

REVIEW



Models of determinants of COVID-19 vaccine hesitancy in non-pregnant and pregnant population: Review of current literature

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ABSTRACT

Vaccination has proven to be the most effective tool in controlling the COVID-19 pandemic. While pregnant individuals are considered to be a high-risk population and are more likely to experience adverse effects from COVID-19, vaccination rates among pregnant individuals are significantly lower than in the general population. The Health Belief Model (HBM), Theory of Planned Behavior (TPB), 3C model, 5C model, and 5A model have been used to assess vaccination hesitancy behaviors. In this paper, we review the use of each of these models to address vaccine hesitancy, with a focus on the pregnant population and the COVID-19 vaccine. The HBM, TPB, 3C model, and 5C model have demonstrated great versatility in their ability to evaluate, explain, and modify vaccine hesitancy and behavior. Up to date, the HBM and 3C models appear to be the most effective models to study and address vaccination hesitancy within the pregnant persons.

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Introduction


As the impact of the COVID-19 pandemic continues to evolve, it has become clear that our greatest tool in controlling the virus is vaccination. Fully vaccinated individuals have a decreased risk of contracting COVID-19, and if they do become infected, the risk of severe illness and hospitalization is substantially reduced.¹ This is especially relevant for at-risk groups such as pregnant persons. Research has shown that pregnant persons diagnosed with COVID-19 are more likely to have higher maternal morbidity and mortality, including higher rates of preeclampsia, preterm birth, and maternal mortality.² Additionally, newborns of persons with COVID-19 have significantly higher severe perinatal morbidity and mortality compared with newborns of persons without a COVID-19 diagnosis.² Pregnant persons who were vaccinated against COVID-19 infection had a reduction in severe COVID-19 infection, if they got infected, and reduction in perinatal death, and in COVID-19-related hospitalization among infants of up to 6 months of age.^{3–7} According to the CDC, as of May 2022, over 205,000 pregnant persons were diagnosed with COVID-19, over 32,000 were hospitalized, and over 290 died from complications due to COVID-19.⁸ However, vaccination of this population remains low—only 69.5% of the pregnant persons are fully vaccinated.⁸ Additionally, Black pregnant persons, who have some of the highest rates of maternal and fetal morbidity and mortality,⁹ are the least protected, with only 54.2% fully vaccinated against COVID-19.¹ Similar findings were seen in countries outside the US, with over 90% of COVID-19 infection-related hospitalizations and 98% of critical care admissions occurring in unvaccinated pregnant persons.^{10,11}

The importance of understanding vaccination behavior and vaccine hesitancy, defined as delay in acceptance or refusal of vaccination despite the availability of vaccination services,¹² has become more important now than ever. Various models have been used to assess vaccine hesitancy including the Health Belief Model, Theory of Planned Behavior, the 3C model, and more.^{12–15} The aim of this paper is to review models that have been applied to research addressing vaccine hesitancy, with a focus on pregnant persons.

Models to address vaccine hesitancy

1. Health belief model

The Health Belief Model (HBM) (Figure 1) is one of the most widely employed theories to understand health behaviors and how they correlate with preventive behaviors.¹³ In its original form, the model aimed to explain the health behaviors of people failing to undergo screening tests for early detection of disease, as well as, the failure of people to take preventative measures such as vaccinations against disease.¹³ Since its creation, the model has been revised and expanded to include behavioral responses to health-related conditions and more fully explain conceptual relationships.¹⁶ The model assumes a perception that an adverse health condition can be avoided, that by following advice an adverse health condition can be averted, and that individuals are able to be convinced to adhere to a recommended behavior.¹⁷ The HBM also assumes that existing beliefs can predict future behaviors. When applied to disease prevention, it suggests that a future behavior can be predicted by the combination of an individual's willingness to prevent an illness and their expectations of a specific action.¹³

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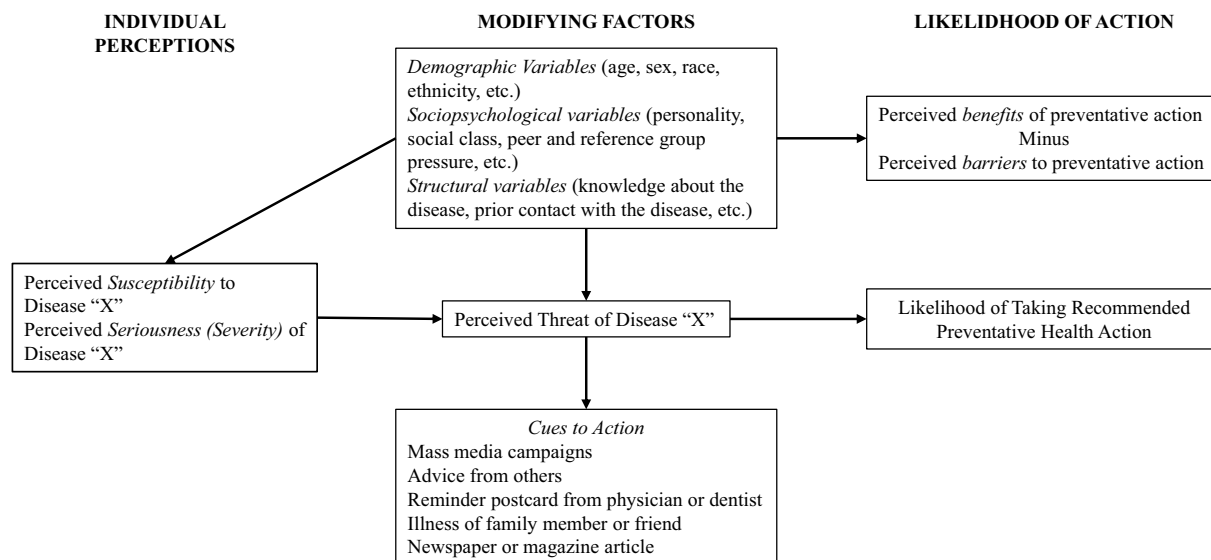


Figure 1. The "Health Belief Model." Figure reproduced from Rosenstock, *Health Education Monographs*, 1974.¹³ Model details the individual perceptions and modifying factors that influence the likelihood of action regarding vaccination behaviors.

The HBM is composed of six constructs: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. **Perceived susceptibility** refers to an individual's belief about their vulnerability to infection, i.e., the risk of acquiring COVID-19 infection. There is a wide variation in a person's feelings of personal vulnerability to COVID-19 infection. **Perceived severity** refers to an individual's belief that a disease is dangerous and has serious consequences. There is a wide variation in a person's feelings of severity, and often a person considers the medical consequences (e.g., death and disability) and social consequences (e.g., family life and social relationships) when evaluating the severity of the possible COVID-19 infection on their life. **Perceived benefits** refer to an individual's belief about the usefulness of a behavior and its ability to decrease the risk of severity of an adverse health outcome. The course of action a person takes in order to prevent COVID-19 infection is based on consideration and evaluation of perceived benefits of the COVID-19 vaccine. **Perceived barriers** refer to an individual's belief about obstacles that may prevent individuals from performing a health behavior. In the case of COVID-19 vaccination, persons would weigh the effectiveness and safety of the vaccine, and the logistics, convenience, or discomfort of getting vaccinated. **Cues to action** refer to factors that may influence a behavior change. These factors may include information, people (obstetric provider recommending the vaccine), news (reading a new study about COVID-19 vaccination or COVID-19 illness in pregnancy), or events (friend of a family member getting severe COVID-19 infection). **Self-efficacy** refers to an individual's trust in their ability to enact change and successfully perform the health behavior, in this case, vaccination against COVID-19.^{18–20} For change to be enacted, individuals must feel motivated to make change based off their perceived susceptibility/severity of the health treatment, their positive interactions with cues to action, and the benefits must outweigh the barriers.

Use of the HBM to promote vaccine uptake in non-pregnant individuals

The utility of the HBM in addressing vaccine hesitancy has been validated in diverse patient populations, vaccine types, countries, and modalities.^{16–18} The HBM has evaluated vaccine hesitancy in many subjects, including patients, physicians, and parents. In a study evaluating physician attitudes, HBM was used to evaluate physician likelihood of recommending vaccinations.²¹ It has also been used to assess pharmacists' and other health-care workers' vaccine acceptance and hesitancy.^{22–26} Studies have used the HBM to assess parent attitudes toward childhood vaccinations.^{27–32} Globally, the HBM has been used to assess general vaccine hesitancy in Nigeria,³³ the United States,²⁹ and Korea;³⁰ measles and rubella vaccines in Romania and Japan;^{27,34} shingles vaccines in the United Kingdom;³⁵ influenza vaccines in the United States,^{36–39} Japan,²⁷ and Australia;⁴⁰ human papilloma virus vaccines in the United States;^{28,31,41–48} and COVID-19 vaccines in the United States,^{21,44–46} China,^{47–53} Bangladesh,^{54–56} Turkey,²² Canada,²³ Vietnam,⁵⁷ France,⁵⁸ Saudi Arabia,⁵⁹ and Pakistan.⁶⁰ Several other studies applied HBM to create interventions to increase vaccine knowledge and uptake,¹⁶ and to create new scales of vaccine attitudes and intentions to assess the effectiveness of health campaigns and advertising.^{21,30,31}

Use of the HBM in pregnant individuals

The HBM has been applied to several studies investigating predictors of maternal vaccination to influenza,⁶¹ COVID-19,⁶¹ pertussis,^{62–65} Hepatitis B,⁶⁶ Zika,⁶⁷ Tdap,^{65,68} and H1N1.^{69,70} It was found that mothers were more likely to receive vaccinations in order to provide their newborn immunity and due to the provision of antibodies.⁴⁹ Recommendation of vaccination from a provider was the most influential factor in increasing vaccination.⁷¹ When assessing the barriers to vaccination, pregnant individuals who believed that seasonal vaccination was not safe during pregnancy or not effective in protecting their fetus had lower levels of vaccine acceptance for

both the influenza and pertussis vaccines.^{47,62} In addition, gestational age was identified as an important predictor of maternal vaccination and testing.⁶⁴

Use of the HBM in COVID-19 vaccination uptake in non-pregnant individuals

The HBM has been used to study COVID-19 vaccination attitudes in a variety of populations. While it has been used to study the attitudes of the general population in a multitude of countries,^{46,53,54,58,59,72} it has also been used to evaluate various subpopulations. The most common subpopulation that has been evaluated has been health-care workers. Several studies have sought to identify and understand the beliefs of physicians, pharmacists, nurses, and health-care workers in general, in both their intent to get vaccinated themselves and their intent to recommend vaccination to others.^{22–26} One study compared health-care workers to different occupational groups of varying occupational risk of COVID-19 infection as classified by public health officials, and found that health-care workers (the high-risk group) had significantly higher scores for cue to action and lower scores for perceived barriers compared to the other groups.⁷³ Another study compared the general population to health-care workers and found that health-care workers perceived significantly higher susceptibility and severity of the COVID-19 infection compared to the general population.²⁶ In addition to health-care workers, the HBM has also been used to evaluate cultural and racial subgroups,⁴⁵ health science students,⁵⁷ and mothers.^{50,74} Between primarily African American and Latinx subgroups, mistrust, fear, and lack of information were the main themes regarding COVID-19 vaccine hesitancy.⁴⁵ These themes were then contextualized within the HBM constructs in which mistrust was identified with perceived barriers, fear was identified with perceived susceptibility and severity, and lack of information was identified with perceived severity and barriers.⁴¹ In a study assessing health science students, vaccine intention was significantly related to perceived susceptibility, perceived severity, benefits of vaccination, and cues to action.⁵³ In the studies exploring non-pregnant mothers' willingness to vaccinate their children, hesitancy was found to be associated with decreased perceived susceptibility, benefit, and severity as well as increased perceived barriers.³⁹ It was also found that previous vaccine behaviors and attitudes did not fully predict a mother's willingness to vaccinate their children for COVID-19.⁷¹ The most commonly identified barrier to COVID-19 vaccination noted in the literature was concern for side effects or adverse effects.^{24,26,51,72,73} Concerns about vaccine safety and effectiveness were also noted as barriers in multiple studies.^{24,26,51,73} The most notable cues to action related to recommendation of the vaccine from the leading authorities or trustworthy individuals including the government,^{72,73} media,^{26,55,73} medical experts,^{26,73} and the World Health Organization.²⁶

In the employment of the HBM in COVID-19 vaccination uptake, the model was used to hypothesize effective strategies to overcome vaccination hesitancy and influence behavioral change interventions.⁴⁶ A study evaluating the ability of communication strategies to modify COVID-19 vaccination hesitancy suggested that willingness to be vaccinated is influenced

by the media and public service messages, especially emotionally- and fear-centered public service messages.⁶⁰ Multiple studies in which participants demonstrated a low level of perceived susceptibility to COVID-19 recommended efforts to enhance public education of the probability of outbreak resurgence and the real susceptibility to COVID-19.^{46,50,52,53} Another study highlighted the importance of physicians in the cue-to-action role and recommended that physicians promote vaccination uptake in targeted campaigns.⁵⁴ Overall, the studies recommended that the HBM constructs may be used to develop targeted communication campaigns to increase vaccine behaviors.

Use of the HBM in COVID-19 vaccination uptake in pregnant individuals

The HBM has been explored in COVID-19 vaccine acceptance among pregnant Chinese individuals.⁴⁸ Higher acceptance was associated with high knowledge score on COVID-19, high level of perceived susceptibility, low level of perceived barriers to vaccination, high level of perceived benefit, and high level of perceived cues to action.⁴⁸ Individual's reasoning for declining COVID-19 vaccination included concerns about side effects, safety, and efficacy of the COVID-19 vaccination both for themselves and their unborn child. This information was used to influence efforts to increase vaccination rates among the pregnant population.⁴⁸ A recent study examined the performance of HBM among pregnant individuals in Iran found that perceived benefits and cues to action components of HBM had significant effects on vaccine hesitancy, while the perceived threat component has no significant effect on it.⁷⁵

Performance of the HBM with annual vaccines versus vaccines given once or twice

The HBM has been used to explore vaccine attitudes about vaccinations with various schedules. The model has been used to assess annual vaccinations;^{36,40} vaccinations given a few times, such as the human papillomavirus vaccination;^{28,41} and the childhood vaccination schedule.^{29,32} While most studies analyze the behaviors of one method of vaccination schedule, a study in Japan explored attitudes toward both influenza and rubella vaccination in tandem.²⁷ This study employed constructs of the HBM to assess how receiving risk information and advice from peers and family members influences individuals' decision-making regarding vaccines. Regarding rubella vaccination, susceptibility information and minor risk information led to the greatest increase in intent to be vaccinated, while severe risk information decreased intent. Likewise, intent to receive influenza vaccination increased after participants were provided minor risk information, susceptibility information, and peer advice.²⁷

The HBM has been used to explore vaccination beliefs about a variety of vaccinations that are given a few times. This includes but is not limited to measles,³⁴ human papillomavirus,^{28,31,41–43} and shingles.³⁵ Similar to its use in the COVID-19 literature, the HBM has been used to examine behaviors and attitudes that make an individual more or less likely to accept the HPV vaccine.^{28,41,42} These studies were able to identify the trend of social media content related to HPV vaccinations and the presence of HBM constructs within the

content to inform efforts to improve vaccine understanding and intent.

The HBM has also been used to evaluate vaccine hesitancy in relation to annual vaccinations, such as influenza. As with all other vaccinations, the model has been used to predict and assess vaccine hesitancy and acceptance behaviors in addition to identifying barriers. Tweets from the 2018–2019 influenza season were also analyzed based on their inclusion of HBM constructs, similar to the social media analysis of the HPV vaccination. Interestingly, tweets in the early flu season were more likely to discuss vaccine uptake self-efficacy, while tweets in the peak flu season were more likely to mention susceptibility to the flu and barriers to vaccination.³⁸

2. Theory of planned behavior model

The Theory of Planned Behavior (TPB) (Figure 2) is built upon the belief that an individual's decision to engage in a behavior can be predicted by their intention to engage in that behavior.¹⁴ The theory suggests that attitudes, subjective norms, and perceived behavioral control predict an individual's intention to engage in a health behavior.⁷⁶ In succession, the intention to engage in a healthy behavior is the best predictor of an individual performing said behavior.^{14,77} The theory depends upon the assumption that people have the ability to practice self-control when moderating their behavior.¹⁴

The TPB relies on three constructs: attitudes, subjective norms, and perceived behavioral control. **Attitudes** refer to an individual's assessment of the favorableness of an action including its necessity, benefit, and effectiveness.^{78,79} **Subjective norms** refer to an individual's measure of perceived social pressure to perform a behavior based on the opinion of others and how much value one places in other's opinions.⁷⁶ This construct may include family, friends, health-care professionals, social media, and mainstream media.⁷⁸ **Perceived behavioral control** refers to an individual's perception of their capability of performing a given behavior. Perceived behavioral control is a combination of both perceived control and self-efficacy and has both a direct and an indirect effect on behavior, through its effects on intentions.^{80,81} Altogether, the TPB assumes a positive correlation between an individual's attitudes, social norms, and perceived behavior control and

increased intention to perform a behavior, which in turn, results in greater health behavior performance.^{14,77}

Use of the TPB to promote vaccine uptake in non-pregnant individuals

The TPB has been used as a tool to assess vaccine hesitancy in a multitude of vaccinations globally. The TPB has been used to evaluate general and childhood vaccine hesitancy in Italy,⁸² China,⁸³ Canada,⁸⁴ and the United States;⁸⁵ influenza vaccination in the United States;^{74,86–88} HPV vaccination in the United States;^{41,89} Hepatitis B vaccination in Uganda;⁶⁶ Swine Flu vaccination in the United Kingdom;⁹⁰ the Boostrix-IPV vaccination in the United Kingdom;⁹¹ and COVID-19 vaccination in the United States,^{46,92} Bangladesh,^{54–56} Ireland,⁹³ New Zealand,⁹⁴ Pakistan,⁹⁵ and Malta.⁹⁶ While this list is not conclusive, it begins to illustrate the versatility and usability of the TPB.

In addition to informing and structuring study questionnaires, the TPB has been utilized diversely. It has provided the foundation for a behavioral analysis approach to examining vaccination acceptance and guided the development of research questions to evaluate vaccination behavior.^{56,97} In addition, the TPB has been used to develop interview questions for studies, including one study that used motivational interviewing techniques in attempts to decrease vaccine hesitancy.⁹⁸ The TPB has also been used as a guide for literature reviews exploring vaccination intention.⁸⁵

Use of the TPB model in pregnant individuals

The TPB has been used to assess pregnant individual's vaccine intention and behaviors.^{66,71,90,91} In a literature review that explored predictors of maternal vaccination, the TPB model was used in eight of twelve reviewed studies that were theoretically based.⁷¹ The model is used to explore pregnant individual's beliefs about the Boostrix-IPV,⁹¹ influenza,⁷⁶ hepatitis B,⁶⁶ and swine flu vaccinations.⁹⁰

Repeatedly in the literature, the TPB is found to be a validated measure of pregnant individual's intentions to get vaccinated. In a study exploring women's hesitancy about the Boostrix-IPV vaccination, the TPB predicted 86% of the variance in vaccine intentions, with subjective norms and attitudes being the best predictors. In regard to vaccine behavior, the

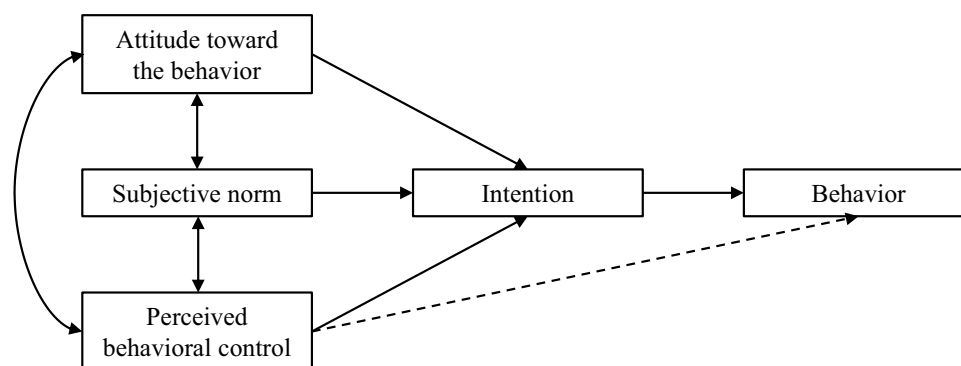


Figure 2. Theory of Planned Behavior. Figure reproduced from Ajzen, *Organizational Behavior and Human Decision Processes*, 1991.¹⁴ Figure details the relationship between various constructs and their ability to influence vaccination intention and overall behavior.

model accounted for 36% of the variance.⁹¹ In another study, which evaluated pregnant individual's intent to receive the swine flu vaccination, the TPB explained 66% of the variance in intention to be vaccinated. In this study, attitude, subjective norm, and perceived control were all found to be predictive of vaccination intention.⁹⁰

While the TPB has been found to be predictive of vaccination intention in pregnant individuals, multiple studies have expressed concerns about the model. One study highlighted that the theory was better at predicting vaccination intent than vaccination behavior and emphasized that public health interventions are more commonly built upon vaccination behavior.⁹¹ This same study also highlighted that the TPB does not account for all variables contributing to vaccine behavior and suggested that further work may need to be done to explore these variables.⁹¹

Use of the TPB model in COVID-19 vaccination uptake in non-pregnant individuals

Within the literature that explores the TPB and COVID-19, the relationship is bidirectional. The literature supports that the TPB is a validated measure to explore COVID-19 vaccine hesitancy.⁹³ Conversely, the literature also supports that attitudes and behaviors toward the COVID-19 vaccine support the TPB.⁹⁶ In multiple studies, attitudes, subjective norms, and perceived behavioral control were found to have a significant impact on vaccination intent and behavior.⁹³⁻⁹⁵ In one study, the constructs of the TPB accounted for 74% of variance in COVID-19 vaccination intention.⁹⁵ In a study that evaluated multiple assessments of vaccination hesitancy, the TPB was found to have the highest predictive power of COVID-19 vaccination hesitancy.⁵⁵

The authors suggested that the constructs of the TPB may be beneficial in the development of COVID-19 vaccination public health messages and efforts to improve vaccination uptake.^{46,93} While the TPB has been used to assess vaccination hesitancy, the application of TPB in promoting COVID-19 vaccine acceptance and uptake has not been tested.

Use of the TPB model in COVID-19 vaccination uptake in pregnant individuals

The use of the TPB model to address COVID-19 vaccine hesitancy and acceptance among pregnant individuals has not been investigated to-date in this review.

Performance of the TPB model with annual vaccines versus vaccines given once or twice

The TPB has been used to assess vaccination hesitancy related to vaccines given at various intervals, including both annuals and vaccines that are given a few times. While most studies analyze one type of vaccine schedule, one study analyzed both annual vaccinations and vaccines that are given once or twice. This study focused on the subjective norm construct from the TPB and found that subjective norms were associated with vaccination intention.⁹⁷

For vaccines that are given on a few occasions, the TPB has been used to investigate vaccine hesitancy about the human papillomavirus vaccine.^{41,89} Both attitudes and subjective norms were found to be predictive of vaccination behavior.⁸⁹ One study

addressed how the constructs of TPB and behavioral intentions may vary based on patient knowledge regarding the HPV vaccination. The authors found that different types of knowledge about HPV and the vaccine (genders affected, HPV manifestations, vaccine efficacy, etc.) have different associations with the TPB constructs and ultimately the intention to be vaccinated.⁸⁹ The other study exploring the TPB and HPV evaluated social media discussions in relation to the vaccination. The attitude construct from TPB was used to analyze social media posts and discussions and observe trends about the vaccination.⁴¹

The TPB has also been used to evaluate vaccination hesitancy for vaccines given annually, specifically the influenza vaccination. Attitude and subjective norms have both been found to be significant predictors of an individual's intention to receive the influenza vaccination.⁸⁷ In this study, a doctor's influence was the strongest subjective norm identified.⁸⁷ In a study that assessed barriers to receiving the influenza vaccination, the negative attitudes (a TPB construct) were amongst the most frequently reported barriers.⁸⁸ The perception that receiving the influenza vaccination was not the norm in a peer group was also a frequently reported barrier.⁸⁸

3. The 3C model

In 2012, the Strategic Advisory Group of Experts on Immunization (SAGE) established the SAGE Working Group on Vaccine Hesitancy in response to the globally low levels of vaccine uptake and the negative impacts of vaccine hesitancy.¹² The group was tasked with establishing a definition for vaccine hesitancy as well as a working model of determinants. The Working Group created a model to explain the factors influencing vaccine hesitant behavior (Figure 3).⁹⁹ The first model, the Working Group Matrix, is more comprehensive and better able to capture the complex factors influencing vaccine behavior. This model groups determinants of vaccine hesitancy into three categories: Contextual influences, Individual and Group influences, and Vaccine/Vaccination specific issues. This matrix was determined to be comprehensive as a systemic review of studies on vaccine hesitancy, and a survey of immunization managers found no other determinants.^{99,100}

Subsequently, the group simplified the model for practical use and named it the 3C model, after Complacency, Convenience, and Confidence, the three factors most substantially contributing to vaccine behavior (Figure 4).¹² Complacency is present when "perceived risks of vaccine-preventable diseases are low and therefore vaccination is not deemed a necessary preventative action."¹² Convenience measures the degree to which an individual's ability to obtain vaccines is affected by "physical availability, affordability and willingness-to-pay, geographical accessibility, ability to understand (language and health literacy) and appeal of immunization service affect uptake."¹² Ineffective or inconvenient delivery of vaccination services was associated with increased vaccine hesitancy. Confidence is defined as "trust in (i) the effectiveness and safety of vaccines, (ii) the system that delivers them, including the reliability and competence of the health services and health professionals, and (iii) the motivations of policy-makers who decide on the need of vaccines."⁵ Confidence is associated with low levels of vaccine hesitancy.

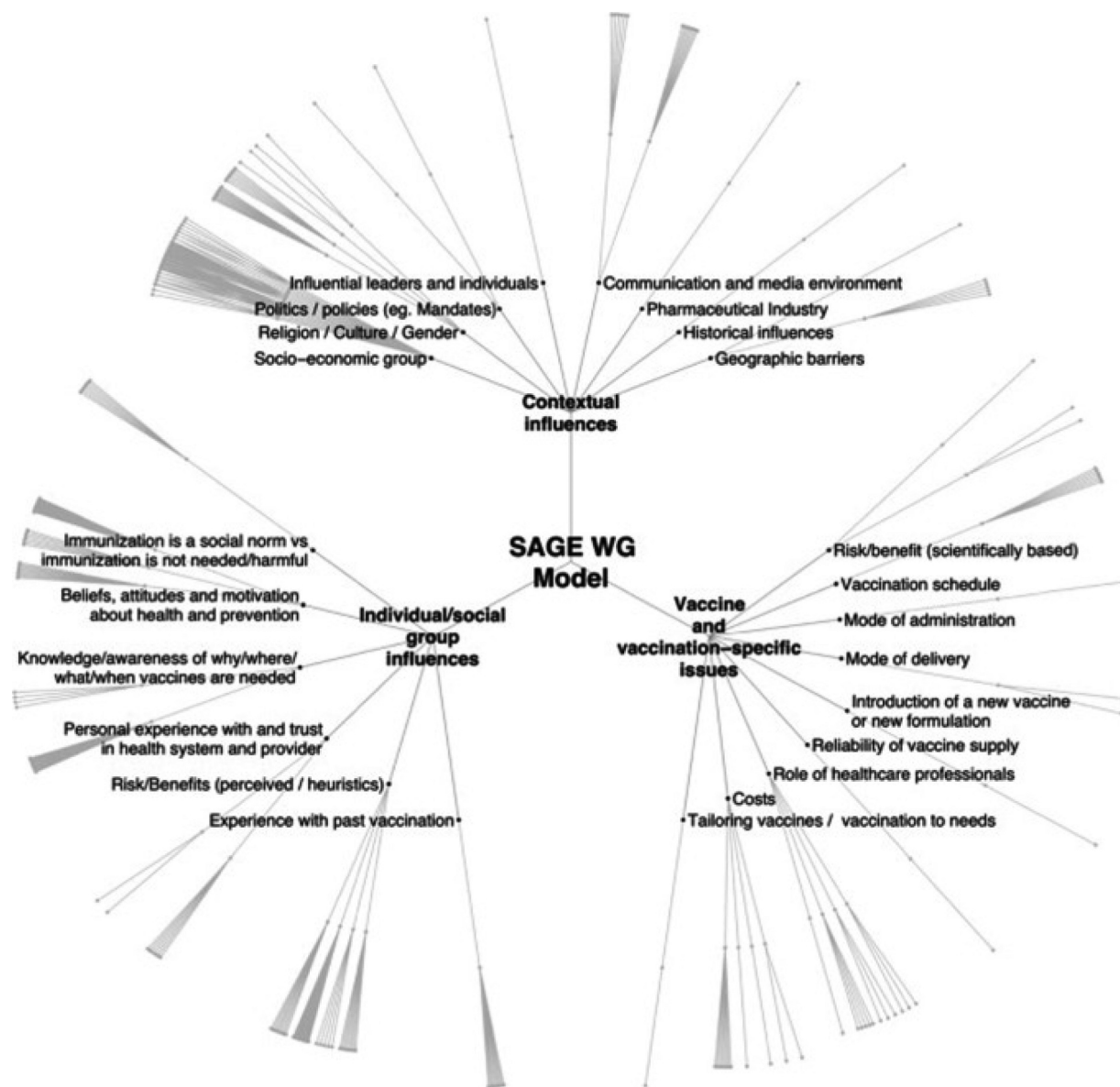


Figure 3. SAGE Working Group Matrix of Vaccine Hesitancy. Figure reproduced from Larson, Jarrett, Eckersberger, Smith, and Paterson, *Vaccine*, 2014.⁹⁹ Figure demonstrates the determinants of vaccine hesitancy as laid out by the SAGE Working Group.

With both models, the Working Group noted that vaccine hesitancy is complex and can vary depending on the contextual time and place.^{12,101} Additionally, while these models provide a framework through which to view vaccine behavior, there is no specific measure associated with the 3C model or the Working Group Matrix—outside of a metric for parental vaccine hesitancy.

Use of the 3C model to promote vaccine uptake in non-pregnant individuals

The establishment of the 3C model and the Working Group Matrix have been beneficial for interpreting vaccination intention and behavior. Application of the 3C model has also been used to better understand vaccine hesitancy globally and to formulate interventions aimed at targeting various aspects of confidence, complacency, and/or convenience. Research has applied this model to better understand hesitancy in measles vaccines,^{102,103} among health-care workers and students,^{104–107}

as well as for general childhood vaccination in Tajikistan.¹⁰⁸ There has also been research using the 3C model to create and analyze vaccine hesitancy interventions.^{109,110}

A large systematic review of the 3C model use in vaccine hesitancy found that safety concerns, questions about vaccine effectiveness, and distrust in health-care authorities accounted for a large part of vaccine hesitancy reported throughout the literature, indicating that low levels of confidence likely play a significant role in vaccine behavior.⁸⁸ A narrative review of vaccine hesitancy among health-care workers found similar trends in vaccine hesitancy as in the general population—low confidence and high complacency led to higher levels of hesitancy.¹¹¹ Health-care workers with high hesitancy were less likely to be vaccinated and less likely to recommend vaccines to patients, highlighting the importance of decreasing vaccine hesitancy not only within patient populations, but the health-care system as well.¹¹¹

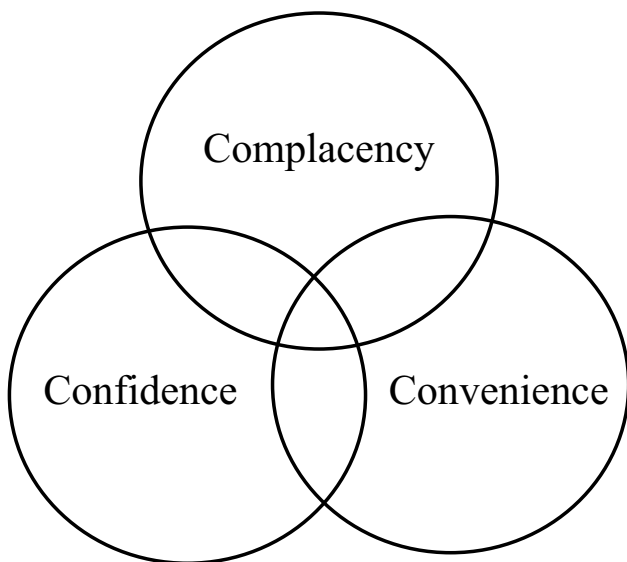


Figure 4. 3C model. Figure reproduced from the World Health Organization's SAGE vaccine hesitancy Working Group, Report of the SAGE working group on vaccine hesitancy, 2014.¹² Figure demonstrates the factors that contribute to the 3C model.

Use of the 3C model in pregnant individuals

Systematic reviews of vaccine hesitancy within the pregnant and lactating population found that low vaccine confidence was a major barrier to receiving recommended vaccinations during pregnancy, with convenience playing a very limited role in attitudes toward vaccination.^{112,113} However, as highlighted in one of the reviews, the majority of research included in the reviews came from Western, high-income countries and may not be applicable globally.¹¹²

A qualitative study of high-risk groups in South America found that, across the board, low levels of vaccine confidence were a major contributor to vaccine hesitancy.¹¹⁴ However, in pregnant women, complacency also played a significant role. They found that many pregnant women did not consider themselves to be in a “high risk” group that contributed to complacency. A qualitative study of pregnant women’s perception of the Hepatitis B vaccine in Uganda found similar results.¹¹⁵ While low levels of confidence in health-care workers contributed to vaccine hesitancy, complacency due to limited knowledge of Hepatitis B also played a role.

The importance of geographical and cultural context when using the 3C model to understand vaccine hesitancy is highlighted here and emphasizes the need for more research into populations outside of the Western countries.

Use of the 3C model in COVID-19 vaccination uptake in non-pregnant individuals

The 3C model has also been used to a greater degree more recently in understanding COVID-19 vaccine attitudes. As with other vaccines, research has shown that low levels of confidence and convenience, and high levels of complacency, are associated with higher rates of COVID-19 vaccine hesitancy.^{116–120}

While most of the studies on COVID-19 vaccine hesitancy used questionnaires to passively assess vaccine hesitancy,^{116–120} an experimental study in France found that they could decrease

levels of complacency, and subsequently decrease levels of vaccine hesitancy, in the working age population by providing participants with information on herd immunity.²¹ Another study, looking at COVID-19,^{121***} explored the underpinnings of low confidence in health-care systems.¹²² Through their research, they found that health-care literacy was a key mediator in the relationship between health care distrust and vaccine hesitancy. Literature using the 3C model has also examined sociodemographic variations in COVID-19 vaccine hesitancy.¹²³ Hesitancy due to low confidence and higher levels of circumspection (this study’s expansion on convenience) were primarily found in Black respondents- particularly in Black women who were found to have the highest rates of vaccine hesitancy of any group. However, this study also found that hesitancy among Black respondents declined faster than in other groups. While research into the COVID-19 vaccine has been rapidly carried out, as noted by the SAGE working group, vaccine hesitancy is complex. More research is needed in this area to better understand the needs of specific populations, such as pregnant and lactating individuals.

Use of the 3C model in COVID-19 vaccination uptake in pregnant individuals

Studies applying the 3C model to investigate COVID-19 vaccine acceptance among pregnant individuals have not been done to date of this review. However, research into COVID-19 vaccine hesitancy in the pregnant population has identified confidence in the vaccine as a key feature in vaccine acceptance in the US and UK.^{124,125}

Performance of the 3C model with annual vaccines versus vaccines given once or twice

Research using the 3C model to compare general vaccine hesitancy to influenza-specific vaccine hesitancy found that one could not necessarily be substituted for the other.¹²⁶ Looking at vaccination attitudes and behaviors of US adults, they found that high confidence and convenience and low complacency were associated with lower general vaccine hesitancy. High confidence in the flu-specific vaccine was associated with lower flu vaccine hesitancy and positively associated with rates of flu vaccination in the past year. However, higher general vaccine confidence was not associated with receiving the influenza vaccine for that given year, suggesting that general vaccine hesitancy or acceptance may be specific and unique to specific vaccines. Additional research into nursing home staff and influenza vaccinations suggest that the variability of influenza strains and misconceptions about the possible severity of infection can lead to low confidence and high complacency specific to this vaccine.¹⁰⁵ These findings highlight the need for vaccine-specific analysis when utilizing this model.

4. The 5C model

The 5C model of vaccine hesitancy, proposed in 2018, expands the SAGE WHO’s 3C model to add Calculation and Collective Responsibility factors (Figure 5).¹²⁷ The 5C model looks at psychological antecedents as a way to better understand an individual’s behavior, “going beyond confidence.”⁸ Calculation

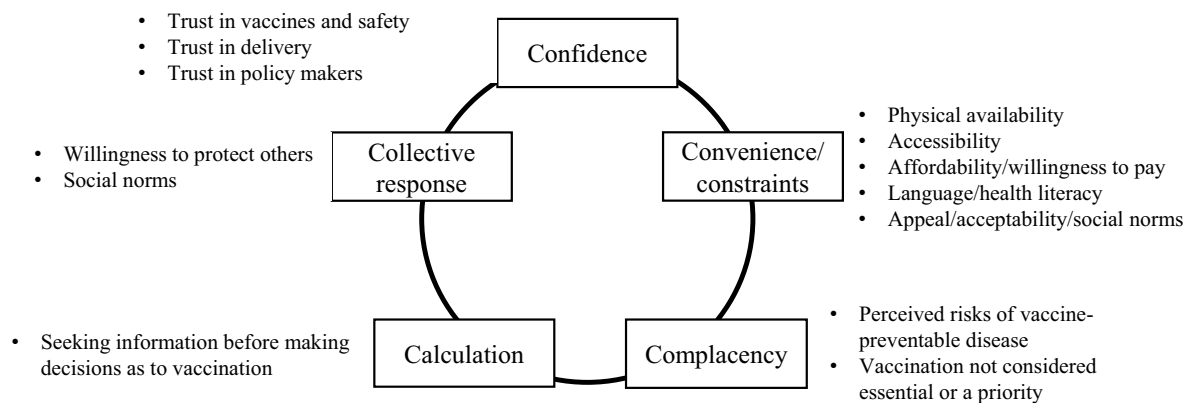


Figure 5. The 5C Model. Figure reproduced from Turner, Larson, Dubé, and Fisher, *Journal of Allergy and Clinical Immunology: In Practice*, 2021.¹²⁷ Figure details the five factors of the 5C model and the various elements that contribute to their composition.

refers to information searching. Individuals engaging in information searching typically do so to conduct their own risk-benefit analysis and are assumed to be more risk averse. Due to the wide availability of vaccine misinformation, individuals with high levels of calculation have positive correlations with perceived vaccination risks and vaccine hesitancy.¹⁵ The calculation factor was added to the 3C model as a way to capture an individual's motivation for thinking about and questioning vaccines.¹²⁸ Collective responsibility is considered an individual's "willingness to protect others by one's own vaccination by means of herd immunity."⁸ Individuals with high levels of collective responsibility will have higher levels of collectivism, communal orientation, and empathy. Those who have low levels of collective responsibility, either due to a lack of knowledge about herd immunity or unwillingness to protect others, will have positive correlations with vaccine hesitancy.

The five factors uniquely interact in every individual to create a psychological state somewhere along the vaccine hesitancy spectrum. The authors of this model note that "the 5C antecedents provide insights in the individual, psychological antecedents and are not suitable to identify systems-related factors—beyond the effect they have on mental representations."¹⁵ For example, low levels of confidence in one individual may be the result of their social environment, whereas for an individual in another country, it may be the result of mistrust in their health-care system. Therefore, the benefit of analyzing vaccination behavior through the 5C model is to better understand the psychological underpinnings behind an individual's vaccine behavior. Further investigation is required to determine the factors informing that state. Doing so can help tailor strategies designed to promote vaccine uptake to specific individual groups by targeting a specific factor.

The 5C model provides both a short and long validated scale for assessing the psychological antecedents of vaccination behavior.¹⁵ While this model is available for adaptation and translation,¹²⁹ some non-English speaking, low-income countries have found it difficult to adapt the scale.¹³⁰

Use of the 5C model to promote vaccine uptake in non-pregnant individuals

Research using this model has explored the role of faith in one's own intuition and the effects of decreasing complacency among target groups through the implementation of prosocial

vaccination interventions.^{131,132} The 5C model has also been explored to understand the attitudes of physicians toward vaccination.¹³³ Physicians with positive attitudes toward vaccine mandates have been found to generally have higher levels of confidence and collective responsibility. Physicians' own vaccination behavior was also found to be significantly related to their recommendation of vaccines, with high levels of confidence in vaccines being associated with active recommendation.¹³⁴ However, even within this group there were differences. Homeopathic physicians were found to have significantly lower confidence and higher complacency compared to other physicians, which influenced their vaccination recommendations.¹³⁴ A qualitative study of health-care workers across Europe also found that confidence largely contributed to vaccine recommendation behavior but also noted that confidence varied widely across nations.¹³⁵ The model has been applied to caregivers of children to assess willingness for vaccination against childhood diseases and Human Papilloma Virus in Malawi.¹³⁰ The study found that confidence in vaccine safety was the strongest predictor of routine childhood immunization, followed by constraints due to everyday stress.¹³⁰ In addition, a husband's positive attitude increased childhood vaccination intention.¹³⁰ This points to the importance of identifying local determinants of vaccine hesitancy to develop successful programs.

Use of the 5C model in pregnant individuals

Little research has been done using the 5C model as a means to understand vaccine hesitancy in pregnant and lactating individuals. Two studies were done using this model in pregnancy.^{136,137} Using the 5C model in the pregnant population was a proposal for a vaccine hesitancy intervention in the pregnant population in India.¹³⁶ They propose administering the 5C scale at prenatal visits to identify individual patients' unique behaviors and apply motivational interviewing techniques to address them in real time. However, the actual study has not yet been conducted. A study in Nigeria using the 5C model to understand drivers of vaccine hesitancy for themselves and their children concluded that the 5C model does not perform well in their population.¹³⁷ Their intention to vaccinate unborn children was lower if they were Muslims, had lower confidence in the public health system, if husband

approval was important, and if they believed in rumor. The authors concluded that the 5C scale needs a revision before being widely used in Nigeria.¹³⁷

Use of the 5C model in COVID-19 vaccination uptake

The 5C model has been increasingly relevant in aiding our understanding of COVID-19 vaccine hesitancy. A technical report for the European Union on COVID-19 vaccine acceptance emphasized the importance of targeting different groups according to their specific needs in order to develop successful programs, using the 5C framework.¹³⁸ Research using the 5C model in COVID-19 vaccination behavior has consistently shown that high confidence and collective responsibility were associated with lower levels of vaccine hesitancy, as is seen with other vaccinations.^{55,138–148} However, differences within groups were also found. For instance, for Japanese men specifically, constraints were significantly associated with COVID-19 vaccine intention, suggesting that convenience may be an important factor in their vaccination decisions.¹⁴⁴ Additionally, a study of Israeli parents' intent to vaccinate their children against COVID-19 found that in addition to higher confidence and collective responsibility, higher calculation was associated with vaccination intent.¹⁴⁰

A recent study of Health Care Workers found that attitudes toward the COVID-19 vaccine were distinct from other vaccines, in that one could be generally accepting of vaccines but hesitant about the COVID-19 vaccine specifically.¹⁴⁵

One study suggested using the 5C model to create profiles predicting COVID-19 vaccination intent and uptake to tailor interventions in nurses.¹⁴⁷ The most likely to vaccinate were 'Believers' (high confidence and collective responsibility, low complacency, and constraint) and Contradictors (high on all 5C measures). In the middle were 'Middlers' (moderate on all 5C measures) and Outsiders (Low calculation and collective responsibility). Least likely were 'Skeptics' (low confidence and collective responsibility, high complacency, and constraint).

Use of the 5C model in COVID-19 vaccination uptake in pregnant individuals

Up to this date, no studies were done examining the 5C model for COVID-19 vaccine acceptance among pregnant individuals.

Performance of the 5C model with annual vaccines versus vaccines given once or twice

The 5C model has been applied to both annual and single-dose vaccines.^{148,149} A study on the vaccination behaviors of the elderly population in the UK used this model to compare annual influenza vaccine to single pneumonia and shingles vaccines and found that low confidence, low collective responsibility, and high constraint and complacency predicted low uptake of the influenza vaccine.¹⁴⁸ However, for the pneumonia and shingles vaccine, calculation was not a contributing factor in vaccine uptake. Another study looked specifically at the annual influenza vaccine among those with chronic respiratory conditions, finding that higher levels of collective responsibility and lower levels of constraints and complacency were associated with higher rates of vaccination.¹⁴⁹

5. The 5A model

The 5A model was proposed by Thompson and colleagues in 2016 includes five barriers and facilitators of vaccine uptake: **Access** – the ability of individuals to be reached by or to reach the recommended vaccines; **Affordability** – the ability of individuals to afford the vaccine both from financial and non-financial aspect (e.g., time); **Awareness** – the degree to which individuals have knowledge of the need for the vaccine and vaccine's objective benefits and risks; **Acceptance** – the degree to which individuals accept, question, or refuse the vaccine; and **Activation** – the degree to which individuals are nudged toward vaccination uptake.¹⁵⁰

Use of the 5A model to promote vaccine uptake in non-pregnant individuals

A systematic review of vaccine uptake in the migrant population in Europe using the 5A model found multiple-access barriers to vaccination, including language, literary, and communication barriers.¹⁵¹ Acceptance barriers were mostly reported in eastern European and Muslim migrants for HPV, MMR, and influenza vaccines. Another recent review examined the 5A model for non-COVID-19 vaccine uptake within Roma communities across Europe.¹⁵² In that study, access was identified as the greatest barrier to vaccination.

Use of the 5A model in pregnant individuals

Up-to-date, no studies were done examining the 5A model for vaccine acceptance among pregnant individuals.

Use of the 5A model in COVID-19 vaccination uptake

A mapping review of COVID-19 vaccine uptake among Adults 55 years and older in Africa with the 5A model taxonomy found that acceptance was the most commonly researched aspect of vaccine uptake (85%), followed by accessibility (25%), awareness (19%), and affordability (7%).¹⁵³ Activation was examined in only one study as a factor affecting COVID-19 vaccine acceptance. The review concluded that more studies are needed to evaluate the impact of nudges (activation) to improve COVID-19 vaccine uptake in African nations.

Use of the 5A model in COVID-19 vaccination uptake in pregnant individuals

Up-to-date, no studies were done examining the 5A model for COVID-19 vaccine acceptance among pregnant individuals.

Conclusion

The HBM, TPB, 3C model, 5C model, and 5A model have demonstrated great versatility in their ability to evaluate, explain, and modify vaccine hesitancy and behavior. While each of these models have demonstrated success, the HBM and 3C models are the most effective for assessing vaccination hesitancy within pregnant individuals. Overall, the HBM is the most utilized model to address vaccination hesitancy. The 3C model is also widely used and has demonstrated great efficacy and thoroughness in its ability to assess vaccination hesitancy. These models have repeatedly proven their ability to holistically explain and create change within vaccination behaviors.

Multiple studies have expressed concern about the TPB's ability to predict vaccination behavior in pregnant individuals. The model has been criticized for not fully accounting for all variables that may contribute to vaccination behavior. Additionally, the model is more likely to predict vaccination intent rather than actual vaccination behavior. Finally, the TPB has not been utilized to assess COVID-19 vaccination promotion and uptake; rather, it has only been used to assess vaccination hesitancy.

While the 5C model can be used to assess the psychological antecedents of vaccination behavior, it is not as efficacious as the HBM and 3C models. Some non-English speaking, low-income countries have found it difficult to adapt the scale used in the model even though it is available for adaptation and translation. Moreover, being a new model, 5C's use and effectiveness has not been well investigated in pregnant individual.

We conclude that the HBM and 3C models are the most effective tools to study and address vaccination hesitancy within the pregnant population. As demonstrated in the literature, there is a need for increased vaccination within pregnant individuals. This is particularly important with the COVID-19 vaccine and boosters. Principles and constructs of the HBM and 3C models may be combined to create the most effective tool for assessing vaccine hesitancy in pregnant individuals. This tool could be used to both further understand vaccine hesitancy and promote vaccination behaviors within pregnant patients for a multitude of vaccinations. Since the vaccine roll out in December 2020, we have robust, high-quality data on tens of thousands of pregnancies confirming vaccine safety and benefits in protecting the mothers and their unborn children from severe COVID-19 illness. Promoting this evidence-based information to increase vaccine confidence and perceived benefits through HBM or 3C model is important next step to decrease COVID-19 vaccine hesitancy.

Highlights

- Health Belief and 3C models are effective to study vaccine hesitancy in pregnancy
- These models could be combined to address COVID-19 vaccine acceptance in pregnancy

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