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ORIGINAL PAPER

COVID-19 Vaccine Hesitancy, Acceptance, and Promotion Among Healthcare Workers: A Mixed-Methods Analysis

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Abstract

Even with vaccine mandates, COVID-19 vaccine hesitancy remains a concern among healthcare workers, in part due to their role in promoting vaccination among patients and communities. To examine COVID-19 vaccine hesitancy, acceptance, and promotion among healthcare workers, we conducted a mixed-methods analysis of (1) survey responses about COVID-19 vaccination and (2) Twitter messages (i.e., tweets) relevant to COVID-19 vaccination and healthcare. A total of 540 hospital employees completed the survey. Those that completed less than 80% of the survey or did not endorse employment at the hospital were excluded, resulting in a total of 511 valid responses; 93.2% reported receiving at least one dose of a COVID-19 vaccine. Approximately 1/3 of vaccinated individuals indicated they posted about receiving the vaccine on social media. Simultaneously, we analyzed a sample of 3845 tweets; 2299 (60%) were relevant to COVID-19 vaccination and 1863 (81%) were coded as authored by an individual. Of tweets authored by an individual, 6% (n = 106) were authored by a healthcare provider/health sciences student. Among relevant tweets, the most frequent code across all sentiment categories was related to the pharmaceutical industry (n = 529 tweets, 28%; n = 33, 31% of tweets authored by healthcare workers). Triangulation of results found themes including vaccine access, trust, and vaccine safety or negative health impacts. Results suggest that promoting the sharing of COVID-19 vaccine personal narratives on social media, combined with interventions targeting specific reasons for COVID-19 vaccine hesitancy and emphasizing freedom from fear once vaccinated could be effective at reducing COVID-19 vaccine hesitancy among this population.

Keywords COVID-19 · Healthcare · Vaccine hesitancy · Social media · Health communication

Background

The novel coronavirus, SARS-CoV-2, and its associated disease, COVID-19, has infected over 500 million individuals worldwide and caused over 6.1 million deaths, as of this writing, since its initial outbreak in late 2019 [1]. Healthcare workers were one of the first groups targeted for the Pfizer-BioNTech and Moderna COVID-19 vaccine distributions in the United States (U.S.); on December 14, 2020 the first dose of the Pfizer-BioNTech vaccine was given to a nurse in New York City [2]. While the requirement by the U.S. Department of Health and Human Services that healthcare workers at facilities paid by Medicare and Medicaid be fully vaccinated has increased vaccine uptake among this population, COVID-19 vaccine hesitancy by healthcare workers remains a concern. A recent national survey found that approximately 10% of primary care physicians (PCPs) lack confidence in the Pfizer and Moderna vaccines, and 32% lack confidence in the Johnson & Johnson vaccine [3]. Additionally, about 10% of PCPs surveyed did not agree that vaccines, in general, are safe [3].

COVID-19 vaccine hesitancy among healthcare workers is particularly concerning due to their role in promoting

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vaccination among patients and communities. A recommendation to receive a vaccine—such as the influenza vaccine—by a healthcare provider is associated with greater vaccine receipt among patients [4]. Likewise, intent to receive a COVID-19 vaccine increases with a healthcare professional recommendation [5]. Healthcare workers can also have impact outside of traditional patient encounters. There is a growing movement encouraging healthcare workers to be visible and vocal about vaccines on social media in order to combat misinformation and encourage public and community health [6]. It is recommended that this be conducted with communication of science-backed factual information enhanced with personal narratives [7]. Indeed, Twitter messages crafted by physicians about COVID-19 that have a personal narrative are viewed as more effective than those with impersonal information [8].

In order develop the most appropriate messaging and interventions to increase COVID-19 vaccine promotion among healthcare workers, it is critical to obtain both a rich picture of COVID-19 vaccine hesitancy and acceptance among these individuals as well as know how healthcare workers present the COVID-19 vaccine to others on social media. Therefore, we conducted a mixed-methods analysis of (1) survey responses from healthcare workers about COVID-19 vaccine hesitancy, acceptance, and promotion and (2) Twitter messages relevant to COVID-19 vaccination and healthcare.

Methods

Survey Sample Selection

In April–June 2021 all employees at a large psychiatric hospital in Western Pennsylvania were invited to participate in an anonymous online survey. Participants were recruited via an employee-only social networking tool and through e-mail. All employees at the hospital over 18 years of age were eligible to participate, including support staff (e.g., housekeeping, food service) and those without direct patient care (e.g., administration, patient records). All participants were entered to win one of five jackets as compensation for their time.

Survey Measures

The survey consisted of 42 items, although many participants completed fewer due to skip logic. Closed-ended items assessed sources of COVID-19 vaccine information, COVID-19 vaccine attitudes and beliefs, receipt of a COVID-19 vaccine, and demographic information. Open-ended items invited participants to provide additional detail about their reasons for receiving the vaccine (or not). These items were adapted from sample survey instrument and interview guides suggested by the WHO [9]. Participants who reported receiving a COVID-19 vaccine were asked if they posted about receiving their vaccine on social media, and if so, to complete an open-ended item describing their post.

Twitter Sample Selection

Simultaneously, we obtained Twitter messages (i.e., tweets) with COVID-19 vaccine-specific keywords (e.g., antivax*, vaccin*, corona*, sarscov2, covid*), informed by prior research [10], using Twitter's Application Programming Interface (API) over the course of 6 months beginning December 11, 2020 (the day of the Pfizer-BioNTech COVID-19 vaccine EUA). Due to Twitter's restrictions on the total number of search requests sent via API in a month, we sent five queries for each date in the date range, with one request for each of the 5 hours of the day with the highest average levels of English-language activity (alternating hours between 3 pm and 12 am United States Eastern Standard Time). Twitter limits responses to 500 returned tweets per request; this gave us an upper limit of 2500 returned tweets for each date that we searched. This elicited 484,495 tweets, of which 338,960 were original tweets (70%) and 145,535 were retweets (30%).

Tweets were filtered using healthcare-related keywords (doctor*, nurs*, scientist*, MD, RN, PhD, MPH, NP, CNM, OB-GYN, and OB/GYN), which resulted in 89,191 tweets. Finally, we obtained a 5% random subsample of tweets for coding (n = 3845). Previous research utilizing this approach to examine vaccine-related tweets has demonstrated that it maintains generalizability of the subsample within context of the full data of tweets [7].

Twitter Codebook Development

We developed an initial codebook for tweet analysis using a hybrid approach based on (1) previous literature on vaccine and COVID-19 content on social media [10–12] and (2) direct analysis of a subset of 100 tweets by two coders and the first and senior authors. To finalize the codebook, the two coders independently examined an additional subset of 100 tweets using the draft codebook, then met with the first author to discuss additional codes, merging of codes, and potential clarifications for the draft codebook. This process was repeated four times, after which the codebook was considered final (Supplemental Table 1).

Twitter Coding Procedures

We used a previously established coding process to examine vaccine-related tweets that involved coding by two

independently working human coders, adjudication of disagreements with the first author, and codebook clarification [7]. After each round of coding, we assessed inter-rater reliability using Cohen's kappa (κ). After six rounds of this process, inter-rater reliability was considered good to excellent (κ = 0.71–1.00) for all categories [13]. Following this, coders independently coded the remaining tweets.

The two coders were provided with an Excel spreadsheet containing the tweet text and a link to each tweet on the Twitter.com platform. Coders viewed all tweets that were publicly available online at the time of analysis to facilitate examination of external content (e.g., link to a news story or blog post). To maintain the comprehensiveness of the original data, we included text from unavailable tweets in the analysis. Coders assessed the content of the tweet itself (including media such as GIFs and videos) and any external linked content.

Coders first assessed if tweets were relevant to COVID-19 vaccines. Tweets that did not pertain to COVID-19 vaccines specifically (i.e., "happy to share that covid has not affected the cornhole world championships #covidvaccine") were coded as not relevant. If the tweet was deemed relevant, coders next assessed if the tweet was authored by an account maintained by an individual using both the tweet text and Twitter bio text. If the tweet was coded as authored by an individual, coders then evaluated if the account identified as a healthcare worker or a health sciences student in either the tweet text or Twitter bio**.**

For all tweets coded as authored by an individual (whether or not they were coded as authored by a healthcare worker/health sciences student), coders assessed both tweet sentiment and content. Tweets were coded as expressing positive sentiment if they contained language indicative of supporting COVID-19 vaccines or vaccination efforts. Likewise, tweets were coded as expressing negative sentiment if they contained language indicative of opposing COVID-19 vaccines or vaccination efforts. If the tweet consisted of a news story or information about COVID-19 vaccines without expressing support or opposition to COVID-19 vaccination, it was coded as neutral sentiment. The codebook contained 17 content categories, which were not mutually exclusive (Supplemental Table 1). For example, the tweet "I am thankful for the chance to share my journey as a #COVIDvaccine trial participant on a podcast!" was coded as both "research and clinical trials" and "personal reference." To protect tweet authors from identification, all example tweets included in the text and tables contain minor modifications to prevent re-identification via direct quotations. All methods described above were approved by the University of Pittsburgh Human Research Protection Office.

Analysis

To analyze quantitative survey data, we calculated descriptive statistics using R statistical software [14]. To analyze qualitative survey data, we entered participant responses into Nvivo software [15]. For each item, two human coders independently performed open coding on the data to identify, name, and describe themes found in the text [16]. Coders then met with the first author to adjudicate differences and collectively perform axial coding, synthesizing the open codes into major themes and their related sub-themes.

To analyze the Twitter data, we calculated descriptive statistics for each coding category using Stata 16 [17], and analyzed the content of coded tweets using a thematic content analysis approach [18]. For the thematic analysis, coders took notes on overarching themes and subthemes and highlighted words, phrases, or visual material that exemplified these themes. Notes and annotations were reviewed with the first and senior authors to further identify and refine themes.

Finally, we triangulated findings between the Twitter and survey results to conduct a comprehensive mixed-methods analysis [19]. Specifically, we noted which themes were present in both the Twitter and survey results and which were unique to each data source.

Results

Survey Sample

A total of 540 hospital employees completed the survey. Those that completed less than 80% of the survey or did not endorse employment at the hospital were excluded, resulting in a total of 511 valid responses. Participants were 42.9 (SD 13.6) years of age on average and primarily female (81%). Regarding race and ethnicity, of which participants could choose multiple, participants identified as < 1% American Indian/Alaskan Native, 4% Asian, 6% Black, 2% Hispanic, Latine, or of Spanish origin, < 1% Middle Eastern or North African, < 1% Native Hawaiian/Pacific Islander, 90% White, and < 1% another race/ethnicity not listed. The most common hospital positions reported were outpatient therapist (16%), administrator (13%), nurse (13%), patient support (12%) and physician (10%). The average annual income was $97,569 (SD $53,869).

Of the full sample, 93% (n = 476) reported having received at least one dose of the COVID-19 vaccine (80% female, mean age 43.2). Thirty-two respondents (6%; 94% female, mean age 38.9) reported they had not received at least one dose. Among these respondents, 3% (n = 1) reported they planned to get the vaccine the next time it was offered, 28% (n = 9) reported they will get the vaccine "after I wait and see how it's working," another 28% (n = 9)

reported they will only get the vaccine if it is required, and 38% (n = 12) reported they will "definitely not get the COVID-19 vaccine." Those who did not get dose one were younger [$t(37.13) = -2.18$, $p = 0.04$] and had lower annual incomes [$t(35.33) = -2.81$, $p = 0.01$], on average, than those who did.

Of the 156 vaccinated individuals who indicated they posted about receiving the vaccine on social media, 61 mentioned which social media platform they used, with the most frequent being Facebook (n = 36) or Instagram (n = 32). Themes in their social media posts included being grateful for receiving a vaccine (e.g., "posted a picture and that I was blessed to be able to receive it"), explaining why they received a vaccine (e.g., "that I got it for my patients, myself, and my friends and family"), and encouraging others to get vaccinated (e.g., "I posted to encourage others in my community to get vaccinated").

Coders identified 16 themes in response to the open-ended item asking those who were vaccinated why they choose to receive a vaccine, which were classified into four motivational categories: societal, work environment, interpersonal, and intrapersonal (Supplemental Table 2). Coders identified 14 themes in response to the open-ended item asking those who were not yet vaccinated why they had not yet received one, which were classified into four overarching categories: waiting, COVID-19 specific concerns, safety and side effects, pre-existing health conditions, and other (Supplemental Table 3).

Social Media Sample

Of 2299 relevant tweets, 2225 (97%) were available for coders to view on Twitter.com and 1863 (81%) where authored by an individual. Of these, 6% (n = 106) were authored by an account that identified as a healthcare worker or a health sciences student either in the tweet text or Twitter bio (Table 1).

Approximately half (n = 909, 49%) of tweets authored by an individual expressed neutral sentiment, 795 (43%) expressed positive sentiment, and 152 (8%) expressed negative sentiment toward COVID-19 vaccines (Table 1). Among tweets authored by a healthcare worker/health sciences student, 36 (34%) expressed neutral sentiment, 65 (61%) expressed positive sentiment, and 5 (5%) expressed negative sentiment toward COVID-19 vaccines (Table 1). Most neutral tweets were either news headlines (e.g., "BreakingNews information on the FDA's approval of Moderna's COVID vaccine moments ago") or announcements that people retweeted from organizations or other individuals about COVID-19 vaccine appointments (e.g., "New Yorkers age 65 + are now eligible for the #COVID19 vaccine! To find out where to get vaccinated, click this link.").

The most frequent code across all sentiment categories was related to the pharmaceutical industry (n = 529, 28%; n = 33, 31% among healthcare workers; e.g., "CDC says The mRNA vaccines (Pfizer-BioNTech/Moderna) are highly protective against getting sick with COVID-19 and also getting infected by SARS-CoV-2"). The next most frequent code was access to COVID-19 vaccines (n = 520, 28%; n = 25, 24% among healthcare workers; e.g., "You need to work on the Covid vaccine wait in Texas. Waiting lists to get vaccinated are tens of thousands of people long!"; Table 1).

Table 1 Descriptive statistics for Twitter coding categories

Category	Frequency for personal accounts (n = 1868)		Frequency for healthcare worker accounts (n = 106)	
	N	%	N	%
Sentiment				
Positive	795	42.6	65	61.3
Negative	152	8.1	5	4.7
Unsure	10	0.5	0	0
Neutral	909	48.7	36	34.0
Content				
Conspiracy	57	3.1	0	0
Trust	6	0.3	0	0
Naturalness	5	0.2	0	0
Rapid nature	16	0.9	0	0
Safety/negative health impacts	172	9.2	9	8.5
Immediate vaccine side effects	136	7.3	7	6.6
COVID-19 is not dangerous	7	0.4	1	0.9
Racial/Ethnic minority	36	1.9	3	2.8
Affordability	35	1.9	0	0
Accessibility	520	27.8	25	23.6
Distribution of vaccines	358	19.2	13	12.3
Pharmaceutical industry	529	28.3	33	31.1
Research and clinical trials	84	4.5	8	7.6
Policies and politics	39	2.1	1	0.9
Health authorities	148	7.9	5	4.7
Personal or proximate experience	207	11.1	15	14.1
Protect patients	25	1.3	4	3.8

Main Themes Across Both Social Media and Survey Groups

Approximately 1/3 of survey respondents noted that they posted about receiving the vaccine on social media, and one theme in the Twitter coding category of personal or proximate narratives related to vaccination (n = 207, 11%; n = 15, 14% among healthcare workers) included the tweet author getting vaccinated (e.g., "Got my COVID-19 vaccine today"). Another theme in this Twitter coding category was excitement over seeing loved ones receive a vaccine (e.g.,

"Seeing friends I know who are nurses getting their vaccines is making me so happy"). Survey themes related to fear of judgement from others at work if they were not vaccinated (e.g., "I feared judgement/ostracism from co-workers if I didn't get vaccinated") and getting vaccinated because they saw others doing so or were encouraged by others to do so (e.g., "I have friends [who] were getting the vaccine. My co-workers were getting it also and I thought it was a good idea for me to get it") suggesting that proximate experiences related to vaccination were motivators among respondents (Table 2).

Societal motivators for receiving a COVID-19 vaccine in both the survey and Twitter samples included wanting a return to normalcy and wanting to achieve community immunity (Table 2). Tweets with these themes were seen in both the safety and access coding categories (e.g., "As of today all Michiganders 16 + are eligible for the COVID-19 vaccine. There is a light at the end of the tunnel, register now!"). An example of a survey responses related to a return to normalcy was "Felt that by getting vaccinated I am helping to move the world back to normalcy."

Table 2 Themes by data source

Themes	Social media	Survey
Personal or proximate experience	✓	✓
Normalcy	✓	✓
Herd immunity	✓	✓
Protect others	✓	✓
Risk vs. reward	✓	✓
Health & Safety	✓	✓
Pregnant or breastfeeding	✓	✓
Trust or lack of trust in science or authorities	✓	✓
Conspiracy theories	✓	✓
Vaccine policy	✓	✓
Vaccine safety and efficacy/lack of research	✓	✓
Lack of evidence concerning virus transmission		✓
Infertility		✓
Vaccine side effects	✓	✓
Vaccine access	✓	✓
Lack of access to vaccine appointments	✓	
Ease of receiving a vaccine at work		✓
Distribution	✓	
Affordability	✓	
Racial undertones	✓	
Moral responsibility		✓
Work environment		✓
Provider recommended		✓
Peace of mind		✓
High-risk population		✓
Already had COVID-19		✓
Pre-existing health condition		✓

Another motivator present in both samples was the interpersonal motivator of wanting to protect others (Table 2). Tweets in this coding category (n = 25, 1%; n = 4, 4% among healthcare workers) mentioned protecting loved ones (e.g., "I am getting vaccinated against COVID-19 so 1 day, I can hug my friends and family again!") as well as patients (e.g., "So thankful my wife and I were able to get the #CovidVaccine to protect our patients, families, friends, and the community"). Likewise, survey respondents also mentioned being motivated to get vaccinated to protect others in their personal life (e.g., "To protect my kids") and the patients they work with (e.g., "I work in healthcare and felt it was my responsibility to keep patients safe").

Intrapersonal motivators present in both the Twitter sample and among vaccinated survey respondents included risk vs. reward and health and safety. The theme of risk vs. reward was found in tweets referencing vaccine safety (e.g., "The risk of a serious blood clot from AstraZeneca vaccine has doubled in a fortnight, but the Government's regulatory agency has said the benefits outweigh the risks") and tweets referencing personal or proximate narratives (e.g., "Today I got my second dose of vaccine to protect myself against COVID-19"). Similar survey responses included "The chances of a serious adverse event befalling me because of the vaccine was much lower than if diagnosed with COVID-19."

Themes related to pregnancy or breastfeeding were also present in both data sources. Survey respondents who had received a vaccine mentioned doing so both to protect the fetus or infant (e.g., "As a pregnant woman…this was an opportunity to potentially give antibodies to my newborn") and as an intrapersonal motivator (e.g., "I am pregnant and concerned about the risks of having COVID-19 during pregnancy"). On Twitter, vaccine safety tweets addressed safety for pregnant people (e.g., "There is zero evidence to suggest that mRNA vaccines are harmful to pregnant women").

For some survey respondents, however, being pregnant was a reason why they had not yet received a vaccine (e.g., "I am pregnant and plan to breastfeed long-term"). Similarly, several tweets mentioned that pregnant women should not receive a vaccine (e.g., "Listen up, crazy people—pregnant woman should not have an experimental vaccine! Leave the children alone!").

Trust in science, research, and public health authorities was another motivator present in both data sources (Table 2). This emerged as a theme under tweets coded as research and clinical trials (e.g., "I'd like to give a huge thank you to the FDA, BioNTech /Pfizer, all the vaccine trial staff and volunteers!") and a societal motivator among survey respondents (e.g., "I trust science and public health and Dr. Fauci").

Conversely, lack of trust emerged as a barrier to receiving a vaccine in both the Twitter sample (e.g., "Who says the COVID vaccine is even safe yet? I know they are and can use us as guinea pigs") and among survey respondents (Table 2). Approximately 8% of all survey respondents (both vaccinated and not yet vaccinated) noted doubting the trustworthiness of the government or pharmaceutical companies as a reason for being hesitant, and mistrust of vaccine technology and pharmaceutical companies (e.g., "I don't trust the make-up of the vaccine") emerged as theme in response to the open-ended item about reasons for not yet receiving a vaccine.

Often related to mistrust of vaccine technology, mentions of COVID-19 conspiracy theories were found in 3% of tweets (n = 57) authored by individuals and as a barrier to vaccination among survey respondents. Conspiracy theories were often related to mRNA technology on both Twitter (e.g., "The lies about the development of a COVID vaccine are insane. They pretend like it was this incredible global team effort. In reality, China published a gene sequence & 1 day after Big Pharma claimed to make a vax in 1 h"), and survey responses (e.g., "I worry it could change my DNA"; Table 2).

Another barrier to vaccination across both the tweets and survey analysis was related to vaccine policy (Table 2). Several survey respondents who were not yet vaccinated indicated they were waiting until vaccination is required for work or travel (e.g., "It will not enter my system UNLESS mandated for work or travel/flight"), and 2.0% of tweets (n = 39) authored by individuals mentioned policies, with one theme related to vaccine mandates (e.g., "Cornell university becomes the first private university to mandate the Covid vaccinations for the upcoming Fal1").

Concerns about COVID-19 vaccine safety and efficacy, including mention of the rapid nature of vaccine development, were also a barrier to vaccination mentioned by Twitter users and survey respondents (Table 2). On Twitter, 9% of tweets (n = 172) authored by individuals and 9% of tweets (n = 9) authored by healthcare workers mentioned safety or negative health impacts of vaccination, with common themes related to death (e.g., "Twenty-three individuals pass away in Norway after receiving the COVID vaccine"), and inadequate testing (e.g., "On average, every vaccine is tested for 10 years before being administered. We do not know the long-term effects of this shot!"). Among survey respondents, 22.3% reported being hesitant about receiving a vaccine due to safety or efficacy concerns, and themes in response to the open-ended item about reasons for not yet receiving a vaccine included wanting more vaccine-related research (e.g., "Until research of the vaccines specifically say they would not cause any [health] issues to exasperate, I will not obtain a vaccine"), lack of evidence that COVID-19 vaccines prevent transmission of disease (e.g., "Experts have stated if you get the vaccine, you can still get covid and spread it"), and prior adverse reactions to other vaccines (e.g., "Since I had a complication with the flu shot so I was told not to get the Covid-19 vaccine").

Related to COVID-19 vaccine safety or negative health impacts, concerns about the effects of COVID-19 vaccines on fertility were seen during the tweet analysis (e.g., "No one has an idea of what COVID vaccines mean for women's fertility long term") and as a reason for not yet being vaccinated from survey respondents (e.g., "I don't know if the vaccine will cause infertility issues").

Mentions of immediate vaccine side effects were found in 7% (n = 136) of tweets authored by individuals and 7% (n = 7) of tweets authored by healthcare workers, with many of these also coded as personal or proximate narrative (n = 207, 11%; n = 15, 14% among healthcare workers; e.g., "Beginning to feel mild side effects of the second dose of the covid vaccine. I felt nothing with the first"). Survey respondents indicated that concerns about potential side effects (e.g., "I worry that the vaccine could trigger an inflammatory response in my body and cause further complications") and witnessing others have a negative reaction to vaccination (e.g., "I have concerns after seeing issues with coworkers who received a vaccine") were barriers to vaccination.

Finally, themes related to vaccine access were present in both groups, but in different contexts (Table 2). For the tweet analysis, themes centered around lack of access, including difficulties scheduling vaccination appointments (e.g., "Just spent 2 h trying to schedule a COVID19 vaccine for my mom only to have the site crash repeatedly as I was confirming the appointment"). However, among survey respondents, themes related to access centered around relative ease of obtaining a vaccine. For example, among respondents who were vaccinated, the vaccine being available at work (e.g., "Easy access—provided by my healthcare employer") was a motivator. Some respondents who were not yet vaccinated also noted the accessibility of the vaccine as a healthcare employee, but wanting to wait until the vaccine was more broadly accessible before receiving it (e.g., "I am just unsure of the vaccine…and would like to wait until more people can get it").

Additional Themes from Survey

Additional themes about motivators for being vaccinated that were not found in the Twitter sample but were present in the survey are presented in Supplemental Table 2. These themes included societal motivators (i.e., being vaccinated as a moral responsibility; being vaccinated due to their work environment) and inter- and intrapersonal motivators (i.e., peace of mind; being high risk or being close to someone high risk). Likewise, additional themes about not being vaccinated that were not found in the Twitter sample but

were present in the survey are presented in Supplemental Table 3. These themes included already having and recovering from COVID-19 and having a pre-existing condition and/or receiving advice from their healthcare provider not to receive the vaccine.

Discussion

Although prior research has examined COVID-19 vaccine communication on Twitter [20], and surveyed healthcare workers about COVID-19 vaccine receipt [21], to our knowledge this is the first study pairing online and off-line data to systematically examine COVID-19 vaccine hesitancy, acceptance, and promotion among healthcare workers. Comparison of themes found in Twitter messages and survey results suggests that reasons why healthcare workers choose whether or not to receive a COVID-19 vaccine were nuanced, and our results offer several avenues for future research and intervention both online and off-line to reduce COVID-19 vaccine hesitancy among this population.

Findings across both data sources suggest that it would be valuable for interventions aimed at addressing COVID-19 vaccine hesitancy among healthcare workers, such as motivational interviewing, to focus on societal motivators such as wanting a return to normalcy, and inter- and intrapersonal motivators of protecting others and the relatively low risk of adverse effects to a vaccine. Motivational interviewing, which emphasizes collaborative communication between individuals, can be used by anyone trained to understand a person's position on the COVID-19 vaccine and explore ambivalence free from judgment or intent to influence the individual's decision [22, 23]. Even a single session of motivational interviewing interventions have increased postpartum mothers' intent to vaccinate their children by 15%, suggesting the viability of this approach [24].

Our findings also suggest that messaging, both online and off-line, could promote trust in science, research, and public health authorities and share results from research studies to counter concerns about the rapid nature of vaccine development, safety or negative health impacts of vaccination, and side effects. Additionally, given prior research that correction of health misinformation by experts may be effective in reducing beliefs of the misinformation [25], it would be valuable for healthcare workers to counter misinformation related to COVID-19 vaccines and reproductive health, including concerns about infertility and vaccine safety while pregnant or breastfeeding—concerns we saw among both survey respondents and online.

While prior research suggests sharing of personal or proximate narratives related to vaccination may positively influence others to receive a vaccine [26], in our study only 1/3 of survey respondents mentioned posting about receipt of a COVID-19 vaccine on social media, and only 11% of tweets included a personal or proximate narrative. Furthermore, among tweets coded as authored by a healthcare worker, only 14% contained a mention of personal or proximate narrative related to vaccination. Considering Twitter messages crafted by physicians about COVID-19 are viewed as more effective when they contain a personal narrative instead of impersonal information, healthcare workers should strive to promote COVID-19 vaccination among the public and communities by including stories of their own experiences [8].

Discrepancies between motivators and barriers to COVID-19 vaccination observed online and through the survey may also provide insight for untapped potential messages for social media. For example, a theme among survey respondents who were vaccinated was receiving one to obtain freedom from COVID-19-related anxiety. Prior research suggests that an emphasis on personal freedom may be particularly prominent among those who have not yet received a COVID-19 vaccine [27]. Thus, it may be valuable for pro-vaccine social media campaigns to deliver messages centered around freedom from fear of contracting COVID-19 as part of promotion efforts. Similarly, messages on social media targeted at healthcare workers could address misconceptions related to not receiving a vaccine due to already having COVID-19 or a pre-existing health condition, themes also observed among survey responses but not online.

The issue of COVID-19 vaccine hesitancy among healthcare workers is a growing concern [3, 28]. While many healthcare workers are employed by facilities covered under the federal COVID-19 vaccine mandate, continued efforts to decrease COVID-19 vaccine hesitancy among healthcare workers are needed as these individuals can be effective ambassadors for pro-vaccine efforts, especially when messages include personal narratives. Two years into the pandemic, healthcare workers have compelling personal narratives, but a minority, according to both our survey and Twitter data, are sharing these narratives online. Future work could explore how to support healthcare workers on utilizing social media as an important health communication tool to bolster vaccine acceptance among the public.

Limitations

With regard to Twitter data collection, while we filtered tweets with healthcare-related keywords, only about 5% were coded as being authored by a healthcare worker/health sciences student. Thus, while we analyzed healthcare-related tweets, our results may not be indicative of the broader discussion about COVID-19 vaccines by healthcare workers on Twitter. Future work could aim to use machine learning or other methods to include a broader sample of tweets authored by healthcare workers. For both the Twitter and qualitative survey analysis, interpretation of text using

qualitative methods can be subjective, although we minimized this by using systematic coding procedures, two experienced coders, and a supervising researcher. Additionally, we did not assess the likelihood that the Twitter accounts in our dataset were automated accounts (i.e., a bot) given prior research suggesting that the vast majority of vaccine-related posts on Twitter are authored by accounts not classified as bots [7]. However, it may be valuable for future work examining COVID-19 related content on Twitter to perform such an analysis.

With regard to survey data collection, although recent data suggests approximately 30% of employees invited to participate in the survey are unvaccinated, less than 10% of survey respondents reported being unvaccinated. In addition to sampling bias, this may reflect hesitancy of respondents to disclose vaccination status to their employer regardless of anonymity. Our sample was also very homogenous in terms of gender, although this allowed us to gain unique insight into reasons for hesitancy related to female reproductive health, which may be particularly valuable given data suggesting healthcare workers who identify as female are less likely to accept COVID-19 vaccines [21].

Conclusions

Reducing COVID-19 vaccine hesitancy among healthcare workers is vital given their role in promoting vaccination among patients. Mixed-methods analysis of a survey of healthcare workers and Twitter messages related to COVID-19 vaccination suggests similarities in themes across data sources, including the sharing of personal and proximate narratives related to receipt of a COVID-19 vaccination. However, this type of sharing was relatively rare in our data, suggesting that healthcare workers need training and support to be effective vaccine advocates on social media. Our results also suggest that interventions intended to explore COVID-19 vaccine hesitancy, address misinformation related to reproductive health, and emphasize a reduction in fear once vaccinated could be effective at reducing COVID-19 vaccine hesitancy among this population.

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Data Availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code Availability Not applicable. Twitter API is publicly available.

Declarations

Conflict of interest The authors declare they have no competing interests.

Consent to Publish Not applicable.

Ethical Approval Approval was obtained from the University of Pittsburgh Institutional Review Board. The procedures used in this study adhere to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all individual participants included in the study.

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