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RESEARCH ARTICLE

Social media and COVID-19 vaccination hesitancy during pregnancy: a mixed methods analysis

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Abstract

Objective: To evaluate the reasons for COVID-19 vaccine hesitancy during pregnancy.
Design: We used regular expressions to identify publicly available social media posts from pregnant people expressing at least one reason for their decision not to accept COVID-19 vaccine.
Setting: Two social media platforms – WhatToExpect and Twitter.
Sample: A total of 945 pregnant people in WhatToExpect (1017 posts) and 345 pregnant people in Twitter (435 tweets).
Methods: Two annotators manually coded posts according to the Scientific Advisory Group for Emergencies (SAGE) working group's 3Cs vaccine hesitancy model (*confidence, complacency* and *convenience barriers*). Within each 3Cs we created subthemes that emerged from the data.
Main Outcome Measures: Subthemes were derived according to the people's posting own words.
Results: Safety concerns were most common and largely linked to the perceived speed at which the vaccine was created and the lack of data about its safety in pregnancy. This led to a preference to wait until after the baby was born or to take other precautions instead. Complacency surrounded a belief that they are young and healthy or already had COVID-19. Misinformation led to false safety and efficacy allegations, or even conspiracy theories, and fed into creating confidence and complacency barriers. Convenience barriers (such as availability) were uncommon.
Conclusion: The information in this study can be used to highlight the questions, fears and hesitations pregnant people have about the COVID-19 vaccine. Highlighting these hesitations can help public health campaigns and improve communication between healthcare professionals and patients.

KEYWORDS
COVID-19, hesitancy, pregnancy, vaccine

1 | INTRODUCTION

Pregnant people are at increased risk of severe illness with COVID-19 infection and COVID-19 is associated with pre-eclampsia, preterm birth, stillbirth and caesarean delivery.[1,2]

Some ways to prevent or slow the transmission of COVID-19 are by increasing room ventilation, minimising human contacts, social distancing and wearing a recommended face mask.[1,3] However, one of the most effective protective measures against serious illness and complications from the COVID-19 virus is the COVID-19 vaccine.[1,3] A large

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body of evidence now suggests that COVID-19 vaccination is effective and safe during pregnancy[2,4] and international organisations and governments recommend vaccination of pregnant people.[2] However, this was not the case at the beginning of the vaccine rollout, as pregnant people were initially excluded from clinical trials[5] and decisions about pregnant people were postponed until further data were obtained.[2]

As of 27 July 2022, 32.8% of the population in the USA are still rejecting the COVID-19 vaccine.[6] One of the largest groups for vaccine hesitancy are pregnant people. Despite concern about being exposed to COVID-19,[7] only 25% of expectant mothers have had at least one dose of the COVID-19 vaccine, compared with 76.9% of all women in the USA.[6]

To implement effective and evidence-based COVID-19 prevention strategies in vaccine-hesitant populations, we first need to understand the reasons behind the hesitancy. As demonstrated by previous vaccination campaigns, uptake can be improved through targeted intervention strategies that address specific barriers.[8,9]

Although surveys have been undertaken to assess the acceptability of the COVID vaccine,[10] many of these only include a small number of participants,[11–14] they sought opinion before the vaccine was available[15] or they focused on patient characteristics (such as race) or the data sources used to make their decision.[13,16,17]

Limitations of survey tools include the modulation of feelings/beliefs of the individual, recruitment bias, researcher bias and participant bias. Surveys or focus groups can also be resource-intensive, financially draining and time-consuming. Utilising natural language processing techniques on social media platforms can be a useful way to obtain a rapid understanding of public opinion[18–20] and to collect unfiltered and self-reported information.

The aim of this study is to utilise the social media platforms WhatToExpect and Twitter to study COVID-19 vaccine hesitancy during pregnancy.

2 | METHODS

All data used in this study were collected according to the Twitter and WhatToExpect terms of use and were publicly available at the time of collection and analysis. Patients were not involved in the development of this research.

2.1 | Data collection

In November 2021, we searched the titles of 891 279 WhatToExpect discussions of mothers with a due date in December 2020 to July 2022 for vaccine-related keywords, including *vaccine*, *vaccines*, *vaccination*, *vaccinations*, *vaccinated*, *vax*, *vaxx*, *vaxed* and *vaxxed* using established methods.[21] We identified 5357 matching discussions. We developed handwritten regular expressions – search patterns designed to match text strings (Appendix S1) – to search for posts within these 5357 discussions indicating that the user had not received a COVID-19 vaccination. We identified 1320 matching posts by 1200 users.

We then used these regular expressions to search our existing Twitter collection[22] of publicly available English language tweets posted from 10 December 2020 to 25 January 2022 by women who have announced their pregnancy on Twitter. This collection of pregnant people's tweets has been developed and validated using in-house Natural Language Programming (NLP) methods[22] and used in previous studies.[23–30] We identified 871 matching tweets that were posted on or after 8 December 2020 by 658 users with a due date that was automatically determined[31] to be on or after 8 December 2020 – that is, during the availability of COVID-19 vaccines.

2.2 | Annotation

We manually filtered the posts generated for those that indicated an intent of a refusal of the COVID-19 vaccine while pregnant with a stated reason. All other posts were tagged as non-relevant posts.

Relevant posts were then coded by two researchers (AMJ and SG), independently with discrepancies discussed and resolved, to one or more of themes (Table 1). These themes were created based on the Scientific Advisory Group for Emergencies (SAGE) working group's 3C model of vaccine hesitancy.[32] This model describes three key barriers to vaccine uptake: *confidence barriers* (such as vaccine safety, vaccine efficacy and trust in the vaccine), *complacency barriers* (such as the perceived need for the vaccine) and convenience barriers (such as how accessible the vaccine is).[32] The 3C model emphasises that while all vaccine hesitancy is grounded in the 3Cs, the specific reasonings will be specific to the population studied, the vaccine itself and the circumstances surrounding the vaccine.[32] With this in mind, we created 12 tailored codes for COVID-19 vaccine hesitancy among pregnant people. The posts were not limited to one particular reason. Where multiple posts were available from one user, these were grouped and care was taken not to double-count themes mentioned more than once by the same user in separate posts.

We were unable to determine any key demographic data of the users of WhatToExpect. However, we were able to run automated detection software to determine the geolocation and age[33,34] of the Twitter users. In addition, two researchers (KO and SG) independently annotated basic race categories (black, Asian and white)[35] of Twitter users using their photos and self-declarations in their bio or recent timelines.

3 | RESULTS

3.1 | Included posts

Of the 2193 posts initially collated, 1452 posts (1017 from WhatToExpect and 435 from Twitter) remained after non-relevant posts were removed. Those posting on WhatToExpect, posted from 26 July 2020 to 31 October 2021,

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TABLE 1 Classification of reasons for hesitancy.

Themes	Description
Confidence barriers	
Safety concerns	Openly expresses vaccine hesitancy due to the vaccine safety on either themselves or their child
Waiting until second trimester	Plan on getting vaccinated once they enter their second trimester
Waiting until after birth/feeding	Plan on getting vaccinated but not until after birth or after they have ceased breastfeeding
Efficacy concerns	Openly expresses vaccine hesitancy due to the vaccine not being effective against COVID-19
Mistrust	When the reason for vaccine hesitancy clearly stems from mistrust in authority (such as government or the pharmaceutical industry)
Misinformation	When the reason for vaccine hesitancy clearly stems from vaccine misinformation (such as false claims regarding ingredients, side effects or purpose of the vaccine)
Complacency barriers	
Complacency	Openly expresses that they have no fear of the COVID-19 virus. They believe that it will not affect them and, if it does, it will only be minor
Taking other precautions	Admits to being worried about the COVID-19 virus but is coping by taking other precautions such as distancing themselves, not going out, wearing masks, eating healthy meals or taking vitamins/supplements
Already had a COVID-19 infection	Have already had a COVID-19 infection, so perceives no risk of acquiring COVID-19
Convenience barriers	
Not advised	A healthcare professional advised them against getting the vaccine for whatever reasons
Not eligible for vaccination	Have a medical reason for not getting the vaccine or asserts that they are in a high-risk group for vaccination
Availability	Cannot or have not received the vaccine because of lack of availability

with only 19 posts before December when the first vaccine was made available. Tweets were posted from 10 December 2020 to 25 January 2022.

Non-relevant posts fell into three categories; (1) post not referencing a reason for their refusal of the COVID-19 vaccine (164 in WhatToExpect and 326 in Twitter), (2) posts stating an intent to have the COVID-19 vaccine or already vaccinated (132 posts in WhatToExpect and 102 in Twitter) and (3) posts relating to vaccines other than the COVID-19 vaccine (seven posts in WhatToExpect and eight in Twitter).

3.2 | Demographics of the people posting

The 435 Tweets from Twitter were posted by 345 Twitter users and the 1017 posts on WhatToExpect were posted by 945 users. We were unable to determine any key demographic data of the people from WhatToExpect. However, we were able to determine the geolocation of 195 of the 345 Twitter users. The majority, 82% (160/195), were located in the USA, followed by the UK (14%, 28/195), Canada (3%, 5/195), Australia (1%, 2/195) and New Zealand (1%, 2/195). Other people were tweeting from Mexico, Botswana, Bermuda, Iceland, Belgium, Brazil and the Bahamas. We were able to determine the declared age of 272 of the 345 people tweeting.[34] The mean age was 29 years old, which suggests that our sample may be representative in terms of age with the pregnant population in the USA.[36,37] Of the 345 Twitter users, we could manually infer race for 213 users: 62% (133/213) were white, 31% (66/213) were black and 7% (14/213) were Asian.

3.3 | Reasons for vaccine hesitancy

Although many cited just one reason for their vaccine hesitancy, others cited multiple reasons, with up to six reasons reported. From the 945 WhatToExpect users, 1635 reasons were reported and from the 345 Twitter users, 545 reasons were reported.

The most common barriers were categorised as relating to 'confidence' (such as safety concerns), followed by 'complacency' (such as not worried about infection) and then 'convenience' (such as availability) (Figure 1).

Although similar patterns in cited reasons for COVID-19 vaccine hesitancy were demonstrated in both social media platforms, 'safety concerns' were more prevalent in WhatToExpect than Twitter (59%, 559/945 and 34%, 117/345, respectively). The second most cited reason on both WhatToExpect and Twitter was 'taking other precautions' (28%, 261/945 and 23%, 80/345) (Figure 2). 'Waiting until after birth/breastfeeding' (22% 204/945 and 21%, 69/345), 'already had COVID-19' (17%, 157/945 and 16%, 55/345) and 'complacency' (16%, 155/945 and 21%, 71/345) were also common. Paraphrased example posts given in Table S1.

3.3.1 | Confidence barriers ($n = 967$, 75%)

This category included 'safety concerns', 'efficacy concerns' 'mistrust', 'misinformation'[38] and 'waiting until the second trimester' or 'after the birth/breastfeeding'. There was some overlap in these categories. For instance, of the 298 waiting until the second trimester or after the birth/breastfeeding, 119 stated explicitly that this was because of 'safety concerns';

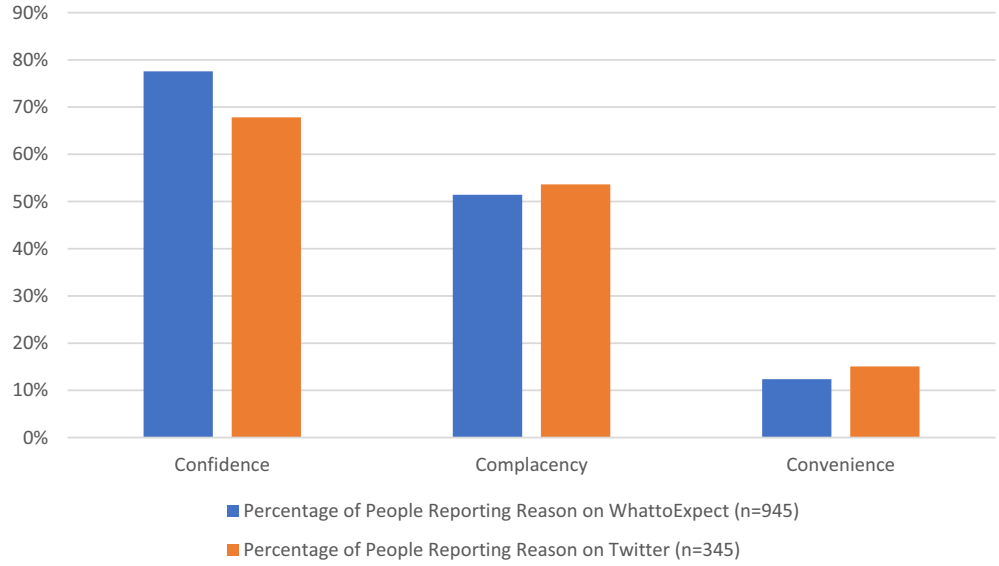

FIGURE 1 Percentage of pregnant people ($n = 1290$) posting at least one reason in each category of the 3Cs.

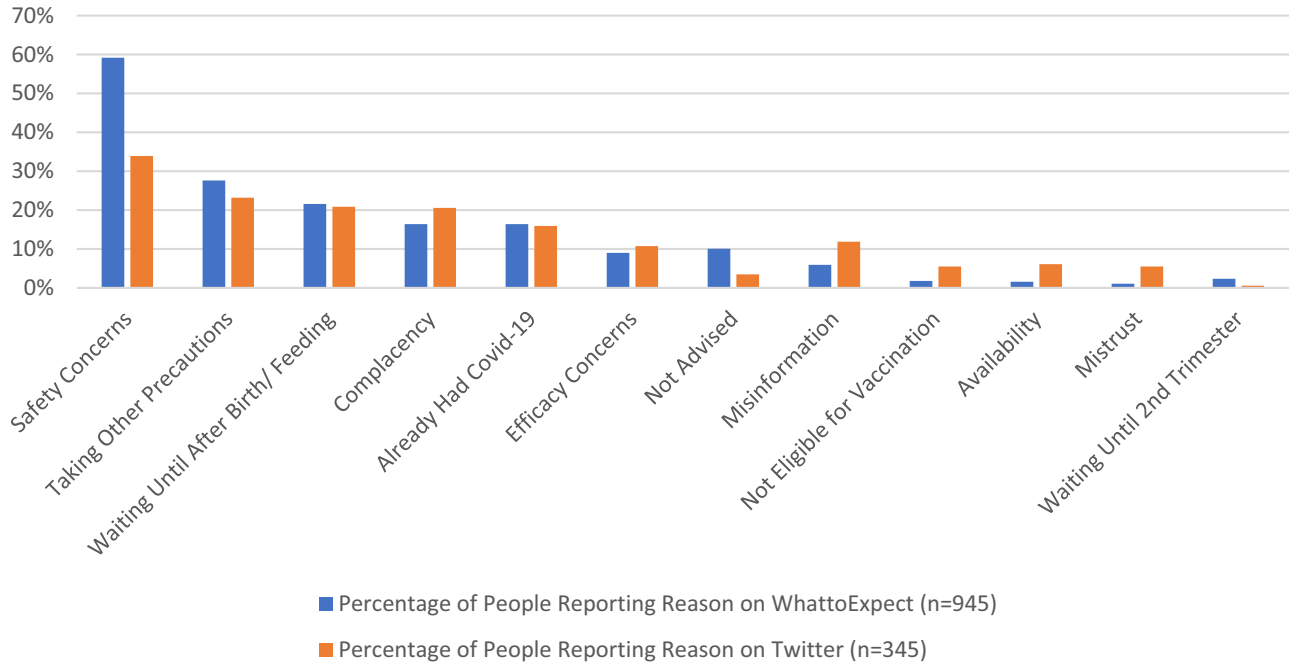

FIGURE 2 Percentage of pregnant people ($n = 1290$) posting each reason for vaccine hesitancy.

however, for others, although it may be implicit that this was due to safety concerns, we coded these posts as 'waiting' only.

3.4 | Safety concerns ($n = 676$, 52%)

Those citing safety as their reason for vaccine hesitancy, expressed concerns over the speed of vaccine development, lack of U.S. Federal Drug Administration (FDA) approval, the lack of data on pregnant people and unborn children, concerns about the vaccine being experimental (especially during pregnancy) or still in clinical trials, or concern over adverse effects (mostly unknown). There was concern that a vaccine created in months could have no long-term safety data and that the necessary clinical trials could not be completed in such a short time frame, particularly for pregnancy.

3.5 | Waiting until second trimester ($n = 26$, 2%) or waiting until after birth/breastfeeding ($n = 276$, 21%)

Some people stated that they were waiting until the second trimester. This was often tied to advice from physicians

or when the person posting deemed it safe to receive the vaccine.

Those people waiting until after the birth or after they had stopped breastfeeding did not always explicitly state their reasoning, although some indicated safety concerns; for others, safety concerns for their unborn child could be inferred, given that they would otherwise accept the vaccine. Many simply stated that they 'will get vaccinated once my baby is born' or 'as soon as my pregnancy is over'.

3.6 | Efficacy concerns (*n* = 122, 9%)

Efficacy concerns were expressed in terms of 'the vaccine does not work', 'I am still just as likely to contract Covid-19 with the vaccine' or 'people with the vaccine can still spread it, so why bother?'. The vaccine was described as 'useless' or 'pointless'. There were references to friends who had the vaccine and then got sick, and studies in which people who had the vaccine could still transmit the virus.

3.7 | Misinformation (*n* = 97, 8%)

Misinformation included false or inaccurate information pertaining to the COVID-19 vaccine; examples included that the vaccine gives you COVID-19, that it causes infertility or death, is toxic or that the mRNA technology changes your DNA.

3.8 | Mistrust (*n* = 22, 2%)

Some posts were linked to a mistrust of government, scientists and the pharmaceutical industry, including suppression of data and information. This mistrust was often linked to adverse effects which were felt to be suppressed. There were concerns about the 'notoriously underreporting' of adverse effects and the 'silencing of debate'. There was also talk of the 'government hiding the side effects' and a general distrust of 'pharma' who 'cannot be held accountable' and whose interests 'lie only in profits'.

3.8.1 | Complacency barriers (*n* = 671, 52%)

Complacency barriers included those 'taking other precautions', those explicitly stating they were 'complacent' and those stating that their reason was 'already having had COVID-19'. There was some overlap between these codes. For instance, 41 people who stated having had COVID explicitly stated that this was, at least in part, why they were complacent. For the other 212 people it may be argued that this was implicitly due to 'complacency', although it was not coded as such.

3.9 | Taking other precautions (*n* = 341, 26%)

Taking other precautions was mostly limited to facemasks, reducing the number of contacts, keeping healthy and social distancing instead of accepting the vaccine. Some posts emphasised boosting their immune system with vitamins and supplements and generally keeping healthy. Others stated that they literally 'don't go anywhere' or, if they did go somewhere, they would 'always wear my mask' or 'follow the rules'.

3.10 | Complacency (*n* = 226, 18%)

Those who were generally not worried about getting COVID were categorised under the heading of 'complacency'; they used phrases such as 'I'm not worried' or 'I've no COVID concerns at all'. These individuals tended not to see the necessity for the vaccine, mainly because they considered themselves 'young and healthy' or 'never sick', or they did not perceive the virus to be serious but more akin to the common cold. References were made to friends or family who had no symptoms or mild symptoms and even pregnant relatives of friends who were 'just fine'. Others stated that despite never taking any precautions they still have not been infected, so did not feel a need to be concerned.

3.11 | Already had a COVID-19 infection (*n* = 212, 16%)

Those people who had already been infected with the COVID-19 virus before, tended to state that either they were now safe due to 'natural immunity' or that they survived the COVID-19 infection once, so know that they will be 'ok'.

3.11.1 | Convenience barriers (*n* = 169, 13%)

Convenience barriers were coded as 'not advised', 'not eligible' or 'availability' issues. It is recognised, however, that some categorised as 'not advised' may in fact be 'not eligible'.

3.12 | Not advised (*n* = 109, 8%)

Some people said that they were not advised by a healthcare professional to have the vaccine while pregnant, stating simply that their 'OB recommended not getting it until I'm done breastfeeding' or 'my GP has advised against it during pregnancy'.

3.13 | Not eligible (*n* = 36, 3%)

A few people posting stated they were not eligible because of an allergy, previous reaction or other medical conditions.

3.14 | Availability ($n = 36$, 3%)

There were some posts indicating a lack of availability, due to a shortage, creating a system of prioritisation for older age groups, or simply to a lack of appointments.

4 | DISCUSSION

The aim of this study was to utilise the social media platforms WhatToExpect and Twitter to study COVID-19 vaccine hesitancy during pregnancy. We identified 1017 posts from WhatToExpect and 435 from Twitter by pregnant people which cited at least one reason for their vaccine hesitancy. The following reasons were identified (in descending order of prevalence):

(1) safety concerns, (2) taking other precautions, (3) waiting until after birth/breastfeeding, (4) complacency, (5) already had a COVID-19, (6) efficacy concerns, (7) not advised, (8) misinformation, (9) not eligible for vaccination, (10) availability, (11) mistrust and (12) waiting until second trimester.

Safety concerns were largely linked to the perceived speed at which the vaccine was created and the lack of data in pregnancy. This led to a preference to wait to have the vaccine or to take other precautions instead of the vaccine. Complacency surrounded a belief that they are young and healthy or already had COVID-19 which was mild anyhow and also meant that they had immunity. Misinformation lead to false safety and efficacy allegations, or even conspiracy theories, and fed into creating confidence and complacency barriers. Convenience barriers were uncommon.

The themes emerging from the WhatToExpect and Twitter data posted during pregnancy exhibited many similarities. Indeed all 12 subthemes were present in both social media platforms. The main difference was that of safety concerns, with such concerns more prevalent on WhatToExpect. This may reflect differences in the implicit communication protocol (health forum versus microblogging) or on the people posting (with differences in age, educational and social status possible but not evident in our study) and reactions to other posts.[39]

Safety concerns have also been found to be the primary concern in other studies of pregnant people[11,12,14,40–44] and in the general population.[20,45,46] Emphasis on the speed of development has also been echoed elsewhere,[20,40] as has the lack of data in pregnancy.[43] Lack of efficacy has also been identified to be an issue, although, as with our study, not as prominent as safety.[43,44] However, issues with mistrust (in either the government, the pharmaceutical companies or the health service) are more prominent in other studies of the general population[20,45–47] and in studies in low- and middle-income countries[44] compared with our study. This may be related to the questioning approach and the identification of an association between lack of trust in authority and the decision to have the vaccine and country of residence – our study was mostly comprised of people from the USA. Our study also used spontaneous reporting by individuals and is thus not subject to investigator bias towards such associations. Nonetheless, the lack of confidence in the vaccine evident from our study may indeed be deep-rooted in a lack of trust. This may prove difficult to overcome; one study indicated that only a tenth of vaccine-hesitant pregnant people are subsequently vaccinated 3–6 months after.[43]

Differences may be expected between pregnant people and the general population, and other studies have also indicated increased caution of parents when deciding to vaccinate their children as opposed to themselves.[48–51] Not noted in other studies, we specifically identified a substantial number of people waiting until the second trimester, after the pregnancy or after breastfeeding. This may represent a lack of knowledge about the protective effect of the vaccine on pregnant people and their unborn, and a lack of safety data available to pregnant people.

Those who stated that they were not advised by their healthcare professional were most likely to be posted early on in the vaccination programme. Indeed, the advice at the initial stages of the programme in the USA was that pregnant people could choose to receive the vaccine if they were in a high risk group, which evolved to they can have the vaccine, to they should get the vaccine.[2,52] Similar evolving advice was given in the UK as data accumulated.[2] This may have led to some confusion among pregnant people and may have seemed contradictory.[2]

The posts analysed in this study indicate that people were not particularly 'anti-vax' but rather decisions were made largely based on a lack of knowledge about the impacts of the vaccine and concern for their unborn. Thus, safety concerns and waiting were common. A total of 84 (7%) of posts even described themselves as 'I am not anti-vax but…' or 'I am not opposed to the vaccine but' and others described being scared or fearful of getting the vaccine while pregnant.

A better understanding for the reasons of vaccine hesitancy within this given population could inform more effective and accessible public health campaigns. Indeed, other studies have indicated that pregnant individuals state that they have access to limited information on vaccine safety and effectiveness.[44,53] The dissemination of widespread education from a wide range of communication channels, including social media outlets, in a sensitive and supportive manner, is crucial. Improving health literacy and helping individuals to check authentication of data sources could also help improve public trust, as could an acknowledgement of past errors and racism. Information needs to be wider than that on the vaccine itself, also considering the disease it is aiming at reducing and the effectiveness of other preventative measures.

4.1 | Strengths and limitations

We used spontaneous free text data direct from pregnant people from a relatively large sample set. Our methods collect

data approaching real-time in a cost-effective manner. Many previous studies have not only been smaller but have relied upon direct questioning and prompts, which may impact on responses. We were able to allow themes to emerge and this led to more granular data. We identified some themes such as waiting until second trimester, after the birth or breastfeeding, taking other precautions or already having had COVID, which are not presented in other studies.

This study used two social media platforms to help improve the generalisability of the results. However, to get a broader sense of vaccine sentiment in pregnant people and a more international perspective, this tool could be used with other platforms, such as Reddit, MumsNet and other parenting forums.

One limitation, which is common when using social media data, was that we did not know how representative our sample was. Although extraction of age and location on Twitter indicates a similar age to the general population of pregnant people and a dominance of people residing in the USA, we were unable to infer these key demographics for the people posting on WhatToExpect, although previous research indicates that the majority of WhatToExpect users are from the USA.[21] In addition, we only extracted race of the women posting from Twitter. Previous studies have indicated that black individuals are more hesitant than Hispanic or white individuals and less likely to believe the vaccine is safe in pregnancy.[10,54] This has been attributed to an increased medical mistrust in the black patient population stemming from discrimination and prior injustices.[10,50,51,55]

Another limitation is that we were limited to social media users who self-declared their pregnancy and COVID-19 vaccination status, as well as stating their reasons for declining the vaccine. We also did not require any 'proof of pregnancy', although we anticipate that few individuals would be announcing false pregnancies on social media.

5 | CONCLUSIONS

This study demonstrates the value of utilising social media as a tool for large-scale, low-cost observational studies to investigate public opinions during times of health crises such as the COVID-19 pandemic. This study further showcased the ability to capture the unfiltered and real-time opinions, and life choices of research groups, such as pregnant people.

The reasons for COVID-19 vaccine hesitancy during pregnancy that are different to those in other groups became evident from our analysis. Specifically, many women were not against vaccination but were rather cautious about getting vaccinated while pregnant. This more nuanced study can help better direct the public health messages required to address the reasons for hesitancy in a sensitive manner, and help us assess the impact of inconsistent messaging. The relative effectiveness and safety of the vaccine as compared with other precautions could be better promoted, as could the high-risk nature of a COVID-19 infection during pregnancy. Improving health literacy could help combat misinformation and transparency and consistent advice could improve public trust.

AUTHOR CONTRIBUTIONS

All authors have materially participated in this research. SG, ACEM-J and GGH conceived the study concept. AK collected the data. SG and ACEM-J created the annotation guidelines and conducted the annotations. SG and ACEM-J drafted the paper, and FGP, AK and GGH critically reviewed it. SG wrote the final article. All authors approved the final version of the article. GGH obtained funding for the study.

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CONFLICT OF INTEREST STATEMENT

None declared. Completed disclosure of interest forms are available to view online as supporting information.

DATA AVAILABILITY STATEMENT

Data are publicly available on Twitter and WhatToExpect.

ETHICS APPROVAL

All data used in this study were collected according to the Twitter and WhatToExpect terms of use and were publicly available at the time of collection and analysis, and are covered by an institutional review board certificate of exemption from the University of Pennsylvania.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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