# Understanding Behavioral Intentions Toward COVID-19 Vaccines: A Theory-based Content Analysis of Tweets

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# Understanding Behavioral Intentions Toward COVID-19 Vaccines: A Theory-based Content Analysis of Tweets

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## *Abstract*

**Background:** Acceptance rates of COVID-19 vaccines still have not reached the threshold for herd immunity. Understanding why some people are willing to be vaccinated and others are not is a critical step to develop efficient implementation strategies to promote COVID-19 vaccines.

**Objective:** We conducted a theory-based content analysis based on the Capability, Opportunity, Motivation-Behavior (COM-B) Model to characterize the factors influencing behavioral intentions for COVID-19 vaccines mentioned on the Twitter platform.

**Methods:** We collected English tweets posted from 2020.11.01 to 2020.11.22, using the combination of relevant keywords and hashtags. After excluding retweets, we randomly selected 5,000 tweets for manual coding and content analysis. We performed a content analysis informed by the adapted COM-B model.

**Results:** Of the 5,000 COVID-19 vaccine-related tweets were coded, these tweets were posted by 4,796 unique users. 97 tweets carried positive behavioral intent, while 182 tweets contained negative behavioral intent. Of these, 28 tweets were mapped with capability factors; 155 tweets were related to motivation; 23 tweets were related to opportunities, and 74 tweets did not contain any useful information about reasons of their behavioral intentions (kappa 0.73). Some tweets mentioned two or more constructs at the same time. Tweets that mentioned capability ($p<0.001$), motivation ($P<0.001$), and opportunity ($P=0.033$) are more likely to have negative behavioral intentions.

**Conclusions:** Most behavioral intentions regarding COVID-19 vaccines were related to the motivation construct. The themes identified in this study could be used to inform theory-based and evidence-based interventions to improve acceptance of COVID-19 vaccines.

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# Original Manuscript

# Understanding Behavioral Intentions Toward COVID-19 Vaccines: A Theory-based Content Analysis of Tweets


## ABSTRACT

Acceptance rates of COVID-19 vaccines still have not reached the threshold for herd immunity. Understanding why some people are willing to be vaccinated and others are not is a critical step to develop efficient implementation strategies to promote COVID-19 vaccines. We conducted a theory-based content analysis based on the Capability, Opportunity, Motivation—Behavior (COM-B) Model to characterize the factors influencing behavioral intentions toward COVID-19 vaccines mentioned on the Twitter platform. We manually coded a random sample of 5,000 tweets from tweets posted in November 2020. Among them, 279 tweets mentioned behavioral intentions. We also generated nine themes based on the COM-B model. The results showed that most behavioral intentions regarding COVID-19 vaccines were related to the motivation construct. Specifically, positive behavioral intentions were affected by the positive values of vaccination (e.g., reduced risk of infection, socioeconomic recovery, return to normal life). In contrast, negative behavioral intentions were associated with attitudes and perceptions about COVID-19 vaccines or the disease itself (e.g., an underestimation of disease severity, low vaccine effectiveness), values and beliefs (e.g., greater belief in the natural immune system), confidence and trust (e.g., distrust of government or vaccines), and lack of knowledge. The themes identified in this study could be used to inform theory-based and evidence-based interventions to improve acceptance of COVID-19 vaccines.


## INTRODUCTION

As a global pandemic, the coronavirus (COVID-19) is affecting 219 countries worldwide [1]. An important component to manage COVID-19 disease is to prevent the infection [2,3]. Fortunately, the vaccine development is progressing well. In December 2020, the US Food and Drug Administration (FDA) authorized COVID-19 vaccines for emergency use. Another pressing issue now is how to increase vaccine acceptance rates [4]. In previous surveys, the acceptance rate of the COVID-19 vaccine was a concern. Of the 672 participants in the United States, approximately 67% said they

would be willing to receive the vaccine [5]. We need an estimated 55%-82% of the population to be vaccinated to create herd immunity and slow the spread of pandemics [6]. Therefore, it is critical to understand why some people are willing to be vaccinated and others are not.

Previous studies have raised potential impediments to COVID-19 vaccines including: questioning the need for vaccines and preferring to use immunity that survives from COVID-19 [7]; vaccine safety issues regarding the rapid development and testing process [7]; mandatory issues [7]; and conspiracy beliefs [8]. Some researchers conducted surveys based on theoretical models to explore facilitators and barriers to COVID-19 vaccination. Williams et al. conducted a survey to examine factors that influence their decisions to vaccinate against COVID-19 and identified three facilitators (personal health, severity of COVID-19 disease, health consequences to others) and one barrier (concerns of vaccine safety) [9]. Lin et al. used the Health Belief Model (HBM) to identify two facilitators (a reduced chance of getting COVID; others getting vaccinated) and one barrier (concerns about efficacy and side effects) [10]. Wong et al. also used the HBM to identify one facilitator as perceived benefits (the belief that the vaccination can reduce infection probability and alleviates concerns about COVID-19) [11].

Compared with surveys, Twitter can gather timely behavioral intentions toward COVID-19 vaccines, especially to understand anti-vaxxers and those influenced by misinformation who are inclined not to get the vaccine. These types of users could be the most vulnerable population for COVID-19 vaccine outreach interventions. On the Twitter platform, there are more than 330 million users, and the median number of posts per person in each month is two [12,13]. A recent survey of US Twitter users showed that Twitter users are younger and have a higher education level; however, gender, race, and ethnicity are similar to the general population [13]. The Twitter platform has been validated as a way to develop a public perceptions tracking tool based on the real-time content [14]. In addition, it is flooded with information about COVID-19, influenced by the social isolation policy

during the epidemic [15]. The Twitter platform could be used to explore determinants of health-related behavior intentions [16]. Because the maximum length of each tweet is 280 characters, in addition to mentioning potential behavioral intentions, users could also briefly describe the reasons that led to the decision. In addition, geotagged Twitter data makes it easier and faster to identify people's perceptions in different geographic locations. Therefore, we chose to use the Twitter platform to analyze behavioral intentions toward COVID-19 vaccines.

To better characterize the factors that influence behavioral intentions on COVID-19 vaccines mentioned in the tweets, we conducted a theory-based content analysis based on the Capability, Opportunity, Motivation—Behavior Model (COM-B). The COM-B model was proposed by Michie et al. in 2011, containing three basic constructs: capability (physical and psychological), motivation (automatic and reflective), and opportunity (social and physical) [17]. It is a comprehensive theoretical model based on causal mechanisms to identify individual and context factors that influence behavioral change. It was developed by merging 19 behavior change frameworks through a systematic literature review and discussions with behavior change experts. It has been successfully applied to many health-related behaviors such as smoking cessation [18–20], obesity reduction [21,22], etc. In contrast to other health behavior theories (e.g., HBM, Theory of Planned Behavior), the COM-B model was developed based on the Behaviour Change Wheel (BCW), which not only provides a theoretical analysis of behavior but, more importantly, allows the results to be used to assist with intervention design [17,23]. In addition, the WHO Regional Office for Europe has adapted it to vaccination behaviors to design tailoring immunization programmes (TIP) [24,25]. They merged subconstructs in capability and motivation, respectively. Because of vaccination behavior, the physical capability is interlinked with the psychological capability. Likewise, automatic motivation (i.e., emotion, impulses) interacts with the reflective motivation (i.e., intentions, beliefs). Another advantage of the adapted COM-B model is that it focuses on the vaccination behavior and provides refined details for each construct in the vaccine context. Therefore, we used this adapted COM-B model (see Figure 1) as the theoretical model of this study. The objectives of this study are to: 1)

determine if the adapted COM-B model can explain behavioral intentions toward COVID-19 vaccines using tweets; 2) examine theory-informed factors that might affect behavioral intentions toward COVID-19 vaccines; 3) extract themes to provide information for researchers in public health to develop theory-based and evidence-based promotion interventions.

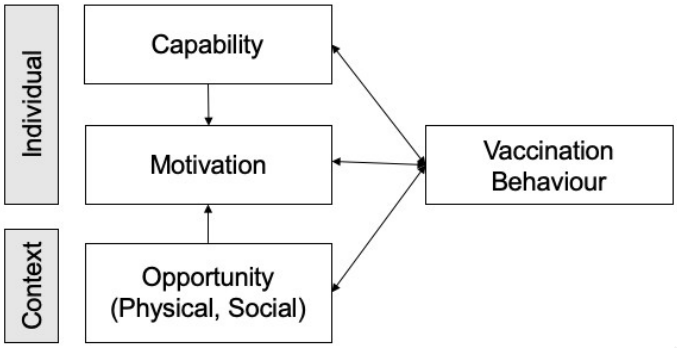


Figure 1. The theoretical model: the Capability, Opportunity, Motivation—Behavior Model (COM-B) adapted to vaccination behavior, developed by the WHO Regional Office for Europe [24,25].

## METHODS

### Adapted COM-B Model

The adapted COM-B model has three theoretical constructs: 1) capability, 2) motivation, and 3) opportunity. The WHO Regional Office for Europe also provided examples for each construct (see Table 1). Capability refers to the individual's physical and psychological ability to perform the behavior, along with the knowledge and skills required to complete the activity [17]. In particular, psychological ability is the ability of an individual to have the necessary thought processes, such as being able to understand, reason, etc. [17]. Motivation has a broad definition that includes, in addition to goals and conscious decision making, all other individual processes that motivate and lead to behavior, e.g., automatic processes (habitual processes, emotional responses) and reflective processes (analytical decision making) [17]. Opportunity refers to the contextual factors that prompt the behavior to occur, including the physical opportunity and the environment and social opportunity [17]. The adapted COM-B model also provided a dynamic relationship between

constructs. For example, both capability and opportunity can affect motivation. All three constructs, competence, motivation, and opportunity, can generate behavior; on the other hand, behavior can in turn influence these three constructs.

Table 1. The theoretical constructs in the adapted Capability, Opportunity, Motivation—Behavior Model (COM-B) model and associated examples by the WHO Regional Office for Europe.[2]

| Theoretical construct | Example |
|---|---|
| Capability | • Knowledge<br>• Skills, trust in own skills<br>• Resilience, stamina, will power, surplus energy<br>• Physical fitness, ability |
| Motivation | • Attitudes, perceptions, risk assessment<br>• Values, beliefs<br>• Emotions, impulses, feelings<br>• Confidence, trust |
| Opportunity (Physical) | • Access, affordability, availability of vaccination<br>• Convenience, appeal, appropriateness of vaccination<br>• Rights, regulation, legislation<br>• Structural efficiency<br>• Availability of information |
| Opportunity (Social) | • Social, cultural demands, support<br>• Social, cultural cues, norms, values |



**Data Collection**

We collected English tweets posted from November 1, 2020 to November 22, 2020, using the combination of relevant keywords and hashtags: (#covid OR covid OR #covid19 OR covid19) AND (#vaccine OR vaccine OR #vacine OR vacine OR vaccinate OR immunization OR immune OR vax). After excluding retweets, we randomly selected 5,000 tweets for manual coding and content analysis. The random numbers were generated through the NumPy package in Python. Then we mapped the random numbers with the index of collected tweets.

**Content Analysis**

We performed a content analysis informed by the adapted COM-B model. The coding schema was

developed iteratively. First, we developed the coding schema based on the definitions of constructs in the adapted COM-B model. Two reviewers (SL and JL) independently coded 1,000 tweets in each round. After completing one round of coding, the two reviewers met with a third reviewer to discuss the disagreements and update the coding schema until consensus was reached. We calculated the inter-rater reliability for the last round. If a tweet mentioned two or more constructs simultaneously, we coded it with multiple labels. We conducted chi-square tests to explore the relationship between theoretical constructs with the positive/negative behavioral intention. The statistical significance threshold is 0.05.

## RESULTS

### Data Collection

We coded 5,000 COVID-19 vaccine-related tweets, which were posted by 4,796 unique users. We found 279 tweets that stated their behavioral intentions. The remaining tweets did not state any behavioral intentions toward COVID-19 vaccines. Ninety-seven tweets were labeled with positive behavioral intentions, while 182 tweets contained negative behavioral intentions. Among them, 28 tweets were mapped with capability factors; 155 tweets were related to motivation; 23 tweets were related to opportunities, and 74 tweets did not contain any useful information about reasons for their behavioral intentions (see Figure 2). The kappa value was 0.73. Two tweets mentioned two or more constructs at the same time. Tweets that mentioned capability ( $\chi^2$ (1, N=28) = 17.286, $P$<0.001), motivation ($\chi^2$ (1, N=154) = 35.558, $P$<0.001), and opportunity ($\chi^2$ (1, N=22) = 4.545, $P$=0.033) are more likely to have negative behavioral intentions.

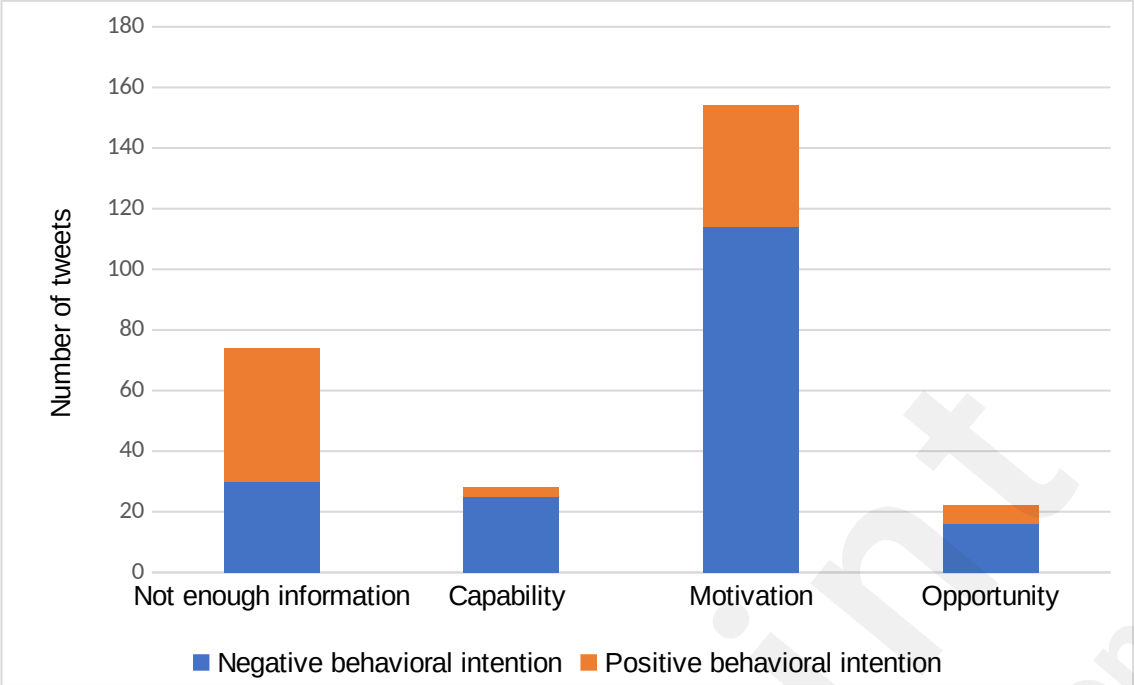


Figure 2. Numbers of tweets containing different theoretical constructs, respectively.

Table 2. Themes and examples.

| |
|---|
| **1. Capability: Knowledge (n=24, 11.7%)** |
| "I am not getting a covid vaccine because there will be a microchip in there so the government can track my weekly shop in Lidls" "No way I'm taking it. In one study out of women became steril from taking the vaccine. Is this the one that alters your DNA and can cause cancer? Thanks but I would rather get COVID." "As I said it's not a 'from scratch' situation...covid is one version of a virus that a lot of work has already been done on. It's just a case of isolating the correct strain to vaccinate against. Look if you don't want to get it fine...all the more for me and my family." |
| **2. Capability: Physical condition (n=4, 2%)** |
| "I got my flu shot a few days ago. For now there is no way I will get a COVID vaccine." "I have severe adverse reactions to vaccines and I meet of the exclusion criteria for the COVID vaccine trials." |

Table 2. Themes and examples (continued).

| |
|---|
| **3. Opportunity: Rights, regulation and legislation (e.g., charging for vaccination, mandatory vaccination, inadequate regulation of vaccines, poor availability of information) (n=11, 5.4%)** |
| "Tbh I'm not against every vaccine in history. Just this specific COVID-19 vaccine. There are many reasons why, for example the nonsensical social regulations, that people like you probably want to be over so bad. But you seem to hot headed to absorb any legit information." "If they charge us for this vaccine. I don't give. Not a single person should have to pay for a Covid Vaccine. " "Please stop volunteering me for this COVID-19 vaccine. I need more information. I've been close enough to death this year, no thank you. -a healthcare worker" |
| **4. Opportunity: Social and cultural demands and support (n=9, 4.4%)** |

| |
|---|
| "Someone that works for the CDC told me, do NOT get the covid vaccine.. Not sure but I'm not OK with her saying that at all.." "I'm not getting a covid vaccine. Do what yall want with that info to write me off. But its against my culture and everything I've been practicing." |
| **5. Opportunity: Social consequences and reactions to vaccination (n=2, 1%)** |
| "when anti vaccs realize everything is gonna start requiring the covid vaccine i can't wait to see. and for natural selection to do what it does best (unless you're immunocompromised and can't take certain vaccines, then they'll accept testing of course)" |
| **6. Motivation: Attitudes and perceptions about the COVID-19 vaccine or the disease itself (e.g., disease severity, vaccine effectiveness) (n=68, 33.2%)** |
| "Yeah, with an average age of over you forgot to mention, a minute percentage of those that have had it and almost elderly and/or with underlying health conditions. For many of us, taking the rushed vaccine may more likely to cause us harm than covid itself" "OK. so we each make our own risk/benefit decision. As the virus is what, % fatality, why would someone choose an unproven mRNA vaccine, with phase trials only since July? a biotech never before used programming RNA transcriptase to produce Covid in your cells? No thx." |
| **7. Motivation: Strong emotions about COVID-19 vaccine (e.g., fear of side effects, unfairness to COVID-19 survivors) (n=5, 2.4%)** |
| "We shouldn't have a COVID vaccine because it'll make those who lost loved ones to COVID angry." |
| **8. Motivation: Values and beliefs (e.g., natural immune system, alternative medicine, value of vaccination) (n=37, 18%)** |
| "My immune system is better than any vaccine. And a vaccine works in tandem with the way how your immune system beats virus No COVID Vax for me!" "I had covid19 because I'm a long haul trucker and travel all over to different states..what I did to cure myself was take % alcohol and pour it on a rag and breathing in the fumes before I went to bed..I did that minutes a night..I got well in no time.. don't need no vaccine" |
| **9. Motivation: Confidence and trust (vaccine, health authorities, science, and government) (n=13, 6.3%)** |
| "I do not trust the FDA, especially concerning the brand new Covid vaccine being rushed to market. Covid poses almost zero risk to my demographic. The pharmaceutical companies face zero risk if the vaccine damages their customers. For me the vaccine is riskier than the virus." "I won't accept COVID vaccine offered by Biden administration..." |

Capability

The first theme regarding capability was that some users lacked knowledge about the COVID-19 vaccines and were influenced by misinformation. As a new technology, some believe that mRNA vaccine could alter DNA. As for the vaccine itself, some users believe it contains a microchip, which can be tracked by the government. Some people expressed that they did not know the side effects of COVID-19 vaccines or even their long-term effects. Based on this concern, misinformation was generated that the vaccine could cause sterility, cancer, etc. Other reasons for not getting the vaccine included: the belief that the vaccine could make people sick, the belief that there is no need

for people who have been infected with COVID-19 to get the vaccine, and that the vaccine does not prevent infection but only alleviates symptoms. All of these reflect a lack of understanding of the COVID-19 vaccines among users. Having more knowledge about vaccines could help people develop positive behavioral intentions; for example, some people mentioned that they could understand why the development process was fast because researchers only needed to isolate the correct strain rather than create one. Others mentioned understanding that vaccines do not contain live viruses, so they would be willing to get the vaccine.

Some users emphasized that their physical condition was not suitable for COVID-19 vaccination and were unsure how their body would react after vaccination, e.g., recently had a flu shot, had a suppressed immune system, had a severe adverse reaction to vaccination before, had a stroke.

Opportunity

In the physical opportunities category, some users said they would not accept the vaccine if they had to pay for it. Many users said vaccination should be a free choice and that they would refuse to receive the vaccine if it became mandatory. Some users wanted more regulation of the COVID-19 vaccine, and some were concerned about the availability of information.

Among the social opportunities, we found some factors influencing the COVID-19 vaccination related to social and cultural demands and support, such as going against religion, defying culture, health workers not recommending, and family members actively discouraging vaccination. Others intended to be vaccinated because of the fear of the social consequences and reactions to vaccination, such as fear of affecting their work and requiring proof of vaccination for many activities in the future.

Motivation

Most of the reasons for behavioral intentions were categorized into the motivation construct. Many

users expressed attitudes and opinions about the COVID-19 vaccine or the disease itself, such as not considering the disease to be severe or life-threatening; not considering the vaccine to be effective (because of low efficiency and the virus's mutation). Others assessed the risks and considered the rushed vaccine to be more harmful than COVID-19. Some of those with positive behavioral intentions stated that they chose vaccination because they did not want to be infected with COVID-19.

Some users showed strong emotions and feelings about the COVID-19 vaccines, such as fear of the vaccine and concern about its side effects because it is new. Notably, others felt that vaccination was selfish or unfair exposing themselves to the same risk compared to others who survived COVID-19 and thus were reluctant to get vaccinated.

Other themes were values and beliefs. Some users believe that the body's natural immune system is better than any vaccine or believe more in alternative medicine. On the other hand, others who wanted to be vaccinated emphasized the positive values of vaccination, such as saving more lives, reopening the economy, and returning to normal life.

Confidence and trust were dominant themes. Users expressed distrust in many areas: the vaccine's quality (hastily manufactured, untested), health authorities, science, companies and government. For Twitter users in the US, we found that unlike other vaccines, part of the reason people do not trust the government is because of their past handling of COVID-19. In addition, the COVID-19 vaccines rollout came during a time when the US was electing a new president, and some people lacked confidence in the opposing party.

## DISCUSSION

This study conducted a theory-based content analysis using a dataset of 5,000 tweets posted from November 1, 2020, to November 22, 2020. We identified 279 tweets that contained behavioral

intentions regarding COVID-19 vaccines and mapped them to constructs in the adapted COM-B model. We generated nine themes that influence intentions to take COVID-19 vaccines. The constructs in the COM-B model could be applied systematically to characterize factors that influence behavioral intentions toward COVID-19 vaccines. In addition, we found that among tweets that simply stated behavioral intentions without including any reason, the number of positive intention tweets was higher than that of negative intention tweets. It is also implied that more than half of the tweets expressing the decision-making process are negative intention tweets. It aligns with our expectation to understand what factors contribute to vaccine hesitancy to better develop tailored vaccine promotion programs.

The novelty of COVID-19 vaccines and the current social context have added further difficulties in vaccine rollout. Identified barriers of influenza vaccination intention and behavior include the lack of confidence (e.g., negative attitudes, mistrust), inconvenience (e.g., cost, access), the calculation (e.g., risk assessment), and complacency (e.g., underestimating disease severity) [26]. Our results revealed the presence of several other factors that influence COVID-19 vaccination. First, misinformation or conspiracy theories about COVID-19 or the COVID-19 vaccines are much more prevalent on social media than about other diseases or related vaccines [27–29]. Some users were influenced, and this led to the refusal of the vaccine. Second, users expressed concerns about mandatory vaccination. At the Emergency Use Authorization stage, mandatory vaccination is legally and ethically questionable [30]. However, with full Biologics License Application approval, policymakers may mandate vaccination for all populations. Given the existence of users who have strongly indicated that they would not accept mandatory vaccination with COVID-19, policymakers need to be cautious in determining vaccination policies for the public. Some studies suggested that vaccine mandates might not improve vaccine acceptance rates and proposed that an alternative approach might be to apply informed risk communication and give people the freedom to choose without compromising personal autonomy [30]. Third, users with positive behavioral intentions emphasized the positive value to society motivating them to vaccinate, such as restoring economic

and normal life from before the epidemic. It is an uncommon facilitator in other vaccination behaviors. This facilitator could be matched with a strategy of converting personal decisions into a public act [31]. Fourth, we observed that some users were reluctant to vaccinate because the COVID-19 vaccine was unfair to those who survived. Based on this concern, it might be helpful to select COVID-19 survivors as opinion leaders to promote the COVID-19 vaccines, increasing public awareness of the disease's severity and risk. Fifth, in addition to the mistrust of vaccines and science that also exists for other vaccines, for the COVID-19 vaccine, users in the US expressed more mistrust of the government for two specific reasons: 1) the previous administration's inappropriate behavior in handling COVID-19 and 2) the lack of confidence in the newly inaugurated political party. These findings were also aligned with previous studies that proposed politics' role in COVID-19 vaccine hesitancy [8]. Sixth, it is worth noting that even though previous studies have identified that past vaccination behavior can be used to predict future vaccination behaviors [32], we found that past experiences with other vaccines might not affect COVID-19 vaccination. For example, one user mentioned, "I'm not against every vaccine in history. Just this specific COVID-19 vaccine. There are many reasons why, for example the nonsensical social regulations." The above differences contribute to the fact that the rollout of the COVID-19 vaccines could be more complicated than other vaccines. Researchers need to develop interventions specific to the COVID-19 vaccine to improve acceptance rates. This also provides an opportunity for future studies to comprehensively analyze why behavioral intentions toward COVID-19 vaccines are different from other vaccines.

Several studies have conducted content analyses of healthcare behaviors other than COVID-19 vaccination using Twitter content. For example, Chew and Eysenbach collected 2009 H1N1-related tweets and identified resource content posted most often, followed by personal experience, personal opinion, jokes, marketing, and spam [14]. Li et al. extracted COVID-19 stigma-related tweets and found group labeling, responsibility, and peril tweets disseminated the stigma [33]. Furthermore, several studies have validated the usability of tweets through theory-based content

analysis to promote breast cancer promotion programs [16,34]. Our study is the first study to analyze the behavior intention of COVID-19 vaccines through a theory-based content analysis using social media content.

### Limitation

This study has several limitations. First, we only analyzed the behavioral intentions of users on Twitter. Previous studies have shown that healthcare providers are the primary advocates for vaccination and largely influence vaccination acceptance rates [35–38]. In this platform, we could not distinguish users' occupations. However, the themes reported in this study could help researchers to develop evidence-based interventions for the general public. For health care providers' vaccine behavior, we will conduct a questionnaire-based survey, and the results from that study could help develop clinical guidelines for health workers. This approach of considering the general public separately from healthcare providers is also recommended by the TIP developed by the WHO Regional Office for Europe [24]. Second, there are differences between behavioral intentions and actual vaccine behaviors. However, behavioral intentions have been shown to influence actual behaviors directly [39–41]. Third, Twitter users are considered younger and have a higher education than the general public [13]. Based on this concern, further qualitative research could be conducted on the older population, those with lower education levels, or those with limited access to the Internet.

Future research could conduct a literature review to summarize current implementation strategies for COVID-19 vaccine promotion and map them to the themes identified in this study to determine gaps in recent research. The adapted COM-B model's inner mechanism – the Behavior Change Wheel – could inform evidence-based and theoretical implementation strategies to improve the effectiveness of COVID-19 vaccine promotion programs.

## CONCLUSION

The study demonstrates the capability of applying the COM-B model to characterize behavioral intentions toward COVID-19 vaccines on the Twitter platform. We successfully generated nine themes of factors that affect behavioral intentions. Positive behavioral intentions were affected by the positive values of vaccination (e.g., reduced risk of infection, socioeconomic recovery, return to normal life). In contrast, negative behavioral intentions were associated with attitudes and perceptions about COVID-19 vaccines or the disease itself (e.g., an underestimation of disease severity, low vaccine effectiveness), values and beliefs (e.g., greater belief in the natural immune system), confidence and trust (e.g., distrust of government or vaccines), and lack of knowledge. The generated themes could be used to create theory-based and evidence-based implementation strategies to promote COVID-19 vaccines.

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