pandemic has disproportionally affected racial and ethnic minorities in the United States, these groups may face additional challenges to adhere to prevention measures. Public health programs should be specifically tailored to these impacted communities. In partnership with the local public health department's contact tracing program, we used the COM-B model and BCW framework to understand participants' adherence to COVID-19 prevention measures and identify intervention functions and policies to increase their uptake. At the time of the study, Spanish-speaking Latinx residents were disproportionally infected by COVID-19 and represented most of the contact tracing program's participants. Using the COM-B model, we used qualitative interviews to identify barriers and enablers for COVID-19 vaccination. Our findings highlight that multiple, often related, barriers existed during the initial months of the COVID-19 vaccine roll-out in San Francisco. The behavioral analysis identified that physical opportunity was our participants' most common COM-B category of COVID-19 vaccine uptake barriers. Lack of health system preparedness for assisting a diverse range of non-English speaking patients, inadequate risk communication for Spanish speakers, and limited health literacy in Spanish and English, were significant barriers Spanish Speakers, a high-risk population, faced to get a COVID-19 vaccine. Using the BCW framework we identified that interventions functions to tackle these inter-related barriers, include education, enablement, and environmental restructuring and policies should center around communication and education. Lastly, we found that Implementation Science frameworks can be used to design and improve public health interventions in real-time.

Our finding that physical opportunity was the most common COM-B category, contradicts other studies that have found automatic motivation to be more common [18]. We did our study in the context of the initial vaccine roll-out, which might explain this difference as there were many incumbrances faced by our sample in terms of access to health care in general. More current

reports have found motivational barriers to be the main drivers of not getting vaccinated. Participants in our study perceived that the roll-out of COVID-19 vaccines in San Francisco, as in other places, was confusing due to strict eligibility criteria and a lack of clear communication; in trying to control who got the vaccine, many people were missed or discouraged. Consistent with other studies, we found that systems relying on technology for information and scheduling were at odds with high-risk groups' limited general literacy and tech literacy [19-21]. This is also true in a study in San Francisco among a similar population as ours. [22] Akin to other studies on ethnic minorities, we found that communication strategies that address the specific communities through education, persuasion, and behavior modeling should be policy priorities [23, 24]. Additionally, as others have found, these interventions are better delivered by or in partnership with local CBOs [25, 26].

Based on our findings, we suggest the following intervention and policy strategies for improving vaccine uptake, with a focus on strategies that health departments can pursue:

(1) Create language and cultural concordant communication campaigns which cover education on the vaccine, science, side effects, the approval process, and education on how and when to get the vaccine in their specific context, which should be persuasive and include behavior modeling.

(2) Provide risk communication training for public health professionals, vaccine outreach workers, and community-based organizations working in vaccine outreach.

(3) Increase social media reach and investment to create tailored campaigns that promote vaccination through various multi-lingual educational sources (by public health departments and others they work with who are doing vaccine outreach).

(4) Work with legislators to regulate the spread of misinformation on social media.

(5) Develop a network of vaccine providers that are connected and in close communication with health officials so that any of them can provide information and resources of alternative venues.

(6) Create broad vaccine eligibility criteria.

(7) Design vaccine sites that are accessible for people with disabilities, literacy barriers, and limited English proficiency.

(8) Build solid and equal partnerships with community-based organizations (CBOs) that go beyond the COVID-19 pandemic and leverage these partnerships for public health interventions.

(9) Invest in CBOs.

The importance of using behaviorally informed strategies in COVID-19 vaccine campaigns had been highlighted even before vaccines were available [27, 28]. Since then, multiple groups, including ours, have found that implementation science frameworks provide the template to achieve this. Similar to their research, we found that these frameworks can be used to tailor the response to specific at-risk populations, ensuring a more equitable pandemic response [29, 30]. This is the first publication, to our knowledge, to apply the COM-B model to understand barriers within a public health COVID-19 contact tracing program. As a result, we believe it provides important insights for health departments beyond the scope of COVID-19 prevention. Our findings highlight the existing vulnerabilities and social inequities that exist within ethnic and racial minorities in the United States. Most of the personal level barriers we identified are directly related to preexisting forms of discrimination in our studied population, including poverty, housing insecurity, and low levels of literacy and education [31]. These characteristics increase their risk of getting COVID-19 and the challenges of getting a vaccine. There is a need to research and develop interventions that account for the intersectionality of risk factors in this group [32].

This study is limited by the small sub-set of interviews conducted throughout the pandemic. However, due to the targeted sampling approach, we could reach thematic saturation with the included participants. With a focus on San Francisco residents, it is unclear how generalizable the findings are. San Francisco has more resources than other cities, and Spanish speakers might face different barriers in other places. Due to the changing nature of the pandemic, our findings might not be reflective of the pandemic over time and might be less salient now than they were a few months ago. Additionally, we only included participants who agreed to be part of the SF-DPH contact tracing program, which could lead to selection bias by having only participants willing to engage in other COVID-19 public health activities. However, the overall program participation rate was high, and as a result, we believe this to be a minor limitation. The purpose of our project was to give policymakers recommendations for program improvement; we did not implement or measure the impact of the intervention and policy proposals. Despite these limitations, our paper suggests how public health departments and academic institutions can work together to bridge the gaps between research and implementation. Most existing implementation science on vaccine uptake focuses on identifying barriers or intervention design outside of an existing program; a significant strength of our project is that it was conceived as an embedded study within an existing public health program and used to identify barriers and solutions in real-time, facilitating implementation. Our sampling approach allowed us to identify the rich diversity of experiences within a sample of the most highly impacted people in San Francisco, which were disproportionately Spanish speakers; we used this unique sampling approach to collect a real-time sample among those in the contact tracing program.

Our findings suggest that the COM-B model and BCW framework can be part of public health programs and provide real-time evidence on how to incorporate human behavior into interventions in a rapidly evolving situation, as with a pandemic. Our alluvial chart shows what intervention

functions and policy categories stakeholders should focus on to increase vaccine uptake within this population in San Francisco and was broadly shared through presentations and reports. Additionally, we show how an academic-public health partnerships can be leveraged in pandemic response and used to improve and design interventions in real-time. Our study results were shared regularly with the SFDPH, and the final findings were disseminated to external stakeholders in other California counties and the California Department of Public Health.

There is no one-size-fits-all approach to public health interventions. Public health departments must tailor the response to each community or sub-population by first understanding the specific barriers they might face. Our research suggests that Implementation Science can provide frameworks for public health interventions to incorporate behavior into their design in a 'real-time' flexible way and help develop adjustments in policy and practice, to ensure the public health response is equitable. This project was a partnership between UCSF researchers and the SFDPH to ensure the COVID-19 response reached the Spanish-speaking population. Future research should focus on how people overcame their perceived barriers and how behavioral and implementation frameworks can be used to plan the roll-out of non-pharmaceutical and pharmaceutical interventions in public health emergencies, such as outbreak and pandemic responses. Our research suggests that incorporating implementation science into public health programs early on can be beneficial. The next steps should include scaling up these strategies and implementing them in broader and more widespread public health programs.

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Chapter 2: Evaluating the impact of a linguistically and culturally tailored social media ad campaign on COVID-19 vaccine uptake among Indigenous populations in Guatemala: a pre/post design intervention study

Abstract

Objectives: To evaluate the impact of culturally and linguistically tailored informational videos delivered via social media campaigns on COVID-19 vaccine uptake in Indigenous Maya communities in Guatemala.

Methods: Our team designed a series of videos utilizing community input and evaluated the impact using a pre-post intervention design. In-person pre-intervention surveys were collected from a sample of respondents in four rural municipalities in Guatemala in March 2022. Facebook, Instagram, and browser ads were flooded with COVID-19 vaccine informational videos in Spanish, Kaqchikel and Kiche for three weeks. Post-intervention surveys were conducted by telephone among the same participants in April 2022. Logistic regression models were used to estimate the odds ratio of COVID-19 vaccine uptake following exposure to the intervention videos.

Results: Pre- and post-intervention surveys were collected from 1,572 participants. The median age was 28 years; 63% (N=998) identified as women, and 36% spoke an Indigenous Mayan language. Twenty-one percent of participants (N=327) reported watching the intervention content on social media. At baseline, 89% (N=1402) of participants reported having at least one COVID-19 vaccine, compared to 97% (N=1507) in the follow-up. Those who reported watching the videos had 1.78 times the odds (95% CI 1.14-2.77) of getting vaccinated after watching the videos compared to those who did not see the videos when adjusted by age, community, sex, and language.

Conclusion: Our findings suggest that culturally and linguistically tailored videos addressing COVID-19 vaccine misinformation deployed over social media can increase vaccinations in a rural, indigenous population in Guatemala, implying that social media content can influence

vaccination uptake. Providing accurate, culturally sensitive information in local languages from trusted sources may help increase vaccine uptake in historically marginalized populations.

Background

Over the course of the COVID-19 pandemic, Latin America has recorded some of the highest COVID-19 mortality rates in the world.[1] The region has had notable challenges in responding to COVID-19, including under-resourced healthcare systems, barriers to healthcare access driven by social inequities, and a lack of hospital beds and skilled healthcare workers to care for patients.[2] These challenges have contributed to significant morbidity and mortality, compounded by low vaccination rates across many countries in the region.[3, 4] Within the region, Guatemala has a widely variable regional vaccine distribution resulting in one of the lowest COVID-19 vaccination rates across Latin America; only 38% of the population has completed the initial two-dose series of the COVID-19 vaccination protocol (as of July 2022).[5]

There are stark disparities in vaccination rates between communities in Guatemala. Most COVID-19 vaccines have been administered in urban settings, leaving many rural indigenous communities without access.[6] Indigenous people represent more than 40% of the country's population, but the regions where most of them live are the least vaccinated. For example, 70% of people in Guatemala City have been fully vaccinated, compared to 29% of people in the department of Sololá, where almost all residents are Kaqchikel Mayan.[7] Multiple system-level barriers to vaccination exist, including unfair distribution between municipalities, the lack of existing health infrastructure and clinics in these communities, and almost no culturally sensitive and linguistically appropriate communication campaigns.[8, 9] At the individual level, research has identified several barriers to vaccination, including fear of side effects, vaccine misinformation, lack of information, and certain religious beliefs.[10-12] All these factors are exacerbated by the

historical mistrust towards the government by these communities after years of human rights atrocities and the marginalization of the Indigenous communities resulting in structural racism.[13]

Evidence shows that distrust of government is a predictor of misinformation. In Guatemala, this was exacerbated by a lack of information in multiple indigenous languages.[14] The government prioritized information and materials in Spanish; however, Guatemala has more than 25 languages and official translation to them began eight months after the vaccine campaign launched. A lack of information created a void that was quickly filled with misinformation, which was amplified through social media. [6, 8] Previous research has shown that marginalized communities are more likely to be exposed to and believe false information which social media have fueled during the COVID-19 pandemic.[15, 16]

To address the information gap and counter misinformation, our team used a community-engaged research approach to design a culturally tailored COVID-19 vaccine campaign in Spanish, K'iche, and Kaqchikel languages and deliver it through social media. The main aim of this study was to evaluate the impact on vaccine uptake of the social media campaign in Patzún, San Andrés Semetabaj, Solalá, and Tecpán, mainly Indigenous rural municipalities in the Guatemala Central Highlands.

Methods

Study design and setting

The study used a pre-post intervention design to evaluate the effectiveness of a social media campaign on vaccine access in four, mainly indigenous, rural communities in Guatemala. Participants were recruited and pre-intervention surveys were conducted during the first two weeks of March 2022 in Patzún, San Andrés Semetabaj, Solalá, and Tecpán, all municipalities of the Guatemala Central Highlands. These are communities where our in-country partner

community partner, Wuqu' Kawoq |Maya Health Alliance, holds regular activities. Post-intervention surveys were collected in the same participants via phone following the intervention in April 2022.

Community and public Involvement

A community-engaged research framework was used throughout our project, including project design, formative work, intervention design, evaluation, and dissemination.[11] Wuqu' Kawoq is deeply entrenched in local Indigenous communities, providing culturally sensitive health care and health education to these communities in Guatemala for over 15 years. Their current activities included COVID-19 prevention, and one of their current priorities is COVID-19 vaccine communications to local communities in Mayan languages. Our intervention was additive to their priorities and efforts. All the fieldwork (survey collection) was done by community health workers from the local communities. Our intervention was developed in partnership and based on formative work with community members, who also provided the script translation and voice-over for the videos, which were disseminated through their channels. Multiple dissemination strategies were used to ensure local stakeholders were aware of the findings, using the community and community partners as the primary messengers.

Participants and data collection

People over 18 years of age who lived in the included communities and provided a phone number to complete the follow-up interview were eligible to participate. Trained multilingual community members were deployed to the communities for two weeks and selected participants through convenience sampling among people at the town center or around the health clinic. Following informed consent, participants were asked questions that the interviewer filled on a phone or a tablet using Qualtrics. Questions included their demographic characteristics, COVID-19 vaccine status, vaccine confidence and hesitancy, vaccine access, vaccine information sources, and

social media use. Participants who provided a working phone number to our study team and consented to be contacted again were followed up with for the post-intervention survey via telephone three weeks later at completion of the intervention. Participants were called three times within two days after which they were considered lost to follow-up. Surveys consisted of 25 closed-ended questions and lasted on average 12 minutes. Interviews were conducted in Spanish, Kiche, or Kaqchikel using a translated survey tool. Pre and post intervention surveys were matched using unique ID numbers randomly generated by Qualtrics. Based on sample size calculations, our study needed 500 participants to estimate the effect of the intervention on vaccine uptake.

Intervention

The intervention was designed in collaboration with the Stanford Center for Health Education's Digital Medic initiative using a qualitative human-centered design approach through in-person, in-depth key informant interviews and community focus groups to understand better vaccination barriers, including access, supply, trust, and fear[17]. The interviews identified the main COVID-19 vaccines myths and sought to understand information sharing using social media networks in that region of Guatemala. Findings from the qualitative phase informed the development of the social media campaign, including two animated video series with three one-to-two-minute video clips each. The first video series focuses on the COVID-19 vaccine basic information, including how vaccines work and the side effects. The second series addresses the central myths and misinformation identified in the community, which are beliefs that the vaccine can kill, there is a microchip in the vaccine, and the vaccine causes infertility. All videos are identical with translations and captions in Spanish, K'iche, and Kaqchikel. Narration is provided by local voice talent. Videos are open source and continue to be available on YouTube. [https://www.youtube.com/playlist?list=PLuhZ6_ONjgIlb0UgAGiWR0_ZfslX3hpt7]

The videos were deployed on users' Facebook, and Instagram Feeds from the Wuqu' Kawoq Facebook page and promoted through the Facebook Advertisement Platform. Users were selected via Facebook's advertising algorithm to receive the campaign videos 1-2 times per week on Facebook, Instagram, and browser ads where Facebook ads were enabled. Campaign videos were available for three weeks, from March 14 - April 4, 2022.

Measurement

Our primary outcome was COVID-19 vaccine uptake, which was assessed by comparing self-reported vaccination status in the pre- and post-intervention surveys. Participants were considered vaccinated regardless of the number of doses they had received and unvaccinated if they had never received any doses. Possible answers were 'yes,' 'no', and 'don't know'; only 4 respondents answered 'don't know and were therefore eliminated from the analysis.

The main predictor of our study was exposure to the intervention. To assess exposure, participants received a screenshot of the videos via WhatsApp and were asked if they had seen them before. Answers were 'yes,' 'no,' and 'don't remember. Participants who could not receive the images (e.g., did not have WhatsApp enabled on their phones) were given an oral description of the videos and asked if they had seen the video; answers were yes, no, and don't remember. For the analysis, only people who said yes or no to either the screenshots or oral descriptions were included; people that could not remember were counted as unexposed.

Co-variates included age, sex, community, language spoken at home and past COVID infection. Age was operationalized as a continuous variable, and sex, had 'male,' 'female' or 'other' (only one participant identified as other). Communities in which the interview took place included 'Patzún,' 'San Andrés Semetabaj,' 'Solalá' or 'Tecpán.' Language spoken at home included

'K'iche,' 'Kaqchikel,' 'Spanish' or 'other.' Lastly, they were asked to self-report a past COVID-19 infection, including yes, no, or don't know.

Additionally, the survey collected information on the participant's social media use and their primary COVID-19 information sources. Social media questions included access to and preferences for social media platforms, exposure to COVID-19 information, and sharing behavior.

Statistical Analysis

All analyses were conducted using StataIC V16.0.809. Differences in baseline characteristics between vaccinated and unvaccinated participants were presented using percentages for categorical variables, medians, and interquartile ranges for continuous variables. Differences between groups were assessed using proportion and Kruskal-Wallis tests. We used logistic regression to estimate odds ratios and 95% confidence intervals to evaluate COVID-19 vaccine uptake in an unadjusted model, an adjusted model among the whole sample, and an adjusted model among those unvaccinated at baseline. The analysis's main predictor was intervention exposure, and our primary outcome was COVID-19 vaccine uptake. Models were adjusted for possible confounders, including age, sex, community, and home language.

Ethical considerations

The study received approval by Institutional Review Boards at the University of California, San Francisco (Study # 21-35160) and Stanford University (Protocol # 63193), and a private Institutional Review Board through Wuqu' Kawoq in Guatemala (Protocol # WK 2021 005). Written permission from the individual community leaders and their local health clinics was given before conducting the surveys. Individual written consent was received before each in-person survey, and participants verbally consented a second time before the phone post-intervention survey.

Results

Baseline characteristics are presented in Table 1. We completed and successfully matched 1,572 pre- and post-intervention surveys. The median age of participants was 28 years (IQR 22-39), 63% (N=998) and identified as female, and 37% spoke an indigenous language at home (28% spoke Kaqchikel and 9% K'iche). Eighty-nine percent of the sample reported having at least one COVID-19 vaccine at baseline. Vaccinated individuals were significantly older and more likely to have had COVID-19 previously. There were also differences in vaccination status by region, with lower vaccination rates in Sololá and higher rates in Patzún. There were also significant differences in vaccination rates by primary language, with Spanish-speaking participants having higher rates and Kaqchikel-speaking participants having lower rates.

Table 2.1. Characteristics of participants surveyed in Guatemala COVID-19 vaccine social media campaign, by vaccination status at baseline

Characteristic	Total (n=1572) N (%)	Vaccinated at baseline (n=1402) N (%)	Unvaccinated at baseline (n=170) N (%)
Age, years, $**	28 (22-39)	28 (22-40)	24 (20-34)
Female sex	998 (63%)	894 (64%)	104 (61%)
Community			
Patzún**	290 (18%)	274 (19%)	16 (9%)
San Andrés Semetabaj	571 (36%)	503 (36%)	64 (37%)
Sololá***	163 (10%)	123 (9%)	40 (23%)
Tecpán	552 (35%)	502 (36%)	50 (29%)
Language spoken at home			
K'iche	135 (9%)	114 (8%)	21 (12%)
Kaqchikel ***	435(28%)	367 (26%)	68 (40%)
Spanish***	993 (63%)	910 (65%)	83 (47%)
Other	9 (0.5%)	9 (0.6%)	0
Vaccinated against COVID-19 with at least one dose&	1402 (89%)	1402 (100%)	0
Previous COVID-19 infection*, &			
Yes	169 (11%)	159 (11%)	10 (6%)
No	1365 (87%)	1208 (86%)	157 (92%)
Not sure	38 (2%)	35 (3%)	3 (2%)

$Median and interquartile range
& Self-reported, *p<0.05, **p<0.01, p<0.00

Twenty-one percent of the participants (N=327) reported having watched the intervention content; there was no difference in exposure between vaccinated or unvaccinated participants at baseline. Among those who saw the videos, 98% reported learning something new about the vaccines. At baseline, 89% (N=1402) of participants said having been vaccinated against COVID-19 with at least one dose compared to 97% (N=1507) in the follow-up. Among the whole sample (Adjusted Model 1, Table 2), those who reported watching the videos had 1.78 times the odds (95% CI 1.14-2.77) of getting their first COVID-19 vaccine compared to those who reported not watching it, adjusted by age, community, sex, and language spoken at home. When stratified by vaccination status at baseline (Adjusted Model 2, Table 2), among those vaccinated, those who reported watching the videos had 3.92 times the odds (95% CI 1.56-9.8) of getting their first COVID-19 vaccine compared to those who reported not watching it, adjusted by age, community, sex, and language spoke at home.

Table 2.2. Unadjusted and adjusted logistic regression evaluating COVID-19 vaccine uptake following COVID-19 vaccine social media campaign

	Unadjusted		**Adjusted Model 1**		**Adjusted Model 2 among those unvaccinated at baseline**	
Characteristic	**Odds Ratio (95% CI)**	**P value**	**Odds Ratio* (95% CI)**	**P value**	**Odds Ratio* (95% CI)**	**P value**
Exposed to vaccine campaign	1.86 (1.20-2.86)	0.005	1.78 (1.14-2.77)	0.01	3.91 (1.56-9.8)	0.04
Age	0.97 (0.96-0.99)	0.02	0.97 (0.95-0.99)	0.004	1 (0.98-1.03)	0.51
Sex						
Men	Ref.		Ref.		Ref.	
Women	0.99 (0.65-1.50)	0.98	0.96 (0.62-1.47)	0.87	1.22 (0.60-2.48)	0.57
Community						
San Andrés (SA)	Ref.		Ref.		Ref.	
Patzún (PA)	0.24 (0.10-0.57)	0.001	0.27 (0.11-0.67)	0.85	0.33 (0.09-1.15)	0.08
Solalá (SO)	1.59 (0.91-2.78)	0.10	1.66 (0.91-3.03)	0.09	0.75 (0.29-1.91)	0.54
Tecpán (TE)	0.70 (0.44-1.12)	0.13	0.75 (0.46-1.24)	0.26	1.07 (0.45-2.56)	0.86
Home language						
Spanish	Ref.		Ref.		Ref.	
Kaqchikel	1.42 (0.91-2.23)	0.12	1.63 (0.99-2.67)	0.05	0.55 (0.25-1.22)	0.14
K'iche	2.33 (1.29-4.21)	0.005	2.07 (1.12-3.83)	0.02	1.52 (0.47-4.85)	0.47

* All variables adjusted for all other variables in column

Despite the high vaccination rate in our sample, about a fourth of those who were unvaccinated had tried to become vaccinated but faced access barriers such as vaccine or clinic? personnel

shortages. The most common reasons unvaccinated people gave for not wanting a COVID-19 vaccine were fear of side effects (30%), fear of dying from the vaccine (19%), and lack of information about the vaccines (10%). Another misperception participants noted was the idea that having a comorbidity, such as diabetes or being pregnant, meant they were not eligible for vaccination or that vaccination was not safe for them.

Additionally, as shown in Table 3, social media was the most common place people accessed vaccine information, with 46% of participants using social media for this purpose. Among those using social media, 76% of respondents said that Facebook was the platform they used the most. Ninety-seven percent noted that the information they've seen about COVID-19 vaccines was in Spanish, despite the high percentage of participants who spoke an indigenous language.

Table 2.3. COVID-19 information sources and social media usage among survey participants (N=1572) in Guatemala, 2022

COVID-19 Information sources	
Social Media	46%
Friends and family	41%
Doctors or other health care workers	41%
TV or radio	28%
Government	7%
Religious leaders	3%
Social Media use	
Have any social media networks	86%
Have ever shared COVID-19 information through social media	16%
Have seen COVID-19 vaccine information on social media (N=1576)	72%
On Facebook (N=729)	88%
Information was only in Spanish	97%

Discussion

It is estimated that COVID-19 vaccines saved between 14.4 million and 20 million lives globally during the first year of their roll-out.[18] Despite this success, global, regional, and national inequities prevent vulnerable populations, such as Indigenous communities, from accessing the vaccine. Complimentary to addressing supply and access challenges, there is a need to improve demand in these communities. Our research shows that providing targeted, culturally, and linguistically appropriate information campaigns via social media may increase vaccine uptake in mostly Indigenous communities in Guatemala. The survey-based evaluation of our intervention showed that participants who reported watching a culturally informed and aware video about COVID-19 vaccines were more likely to become vaccinated against COVID-19 compared to those who had not watched the video. The observed impact was more significant when only unvaccinated participants at baseline in the analysis were included.

Like other studies, our findings show that social media offers a unique opportunity to improve health communications targeted at hard-to-reach populations.[19-22] In addition to providing educational information, these campaigns help counter the increasing amount of misinformation on these platforms. Although indigenous people are often considered "hard to reach," 86% of our predominantly indigenous participants reported using a social media platform. Our study also found that social media was participants' most common source of information about COVID-19 vaccines. Participants reported receiving more information on social media than from doctors and healthcare workers. All too often social media or Mhealth interventions are assumed not to be appropriate for non-urban, poor or non-educated populations—but this is clearly not the case, and this assumption could lead to vast missed opportunities. Understanding social media use and how populations access information locally and nationally is critical for governments, policymakers, and healthcare systems to optimize vaccine education and encourage vaccine uptake or any other health condition or behavior. Additionally, ensuring people can access

information in a language they understand, alongside visual depictions of their culture reflected in videos or graphics, may significantly impact their trust.

This project was done using a community-engaged approach, which we believe should be the standard for any public health research, especially in marginalized communities.[23] Our partnership with Wuqu' Kawoq enabled us to find sustainable solutions for a priority of the organization and community. Community partners are critical to guiding research activities and creating trust, but unfortunately, many community organizations do not have the resources or the infrastructure to lead and implement research activities. A well-balanced partnership that is open and honest about power differentials, money, and time has the potential to create and sustain impact. By involving the community in every step of the research process, we could tailor the intervention to them and gain the participants' trust.

This study has many strengths. Most existing evaluations of social media campaigns rely only on data collected over social media and cannot ascertain the impact on the ground. Our study team measured the effect of a social media campaign on individual vaccine uptake via data collected at a community level. Additionally, our large, diverse sample of rural, indigenous participants allows us to make solid statistical claims. However, this study also has limitations. The exposure (seeing the videos) and outcome (vaccination status) were self-reported and, therefore, could be prone to recall bias or other forms of bias. We could not randomize individuals or communities for the intervention; consequently, we had to rely on pre/post surveys and a convenience sample of individuals to participate. Collecting two rounds of data from the same people added strength to our analysis. Additionally, our sample may not represent everyone living in these communities, and there may be differences between those who were recruited and agreed to participate and the broader community. Finally, our sample was more vaccinated than the national average, perhaps because many participants were recruited from around health care facilities and towns

where our community partners have regular activities and not rural villages. However, the increase in vaccine uptake among a highly vaccinated population provides more evidence of the potential impact of the intervention.

Our study team is also working on an evaluation of the social media campaign using Facebook user analytics. Specifically, we are measuring the impact of the videos on increasing the social acceptance and perceived safety and social acceptability of the COVID-19 vaccine in Guatemala, with a comparison of the effectiveness of Mayan language content with Spanish language content among Mayan language speakers. Additional research is needed to understand the impact on other Mayan groups and languages not included in this project, who the most trusted groups or messengers are, and a comparison of communication campaigns using alternative channels to reach older populations or those who might not have a mobile device.

Conclusion

Our findings showed that a culturally and linguistically concordant, community-informed campaign using social media could be used to increase vaccine confidence and address misinformation. Our intervention was associated with increased vaccination rates in a predominantly indigenous population in rural Guatemala. This demonstrates that social media can be a channel to influence health behaviors. Providing information in local languages may be essential for vaccine uptake in hard-to-reach, historically marginalized populations. Additionally, our findings provide key stakeholders, including Guatemalan public health and government officials, with data on vaccine attitudes and information sources that could be leveraged to increase COVID-19 vaccine uptake in other regions of the country and perhaps regionally in Central America as well.

COMPETING INTERESTS

None declared

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Chapter 3: A Co-Created Tool to Help Counter Health Misinformation: Empowering Spanish-Speaking Communities in the San Francisco Bay Area

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Abstract

Background: Health misinformation has become increasingly prevalent during the COVID-19 pandemic, posing a significant challenge to public health efforts. Spanish-speaking communities are particularly vulnerable due to factors such as low digital health literacy and mistrust in science and health professionals. This study aims to address health misinformation among Spanish-speaking communities in the San Francisco Bay Area, through developing a co-created checklist based on community insights.

Methods: Employing a multistage methodology, we investigated the barriers to COVID-19 vaccine uptake among Spanish-speaking populations in Alameda and San Francisco counties. The formative work involved key informant interviews with health personnel (N=21), in addition to a series of individual and group interviews with Black and Latinx-identified young people (N=9) and conducted from August-December 2021. Key informants included providers, health department staff, and community-based workers focused on COVID vaccine uptake. Group interview participants were young people ages 18-24 who chose to be vaccinated and who chose not to be vaccinated for COVID-19, including several parents. Using these findings, we then collaborated with a community-based organization to co-create a practical tool to identify misinformation through conducting three workshops (N=12). This collaboration resulted in a visually engaging and user-friendly tool, deeply rooted in the target community's experiences.

Findings: Misinformation emerged as a significant concern for COVID-19 vaccine uptake during formative interviews. Participants identified common myths surrounding vaccine safety, side

effects, and government control, as well as concerns about fertility and reproductive health. In three workshops with Spanish-speaking women from a local community-based organization, we co-created a 10-step checklist to identify and counter health misinformation. Participants emphasized the importance of examining sources, messengers of health information, trustworthiness, and assessing how cues in visual content elicited fears or perceived threats. The checklist itself empowers users to distinguish between reliable sources and verify information, provides easy-to-follow steps such as checking the source, comparing it to others, engaging with the full content, and leveraging resources from local community-based organizations.

Conclusion: This co-created checklist is a tool for Spanish-speaking communities to identify and counter health misinformation. Tailored tools are needed to aid populations at increased risk of exposure to or belief in misinformation.

Background

The COVID-19 pandemic has highlighted the health disparities between racial and ethnic groups in the United States, including in the San Francisco Bay Area, California.[1] While social, structural, and individual factors contribute to these disparities, health information and education have also played a role.[2] The COVID-19 pandemic has caused a surge in misinformation and false claims about the virus, which, amplified by social media platforms, has created a challenging environment for individuals to make well-informed decisions.[3] Health misinformation is health-related information that goes against current scientific consensus.[4] This spread of misinformation has been labeled an "infodemic," characterized by conspiracy theories, propaganda, and unproven scientific claims about the disease.[5]

During the pandemic, many people used social media to find information about COVID-19. However, due to the increase of health-related content circulating on social media, which may

lack proper scrutiny and fact-checking, it's become more challenging for people to separate accurate from inaccurate information. Studies have shown that many posts about COVID-19 on social media are untrustworthy and contain false information and conspiracy theories about the disease and vaccines.[6] False information spreads faster and farther than accurate information.[7, 8] The COVID-19 infodemic has challenged public health officials to tackle online health misinformation. One key factor contributing to the spread of COVID-19-related online misinformation is the low level of digital health literacy, which is prevalent in large segments of the population worldwide.[9] Digital health literacy involves not only the ability to access health information online but also to understand and apply it accurately. Additionally, restoring or strengthening trust in science and health professionals is crucial in mitigating the spread of COVID-19 misinformation and promoting accurate information.[10]

Latinos and Spanish-speaking individuals are particularly vulnerable to misinformation. Spanish-speaking Latinx households are more reliant on social media for health information compared to other racial and ethnic groups. Univision, a leading Spanish media company, found that Spanish speakers rely 57% more on social media for COVID-19 information than non-Hispanic Whites.[11] Political and health-related research has shown that Latinos are more likely to consume and share disinformation and misinformation online than the general population. According to a survey conducted by Voto Latino in April 2021, over 50% of unvaccinated individuals in the Latinx community believed that the vaccine was not safe; the percentage was 67% among those who primarily spoke Spanish.[12]

Social media platforms, such as Facebook, are less effective at identifying and flagging Spanish-language misinformation compared to English-language. One study found that the platform failed to flag 70% of misinformation in Spanish compared to 29% in English.[13] Moreover, most social media platforms invest about 9 times less in fact-checking in languages other than English, further

amplifying the risk of spreading misinformation.[14] This vulnerability is exacerbated by a history of discrimination, medical racism, and limited access to healthcare, which has created a foundation of mistrust that allows Spanish-language COVID-19 vaccine misinformation to thrive on social media platforms.

Participatory design methods are increasingly recognized as a valuable approach for creating health and public health interventions.[15] Participatory design methods lead to more relevant, effective, and sustainable public health solutions by actively involving end users, fostering collaboration, and promoting adaptability. Within participatory design, co-design workshops enable users and researchers to exchange and develop ideas, aiming to ensure that the tools being created are rooted in users' lived experiences while actively involving them in the design process.[16] User narratives, such as stories and scenarios, may also be employed in co-design to communicate design concepts and envision their potential applications.[17] Although originally developed and primarily used for new technologies and mHealth, these approaches can be adapted for developing more traditional and non-technological health tools, including information and education campaigns, infographics, and more. The collaborative development process provides vital insights into how end users interact with health tools, leading to relevant and timely solutions for health issues. As both tools and the sociocultural context of end users continuously evolve, the collaborative development process should remain dynamic.[18]

Creating efficient strategies and tools to assist Spanish speakers in recognizing misinformation on the internet is critical. These may include various techniques such as machine learning, health literacy guidelines, checklists, mythbusters, and fact-checkers. A comprehensive, collaborative approach that incorporates the most effective methods and services is strongly encouraged to address health misinformation on the internet and limit its harmful consequences during pandemics such as COVID-19. [19] With this study we aimed to explore the content, causes, and

sources of misinformation affecting Spanish speakers in two counties of the San Francisco Bay Area, in order to co-design a user-friendly checklist for Spanish speakers to identify and counter online misinformation about COVID-19 vaccination.

Methods

We employed a multistage methodology to understand and address the barriers to COVID-19 vaccine uptake faced by the Spanish-speaking populations in Alameda and San Francisco counties. From August to December 2021, we conducted key informant interviews with health personnel (N=21) augmented by individual and group interviews with young people (N=9) to identify the specific challenges this population faced in accessing COVID-19 vaccines for themselves and their children.

As we analyzed the formative phase data, we uncovered misinformation as a recurring theme and subsequently identified it as a significant barrier to vaccine uptake among the Spanish-speaking community. In response to this finding, we partnered with a community-based organization representing Spanish-speaking members and organized co-design workshops in July 2022. Through these workshops, we aimed to further explore the problem of misinformation and collaboratively develop a practical tool to help community members identify and counteract false information.

Formative interviews

Participants

We employed a purposeful recruitment strategy to engage key informants (KIs) in San Francisco and Alameda Counties, California. These individuals were identified through recommendations

from the San Francisco Department of Public Health, the Alameda County Public Health Department, and attendance lists of local task force and community meetings. Our KIs included healthcare professionals, personnel from community-based organizations and county health departments, and community leaders involved in COVID vaccination efforts in the Latinx and African American communities. Additionally, we recruited vaccinated and unvaccinated community members to participate in group interviews through community-based organizations and social media.

To pre-screen potential participants, we used a brief Qualtrics survey. Those who qualified received a phone call from a research team member who screened them, provided information about the study, and obtained verbal consent for participation. Data collection took place via Zoom and was audio-recorded. We used Otter.ai software to transcribe English recordings and Veer.io for Spanish recordings. A bilingual team of researchers conducted the interviews and group interviews, which lasted between 30 and 60 minutes, respectively. All participants received a $50 online gift card for their participation, delivered electronically. The study was approved by the Institutional Review Board of UCSF (IRB 21-34502). Verbal informed consent was obtained from all participants in their language of preference (English or Spanish) by phone before the start of the interviews and workshops; participants received a copy of their informed consent and study information electronically.

Data collection and analysis

The semi-structured interviews and group interview guides included domains such as community perceptions, perceived barriers and facilitators to COVID-19 vaccine uptake, COVID-19 misinformation, and intervention recommendations. We employed a rapid qualitative analysis approach using template analysis, which is useful for quickly answering specific research questions and producing actionable pragmatic findings.[20, 21] This method involves creating

domains for each interview question and developing a template to summarize each transcript by domain.[22] We piloted the templates on a sample of transcripts, and upon validation, applied them to the remaining transcripts. A team of analysts templated the transcripts, with one primary analyst do an initial templating of the data and a secondary analyst providing a review. Instances where there were disagreements over templating decisions were resolved during discussions that took place at weekly analytic meetings. After templating all the transcripts, we excerpted all relevant narratives categorized under the misinformation domain to identify specific barriers the Spanish-speaking community was facing in getting vaccinated against COVID-19.

Workshops

Participants

Upon identifying misinformation as a significant issue within the community, we collaborated with a Bay Area community-based organization, Mujeres Activas y Unidas (MUA), which works with immigrant women from Latin America, to recruit participants for three 1-hour workshops to help develop a tool on discerning and combatting misinformation using a co-design process. Interested participants were contacted by a Spanish-speaking member of the research team who screened them, discussed the study, and obtained verbal consent for their participation. They were also sent a copy of the informed consent via text or email.

Data collection and analysis

The workshops aimed to co-design a tool that could help Spanish speakers identify misinformation. Conducted in Spanish by a bilingual moderator and bilingual note-taker, the workshops took place over Zoom and were designed based on findings that emerged from the formative phase's interviews. The workshop began with an open-ended discussion where participants shared their experiences in assessing the veracity of COVID-19 vaccine-related

information. Participants discussed the source, messenger, and content of the information and shared strategies or techniques they used to identify misinformation or disinformation.

Following the open-ended discussion, participants engaged in a practical exercise comparing two pieces of information on COVID boosters. Both posts were shared side by side using Zoom's screen share function without revealing which piece of information was true or false. Both Facebook posts displayed the blue checkmark, indicating the account had been verified by Facebook. The misinformation post from Dr. Mercola's Spanish website showed a hand holding a syringe with a long needle and read in Spanish: "Why do people with all of their booster shots continue to get COVID and the unvaccinated don't?" The post also included a link that read "Booster shots are a terrible risk for your health." Conversely, the CDC post depicted a cartoon of a man with a band-aid on his arm and discussed the benefits of COVID-19 booster shots. Both posts were from the same week in May 2022 (see figure 1).

Participants were asked to compare the two pieces of information and identify any differences that could help distinguish between accurate and inaccurate information. They were also asked what actions they would take if presented with such information (e.g., would they click the link? Would they share it?). The exercise aimed to guide the discussion and identify practical steps that low-literacy Spanish speakers could take to identify misinformation.

Data collection and analysis for the workshops followed a similar approach to that of the formative work. The workshops were recorded on Zoom, and the audio were transcribed using VEED.IO.[23] We employed a rapid qualitative analysis approach to analyze the workshop transcripts, focusing on identifying themes related to actionable steps for identifying misinformation. These themes encompassed various aspects such as source, messenger, visual appearance, tone, website and URL, content, and trust. Once the data were templated, narratives were extracted based on these

dimensions to provide practical guidance for tool development. These practical insights were instrumental in developing the misinformation identification tool for the target community.

Figure 3.1: Facebook posts used for co-design workshops

Translation.
Figure 1. Text above image: Dr. Joseph Mercola in Spanish, May 10. Why do people who have received all of their booster shots keep getting infected with COVID and unvaccinated people do not? Is this pure coincidence or does a relationship between the number of doses and the risk of getting COVID exist? Here is everything you need to know. Text below image: Booster shows represent a terrible menace to health
Figure 2. Text above image: Your body's capacity to combat COVID-19 can decrease with time. Getting a booster shot can help your body get additional immunity. Is it time to get a booster shot? More information: [link]. Text in image: What you need to know about COVID-19 booster shots. COVID-19 booster shots can help increase immunity you might have lost over time. Keeping up to date with COVID-19 vaccinations includes getting a booster shot for those eligible, which provides the best protection against the risk of getting severe COVID-19.

Tool Development

Utilizing insights gathered from the workshops, we developed a comprehensive list of steps in Spanish for identifying misinformation. This list was subsequently translated into English to ensure broader accessibility. To fine-tune the tone and wording of the steps, and to provide a form of member checking, we shared a draft of steps within the tool kit with MUA participants, incorporating their feedback to make the content more relatable and user-friendly.

To enhance the visual appeal of the tool, a designer on the research team created visually engaging elements, such as icons and color schemes, tailored to resonate with the target audience. To invite community input and member checking, we also solicited feedback on the design aspects of the tool from other researchers and participants, ensuring that the final product was both visually appealing and effective in helping users identify misinformation. This iterative and collaborative process ensured that the tool was grounded in the real-world experiences of the community members and reflected their perspectives on misinformation identification.

Results:

Participants

Formative interviews

The study team conducted 21 interviews with key informants (KI) directly involved in COVID-19 vaccination efforts in San Francisco (N=6) and Alameda County (N=15), California. The participants included public health department representatives, employees from local faith-based and community-based organizations (CBOs), and clinicians (N=21). Additionally, the study conducted additional 9 individual and group interviews (GI) with young community members ages 18-30 who were vaccinated and unvaccinated for COVID. There were two individual interviews with unvaccinated individuals (N=2). In addition, there were three group interviews (N=7), one which included three vaccinated Latinx youth (one male and two females), one with two vaccinated Latina mothers with vaccinated children, and one with two unvaccinated mothers (one Latina and one Black).

Workshops

The workshops (WS) were attended by 12 self-identified Hispanic or Latina women. Most participants were in the age range of 45-54 years, with a diverse range of ages represented (35

to 75 years). All participants spoke Spanish, with the primary language of the two participants in the last workshops being Mam, a Mayan language. Regarding COVID-19 vaccination status, one participant had received one dose, ten were fully vaccinated, and one was unvaccinated.

Below are the themes from our formative work which directly impacted the areas explored in the co-design workshops.

Importance, Impact and content of Misinformation

The impact of misinformation on COVID-19 vaccine uptake emerged as a significant concern among participants in the formative phase of this study. Key informants identified misinformation as a primary reason why many individuals they serve or have talked to refuse or delay getting vaccinated. As one key informant noted,

> "There's a lot of… misinformation. And there is misinformation about any health topic, like this was before the pandemic there is… go to sleep with your phone, … this is how you'll get like, cancer, this is how you'll get like a nosebleed. … there's always been misinformation, but like now it's like, through the roof." (KI,06)

Group interview participants similarly identified misinformation as a major reason why many of their peers or themselves had not received the vaccine. Some participants who were themselves unvaccinated cited misinformation as the reason for their hesitancy. As one participant stated,

> "We have been bombarded with a lot of misinformation or untruthful information that has frightened us. I had to be given the COVID twice to get the vaccine. Because I was more scared about the vaccine than the COVID. So, I think that's why a lot of us are reluctant to get the vaccine or we're sensitive to getting untruthful information to be afraid of the vaccine". (GI,01)

Several participants highlighted the prevalence of misinformation online, including echo chambers and anti-vaccine sentiment. Additionally, participants noted that misinformation disproportionately affects Spanish speakers. As one key informant explained*, "in English language, if you put*

something COVID, fake news, you were over 70% likely to get that tag as false. And if you did the same thing in Spanish, it was like less than 30% likely to be false" (KI,04).

Key informant and group interview participants identified several common myths surrounding the COVID vaccine, which were recurrent throughout the formative interviews. These myths were often related to vaccine safety, serious adverse side effects mainly affecting the reproductive system or fertility, conspiracy theories concerning microchips and government control, and doubts about the scientific process, development, and effectiveness of the vaccine. Participants shared personal experiences with these conspiracy theories and expressed concerns about the rapid development and long-term effects on health, particularly for pregnant women and children. The lack of understanding of the approval process and the perception of constantly changing guidelines contributed to vaccine hesitancy, highlighting the need to counter these misconceptions.

The study's participants expressed a range of conspiracy theories related to the COVID vaccine, with prevalent beliefs centering around microchips and government control. One key informant noted that they had encountered “every conspiracy theory” imaginable and also highlighted how conspiracy theories were intertwined with fears of government control, particularly in the Latino immigrant community:

> "Since COVID has started, we've heard every single conspiracy theory out there, the 5G towers, the metal chip or whatever, the magnet in the arm, like, there's like, Tiktok videos, or whatever it is, like, going around and people will show them to me, and I'll be like, ‘this just that's not like, that's tape or something, you know, it's like not real... Something that we hear frequently is that […] if you get the vaccine in 10 years, it's programmed that it's gonna kill Latinos. And, you know you're putting a microchip in, that microchip thing is across every community. And there's a different logic to it in every community. So, in the Latino community, immigration, you know, the government wants to track […] just persecution of Latinos in general." (KI,06)

These findings underscore the pervasive nature of conspiracy theories and their impact on vaccine hesitancy across different communities.

Key informants raised concerns and myths surrounding the scientific process and vaccine effectiveness, with many expressing a lack of trust in the FDA approval process as a barrier to vaccination. Additionally, participants noted that the perception of constantly changing guidelines for the vaccine may contribute to increased mistrust in the research community's understanding of the vaccine. As one participant observed, these myths and concerns were pervasive and not limited to specific demographics:

> "The hard part was trying to tease apart that myth that it wouldn't work well, or what side effects it could, you know, bring about, and I think that was across the board. It wasn't just age-related or race-related, it was everyone." (KI,07)

The speed of the vaccine's development was another area of concern, as one unvaccinated focus group participant noted,

> "The vaccine is supposedly new; I think that's also where a lot of misinformation comes from. Because we've been put in a lot of fear about the vaccine. It was developed in such a short time they're going to come out with a vaccine. Why haven't they come out for AIDS, for cancer? Why don't they cure those diseases?" (GI,P1)

These comments highlight the uncertainty surrounding the vaccine's scientific development and effectiveness, which contributes to hesitancy among diverse populations.

Participants in this study expressed concerns about the COVID-19 vaccine's potential impact on fertility and reproductive health. A youth group interview participant expressed concerns about the medical field's understanding of the vaccine's impact on long-term development in these

areas. An unvaccinated, pregnant participant expressed fear for herself and her baby, noting that she had heard misinformation about the vaccine potentially causing stillbirth or instant death:

> "So when I take this vaccine, if I were to hypothetically take it, it's gonna be in my body forever. And I just don't know how I feel about that, especially being pregnant, I don't know what that's gonna do to my baby. I've heard like, oh, your baby will be stillborn. And I don't know what if I'm that rare case to where I just die instantly, or the baby dies instantly." (GI, P1)

One key informant noted that men also expressed hesitancy due to fears of infertility and doubts about their manhood:

> "Their big hesitancy, and most of it were men, [was] that they were hearing myths about fertility and that they would become infertile. And I don't even know if it was just infertility. But you know, would they not be able to be manly, that somehow it would affect their manhood." (KI, 08)

These concerns about the COVID-19 vaccine's potential impact on fertility and reproductive health contribute to vaccine hesitancy regardless of sex. The pervasive nature of the myths identified in our formative work, combined with their resonance with cultural values and beliefs such as sexual and reproductive freedom, governmental surveillance, and trust in scientific innovation, highlighted the need for a tailored approach specifically addressing the needs of Latino immigrant communities. Recognizing this, we sought to develop a co-designed toolkit to empower community members with the necessary tools to counter misinformation effectively.

Features to consider for a co-designed toolkit to counter misinformation: Findings from the workshops

Source

During the workshops, participants emphasized the importance of examining the sources of stories, including their origins and the destinations of embedded links. They stressed the need to

verify the reliability of sources, noting that even medical professionals can spread misinformation. One participant noted, *"when [the link] it is more secure, it always starts with http. And it doesn't just send you to an unrelated link" (WS1, P5)*. They highlighted the importance of thoroughly investigating information, especially when it involves significant health decisions for themselves or their families, and recommended seeking input from multiple sources and comparing them rather than relying on a single post.

When presented with two Facebook posts, participants expressed skepticism about Dr. Mercola's post, with one participant stating, "*For me it is garbage or it is not credible because it does not give you access to that information without you having to give personal information or without you having to put your e-mail address and then they invade with advertisements"* (WS1, P5). In contrast, the CDC was viewed as a trustworthy source with free access to information, as one participant shared, *"To me, the CDC is better, I believe it is the most trusted source. It is giving us all the information. Its updating us day by day. And it's giving us a link to keep us informed, It doesn't say, 'Subscribe or pay*'" (WS2, P2).

Some participants saw government-related sources as unbiased and trusted, contrasting those to other sources that clearly were profit-based.

Messenger

Participants said that aside from considering the source it is important to consider the messenger, or who shared the piece of information with them. They reported receiving information primarily through Facebook and WhatsApp and noted that trust in the person sharing the information was a key factor in determining their own level of trust in that information. One participant cited the example of her sister, indicating that she would be more likely to trust COVID-19 information if it was shared by someone she knew and trusted. *"… I think if I saw a sister of mine post, it on her Facebook, maybe I would read it." (WS2, P1)* Another participant added that people can have a

strong influence on others, including through fear-mongering, highlighting the significance of the messenger's role. *“For me it does influence a lot, because even a very close friend tells you: "No, look, it's like this, it's like that, it's because of this and that and that" and I think that sometimes they do have an influence on you. They also influence you with fear. "If you go out, it's going to happen to you and it's going to hit you..." and all that.” (WS1, P4)* The trustworthiness of individuals within one's social network plays a vital role in shaping their perception and acceptance of shared information, emphasizing the importance of considering both the source and the messenger.

Visual characteristics

Participants also highlighted the importance of visual presentation when assessing the trustworthiness of COVID-19 information sources. They recognized that images could have a significant impact on their perception of the information being conveyed. Specifically, several participants noted that a photo of a syringe used in a post by Dr. Mercola was perceived as aggressive and fear-inducing. However, participants also acknowledged that fear-based messaging could have mixed effects on their level of trust in the information. One participant pointed out that images can be particularly influential for illiterate individuals who rely on visual cues to understand the content, stating:

> “From a visual point of view, the photograph they put up looks rather cruel, because it is like an attack with a syringe... the image that stays with you: "Oh, they want to attack us with the vaccine. They want to manipulate my brain in terms of my image that I'm seeing" (WS1, P2).

Trust in community-based organizations

The role MUA had in providing them with COVID-related information they could trust, was a common theme among participants from the three workshops. As a participant mentioned, belonging to an organization doesn’t only help them be informed but allows them to share with

and support others*. "And even more so if they don't have anyone who belongs to an organization, where they are being updated on many things. Because belonging to an organization helps us a lot to be able to help other people. All the information that I receive there, in Mujeres, I am always sharing with the community." (WS2, P1)* Participants expressed trust in community-based organizations, such as MUA, that regularly provided them with COVID-19 vaccine information. The same participant stated, *"we trust what MUA gives us, I trust because when they - on Mondays we have the meeting where experts come and give us talks. Every Monday. The people who have come work in hospitals. A doctor has come, a nurse has come, they are people who are informed" (WS2, P1).* CBOs played a vital role in bridging the gap between public health and clinical professionals and the communities they serve. Through the trust established with these organizations, they effectively acted as conduits for disseminating accurate, science-based information to the wider community*.*

Community characteristics

Participants discussed how personal and community characteristics can impact trust in COVID-19 vaccine information. They mentioned that people with limited education and exposure to different sources of information may be more vulnerable to misinformation and are more likely to believe everything they read on social media or hear from their immediate social circles. One participant highlighted that some immigrants may not have had the opportunity to access education or might not be exposed to diverse sources of information, making them more susceptible to believing misinformation about vaccines and other health-related topics:

> *"There are many people, maybe not illiterate, but very humble people who use Facebook and believe everything they say... That's why people believe anything. They believe anything from anyone" (WS2, P2).*

Furthermore, participants highlighted how fear and shame can hinder individuals in the community from seeking accurate information or asking questions about COVID-19 vaccines. "*But, in reality, we are not informed. We don't know our rights as people. Another thing is that we are afraid to speak up. We are afraid to ask. We are ashamed... That makes the Latino community more intimidated" (WS2, P2).*

Sources of misinformation

Participants also cited a wide range of misinformation sources including news media, social media platforms like Facebook and YouTube, personal doctors, and even religious beliefs. As one participant noted, *"Not only people, but the media, YouTube, news and doctors who are [Epidemiologists?]. Yes. They have also come out, many of them, saying that the vaccine is dangerous, and so many things."* (WS1, P3) Participants agreed that in their communities, misinformation was often spread through social media and amplified by personal social networks, as one participant explained,

> "*And, unfortunately, the misinformation we have is precisely because of that, because of what I saw on Facebook and told my comadre and my comadre shared it with my compadre and then shared it with the neighbor, and that's how misinformation is in our community*." (WS3, P2)

WhatsApp groups were identified as significant sources of both accurate information and misinformation related to COVID-19. One participant revealed their mixed experiences with WhatsApp groups: "*I do trust WhatsApp because they send us a lot of information from the organization [MUA"]* (WS2, P3). However, participants also acknowledged that there were other WhatsApp groups that disseminated false information.

Tool

Following the in-depth discussions and exercises conducted in our workshops, we developed a comprehensive checklist to assist Spanish speakers in identifying and countering online misinformation. This list encompasses ten practical strategies for distinguishing between reliable sources and verifying information, ultimately empowering individuals to seek out and disseminate accurate content on the internet (figure 2., original Spanish version in supplemental materials). The wording, coloring and format was revised with the research group and MUA members.

This user-friendly tool is designed in a visually appealing blue color scheme, featuring icons that illustrate each step. The tool, originally created in Spanish and later translated into English, guides users through a series of simple yet effective steps to assess the accuracy of information found online. The tool emphasizes the importance of checking the credibility of sources, cross-referencing with multiple sources, and consulting trusted healthcare providers. It also encourages users to be cautious of alarmist, exaggerated content or miracle cures, as well as ensure that links and web addresses appear legitimate. Additionally, the tool highlights the value of staying informed and seeking assistance from trusted community organizations when in doubt. Through a combination of practical tips and a visually engaging design, our tool aims to empower users to navigate online health information with confidence and discernment.

Figure 3.2. Ten-step list to identify misinformation co-designed with Spanish speakers.

Discussion

The COVID-19 pandemic has disproportionately affected racial and ethnic minorities, including Latinx and Spanish-speaking individuals, due to various factors such as health disparities, social determinants, and limited access to accurate health information.[14] Our study focused on understanding the content, causes, and sources of misinformation affecting Spanish speakers in two counties of the San Francisco Bay Area and developing a user-friendly tool to help them identify and counter online misinformation about COVID-19 vaccination.

Our formative findings revealed that misinformation is a significant concern among participants, with key informants identifying it as a primary reason for vaccine hesitancy. Common myths surrounding the COVID-19 vaccine included concerns about vaccine safety, fertility, conspiracy

theories, and doubts about the scientific process. Participants recognized the prevalence of misinformation online and its disproportionate effect on Spanish speakers. In response to these findings, we hosted a series of workshops with community members to develop a comprehensive checklist to assist Spanish speakers in identifying and countering online misinformation about COVID-19 vaccination. The workshops highlighted the importance of evaluating the sources and messengers of information, with participants expressing trust in community-based organizations such as MUA and skepticism toward unverified sources or those requiring personal information or pay for access. Furthermore, participants acknowledged the influence of personal and community characteristics, such as limited education, fear, and shame, on their susceptibility to misinformation and reluctance to seek accurate information. The resulting checklist encompasses practical strategies for distinguishing between reliable sources and verifying information, empowering individuals to seek out and disseminate accurate content on the internet.

Several checklists, guidelines, and initiatives have been developed to help identify and counter misinformation, with some evidence supporting their effectiveness.[24-27] For instance, Agley (2021) discovered that briefly viewing an infographic about science led to a small aggregate increase in trust in science, potentially reducing the believability of COVID-19 misinformation.[10] Another study evaluated the impact of the WHO misinformation checklist and a modified version they created in Germany and the US, yielding mixed results. While people in Germany benefited from the tool, Americans did not, suggesting that different populations might require different approaches.[28] To the best of our knowledge, this is the first checklist co-designed with the specific target population it is meant to help. Although it shares many commonalities with other existing checklists, such as checking the source and the date, it adds new suggestions that cater to the unique needs of this population. These include examining the tone and sensationalization of the information, considering the financial motives behind the information, and relying on local community-based organizations.

Participatory design approaches in tool development and public health interventions offer valuable opportunities to gain specific insights into the unique concerns and needs of community members.[29] By involving the target population in the design process, co-design workshops ensure that the resulting tools are tailored to the community's context and address their specific concerns while fostering a sense of ownership and trust in the resulting tools, which is essential for their successful adoption and use. These methods can identify potential cultural, linguistic, and social barriers that may hinder the effectiveness of public health interventions, helping to create more inclusive and accessible tools.

It is important to acknowledge the limitations of our study. Our findings may not be generalizable to all Spanish-speaking populations, as the workshops were conducted with a specific group of participants during the COVID-19 pandemic, a particular historical moment. Additionally, further research is needed to assess the long-term effectiveness of the developed checklist and to adapt it for use in other contexts and populations. Despite these limitations, our study provides valuable insights that can inform the development of future tools and interventions designed to combat online misinformation.

Our study underscores the urgent need for effective strategies and tools to combat health misinformation among vulnerable populations, such as Spanish-speaking individuals, who are at higher risk of being exposed to and affected by misinformation. By increasing digital health literacy, promoting trust in science and health professionals, and investing in culturally appropriate resources and interventions, public health officials can help mitigate the negative consequences of misinformation during public health crises like the COVID-19 pandemic.

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Conclusion

Overview of findings

The research presented in this dissertation aimed to explore ways to increase the uptake of COVID-19 vaccines with the end goal of reducing health disparities in the context of a global pandemic. My doctoral research focused on understanding barriers and enablers to COVID-19 vaccination and developing effective interventions that address these barriers in at-risk populations both locally and internationally.

The first chapter, published in *Global Implementation Research and Applications,* identified difficulties San Francisco's Spanish-speaking population were facing to adhere to COVID-19 preventive measures. Using qualitative interviews and implementation science frameworks, the study found that unprepared health systems, fear of side effects, limited knowledge, and conflicting information were significant barriers to vaccine uptake. Education, enablement, and environmental restructuring were identified as effective intervention functions to address these barriers, along with policies such as communication and marketing and environmental planning.[1]

The second chapter evaluated the impact of culturally and linguistically tailored informational videos on COVID-19 vaccine uptake in Indigenous Maya communities in Guatemala. The study published in *BMJ Open* utilized a pre-post intervention design and found that exposure to the intervention videos significantly increased vaccination uptake in the population (OR 1.78 95% CI 1.14-2.77). These findings suggest that tailored social media campaigns can be an effective way to address vaccine misinformation and promote vaccine uptake in rural, indigenous populations.[2]

Lastly, in the third chapter, we co-designed a tool to combat health misinformation among Spanish-speaking individuals in the San Francisco Bay Area. The study partnered with a

community-based organization and conducted workshops with self-identified Hispanic or Latina women to co-develop the tool. The resulting tool outlined 10 steps in Spanish and English to help Spanish speakers challenge health misinformation and access reliable sources of health information.

Translating findings into action

Despite being the most significant global health emergency of this century, COVID-19 is not the first disease outbreak requiring swift and effective interventions, and it will certainly not be the last. Research done in real-time during the pandemic provides valuable knowledge of what we need to accomplish to be more successful in future public health emergencies.[3] My research provides insights that are specific to COVID-19 but are also generalizable to other public health interventions targeting vulnerable populations in the context of public health emergencies, including lessons on vaccine distribution, vaccine information and communication, and countering misinformation.

Vaccine distribution

The first chapter of this dissertation provides valuable findings and recommendations that can assist public health departments in designing and implementing more effective vaccine campaigns with a focus on health equity. Based on our research, we have developed nine key recommendations for public health departments to improve vaccine uptake. These include creating language and culturally appropriate communication campaigns that are inclusive of all populations, providing risk communication training for all individuals involved in vaccine outreach and provision, increasing social media investment to provide accurate information and counter misinformation, working with legislators to combat false information, developing a close and connected network of vaccine providers, broadening vaccine eligibility criteria at rollout, increasing accessibility of vaccination sites, building strong and sustainable partnerships with

community-based organizations beyond public health emergencies, and investing in these partners.

Implementation Lessons for Vaccination Communication Campaigns

In our research outlined in chapter two, we found that developing an information campaign tailored for specific populations increases vaccine uptake. The success of the campaign outlines essential and practical steps public and global health professionals should take when designing health communication campaigns:

1. Qualitative formative work should be conducted to understand the community's experiences and identify any barriers or misinformation around the health problem of interest. This information should inform the content of the education campaign.[4]
2. The content should be linguistically and culturally appropriate, considering the language and cultural norms of the target audience. Similarly, it should be visually and culturally appropriate so that people identify with what they are seeing. This is especially important when targeting indigenous communities, which may have unique cultural norms that need to be respected and considered.
3. Social media has become a prevalent means of communication in communities that were previously considered remote or difficult to reach. As such, it presents a valuable opportunity for public health to engage with these populations and disseminate critical information.
4. Health communication and education campaigns should be designed and delivered in partnership with the communities they aim to target. Working with community leaders, representatives, or community-based organizations from the beginning can ensure that campaigns are culturally appropriate and resonate with the community. This approach promotes community engagement, builds trust, and increases the likelihood of successfully adopting recommended health behaviors. Additionally, involving community

partners in campaign dissemination can help reach a wider audience and ensure the message is delivered through trusted sources.

5. Despite the challenges, health communication campaigns should be rigorously evaluated. evaluations can provide valuable insights into the effectiveness of the campaign, identify areas for improvement, and inform decisions regarding the expansion or modification of the campaign.

Countering misinformation

The tool developed in the last chapter of this dissertation provides a practical solution that can be adapted and distributed to communities by public health departments. Currently, I am collaborating with the California Department of Public Health to expand the toolkit and incorporate the actionable steps we identified to other mediums. As part of this initiative, we plan to develop social media content, such as short videos, to educate people on the different strategies described in the toolkit. While the initial tool was designed for Spanish-speaking communities, it can be adapted and translated to other communities as well. This tool has the potential to make a significant impact in addressing misinformation by teaching people how to identify it, which is relevant not only for COVID-19 but also for various health and political issues currently plagued by misinformation online.

Impact on the field

My research has contributed to the broader field of public health and global health by highlighting significant lessons that can guide both research and practice. One of the major takeaways from my research is the critical importance of partnerships, particularly between academic institutions, public health departments, and community-based organizations to ensure the success of health interventions. Additionally, my research highlights the effectiveness of utilizing implementation science and community participatory research as methodologies for developing and implementing

health interventions among vulnerable populations. It also emphasizes the significance of appropriate evaluation methods for emerging technologies such as social media. Lastly, my findings underscore the importance of tailoring interventions to the specific needs and cultural context of the populations being targeted.

Partnerships

Chapter one showcases the success of a partnership between an academic institution and a public health department, specifically the UCSF/SFDPH partnership during the COVID-19 pandemic. This collaboration was essential in the city's success in mitigating the spread of the virus, resulting in one of the lowest death counts among metropolitan cities in the US. Through this partnership, SFDPH was able to access the research expertise of the university, while researchers had the opportunity to establish and implement interventions to reduce the transmission of COVID-19, such as contact tracing.

Partnerships between academic institutions and public health departments have many benefits, which proved invaluable during the pandemic. First, they enhance research capacity by providing access to the latest research and expertise to respond effectively to emerging issues related to the pandemic. Universities are at the forefront of research and innovation, making them well-positioned to respond quickly to health crises. Second, partnerships offer opportunities for capacity-building and training, helping to strengthen the workforce and build resilience for future health crises. For instance, the virtual training academy (VTA+) that UCSF partnered with CDPH to develop provided training for contact tracers and vaccine outreach workers, among others. Finally, partnerships between academic institutions and public health departments lead to data sharing, which is crucial for informed decision-making during a pandemic.

Chapters two and three showcase the importance of partnering with community-based organizations (CBOs) in public and global health research and practice. In chapter two, we worked directly with a trusted and well-known community-based organization in Guatemala, while in chapter three, we partnered with a local organization in the Bay Area. As illustrated by our research, there are many benefits of working with local CBOs:

- CBOs have a deep understanding of the community they serve, including cultural beliefs, practices, and norms which should inform the development of effective interventions.
- CBOs can help researchers develop interventions that are tailored to the specific priorities, needs, and challenges of the community.
- CBOs can help build trust between researchers and community members, particularly in communities that have historically been marginalized or mistreated by the healthcare system.

Methods

This dissertation highlights the effectiveness of implementation science and community participatory research in developing and implementing successful health interventions. By incorporating implementation science frameworks such as COM-B, interventions can be designed to address barriers identified during implementation, ensuring adherence to prevention recommendations.[5] Implementation science frameworks can enable public health interventions to include human behavior in a dynamic and adaptable manner, leading to modifications in policy and practice that promote equity in the public health response.[6] Other implementation methods such as human-centered design and participatory design, have proven effective in engaging with at-risk populations and developing tailored interventions.

Although evaluating health information campaigns on social media poses challenges due to the lack of established methodologies, this should not discourage or preclude the evaluation of public health interventions on emerging digital platforms.[7] In our research, we demonstrate how traditional on-the-ground methodologies, such as in-person surveys, can complement the evaluation of health campaigns on social media. While social media platforms have campaign evaluation functions designed for marketing and commercial purposes, these tools can also be leveraged for research purposes, with certain limitations that more robust surveys like ours can address.[8] Additionally, by conducting offline evaluations of online campaigns, researchers can identify and reach individuals who were not captured online, providing invaluable insights into the campaign's reach.

Tailoring public health interventions

The COVID-19 pandemic has highlighted the need for tailored interventions in public health. The disparities in vaccine uptake, despite having an effective vaccine available, show that a one-size-fits-all approach does not work. It is important to consider human behavior and differences between groups and communities before the roll-out of public health interventions, including non-pharmaceutical and pharmaceutical interventions, to ensure equitable adoption. Failing to consider this has led to an initially inequitable distribution of vaccines and treatments for COVID-19, among other problems. To address these inequities, we can adapt the strategies outlined above, such as creating partnerships and using community-driven implementation science methods. By doing so, we can better design, implement, and evaluate interventions that prioritize uptake for the most affected groups and ensure equitable distribution of public health interventions.

Next steps

The research presented in this dissertation served as foundational work for my future global and public health practice and research efforts. Thanks to the success of this research, we have been

able to secure funding to expand our work on COVID-19 to include additional areas of research. Specifically, we are now exploring childhood routine immunizations and Human Papilloma Virus (HPV) vaccinations. Additionally, we are conducting a cross-border, intertribal social network analysis to better understand vaccine decision-making in indigenous communities. Additionally, I am working closely with the California Department of Public Health to enhance the misinformation toolkit by creating a social media campaign that teaches people how to identify and combat misinformation. This campaign is based on the list developed in chapter three.

By building on the research emerging from my doctoral work, I am committed to advancing our understanding of public health issues and developing interventions that improve the health outcomes of vulnerable populations worldwide.

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Supplemental materials

Figure 4 Spanish version Ten-step list to identify misinformation.

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