SARS-CoV-2 vaccine uptake and reasons for hesitancy among Canadian pregnant people: a prospective cohort study

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Abstract

Background: Several vaccines against SARS-CoV-2 have been developed and approved at an unparalleled speed. Given that SARS-CoV-2 vaccines are recommended to pregnant people, our aim was to quantify vaccination uptake, and describe vaccination hesitancy and behavioural attitudes surrounding SARS-CoV-2 vaccination in pregnancy in Canada.

Methods: The CONCEPTION study is an ongoing international study started in June 2020, evaluating the impact of the COVID-19 pandemic on the health of pregnant people and their children. For this study, pregnant people recruited from Apr. 20, 2021, to Feb. 8, 2022, and residing in Canada were invited to complete a Web-based survey. In addition to all CONCEPTION variables, data on vaccine uptake as well as personal knowledge of COVID-19 severity in pregnancy and of SARS-CoV-2 vaccine safety and efficacy were collected. Marginal risk differences and adjusted odds ratios (ORs) were calculated to assess determinants of SARS-CoV-2 vaccination during pregnancy.

Results: From Apr. 20, 2021, to Feb. 8, 2022, 603 pregnant people were recruited and gave consent, of which 83.7% ($n = 505$) were vaccinated and 16.3% ($n = 98$) were not vaccinated against SARS-CoV-2. Uptake of the influenza vaccine in 2020/21 was a significant predictor of being vaccinated against SARS-CoV-2 or intention to be vaccinated (marginal risk difference 3.2%, 95% confidence interval [CI] 3.0% to 3.3%, adjusted OR 4.43, 95% CI 2.32 to 9.25), and being employed (marginal risk difference 11.2%, 95% CI 10.6% to 11.9%, adjusted OR 2.17, 95% CI 1.03 to 4.35) increased the likelihood of being vaccinated against SARS-CoV-2. Self-assessed knowledge of COVID-19 severity and vaccine efficacy was not associated with vaccine uptake.

Interpretation: Among the Canadian pregnant people who responded to this study, vaccine uptake against SARS-CoV-2 was high. However, our results underscore the importance of improving knowledge transfer about the efficacy of SARS-CoV-2 vaccines in pregnancy to guide vaccination efforts.

Several SARS-CoV-2 vaccines have been developed and approved at an unparalleled speed, while maintaining rigorous regulatory processes.[1–4] At the start of our study period in April 2021, there were limited data available on the efficacy of SARS-CoV-2 vaccines in pregnancy, mostly owing to the fact that pregnant people were excluded from pre-authorization clinical trials, and only limited human data on safety during pregnancy were available at the time of authorization. However, we know that pregnant people with COVID-19 are at increased risk for severe illness (e.g., resulting in admission to an intensive care unit, extracorporeal membrane oxygenation or mechanical ventilation) and death, as compared with nonpregnant people of reproductive age.[5,6] Following the Pregnancy Research Ethics for Vaccines, Epidemics, and New Technologies (PREVENT) working group recommendations,[5] both the Society for Maternal-Fetal Medicine and other women's health organizations have included pregnancy as a risk factor for severe COVID-19.

Thus far, the SARS-CoV-2 vaccines appear to be equally effective in pregnant and nonpregnant people.[7] Indeed, data from developmental and reproductive toxicity animal-model studies for the Pfizer-BioNtech, Moderna and Janssen (Johnson & Johnson) SARS-CoV-2 vaccines did not demonstrate any safety concerns in pregnancy.[7,8] Moreover, in a sample of pregnant people in the United Kingdom admitted to hospital for COVID-19-related symptoms during the wild-type, Alpha and Delta dominance periods, efficacy data of the Pfizer-BioNtech and Moderna vaccines showed that no fully vaccinated pregnant people were admitted to intensive care units between Feb. 1, 2021 (when vaccination data collection commenced) and Nov. 7, 2021.[9]

On Apr. 20, 2021, the Society of Obstetricians and Gynaecologists of Canada (SOGC) declared supporting the use of all available SARS-CoV-2 vaccines approved in Canada in any trimester of pregnancy.[10] Recommendations for vaccination against SARS-CoV-2 in pregnant people were further revised and approved on

May 13, 2021, by the Public Health Agency of Canada,[11] and the SOGC statement related to vaccination in Canada was later updated on May 25, 2021, approving SARS-CoV-2 vaccination in pregnant people.[8] The Comité sur l'immunisation du Québec later recommended that the mRNA vaccines, such as those from Moderna or Pfizer-BioNtech, should be preferred over non-mRNA vaccines for pregnant people as there are more safety data with these vaccines during pregnancy.[12]

Data on SARS-CoV-2 vaccine acceptance among pregnant people are critical, as vaccine hesitancy is a major threat to global health, as described by the World Health Organization (WHO).[13] Vaccine acceptance has been shown to depend on several factors, such as sociodemographic characteristics, confidence in vaccine safety and efficacy, available information on disease severity, and trust in the health system and health care providers.[8,14–17] Additionally, the KFF (Kaiser Family Foundation) COVID-19 Vaccine Monitor report noted in December 2020 that about 27% of a random sample of 1676 American adults would probably not or definitely would not get a SARS-CoV-2 vaccine if available.[18] In July 2021, the 2 age brackets with the lowest vaccination rates among Canadian adult females were 18–29 years and 30–39 years (73% and 76% of 1-dose vaccination, respectively),[19] which would include most people of childbearing age.

In the context of this pandemic, we aimed to quantify vaccine uptake in pregnancy and describe the level of and reasons for hesitancy and behavioural attitudes surrounding the SARS-CoV-2 vaccine among pregnant people in Canada. We hypothesized that influenza vaccine uptake in the previous flu season, socioeconomic status and education level would be predictors of SARS-CoV-2 vaccine acceptance and uptake.[20]

Methods

The CONCEPTION cohort started on June 26, 2020, and is ongoing.[21,22] The CONCEPTION study is an international study (Canada, China, the United States and France being among the most represented), which evaluates the impact of the COVID-19 pandemic on maternal mental health in pregnancy and its impact on their children, with long-term follow-up on both mothers and children. Since Apr. 20, 2021, CONCEPTION has collected data on vaccine acceptability, uptake prevalence, adverse effects and vaccine hesitancy. This date was chosen as it coincides with public messaging from the SOGC and Canadian public health agencies, as well as the time when pregnant people were considered to be a prioritized group for the vaccination campaigns. The study obtains patient consent and collects data online using SurveyMonkey (Appendix 1, available at www.cmajopen.ca/content/10/4/E1034/suppl/DC1), which is a secure platform that enabled recruitment worldwide, and facilitates the validation of double entry and participation by deleting questionnaires filled using the same IP address.

Eligibility criteria

Study eligibility assessment, consent and baseline data collection are completed electronically; the information is thereafter downloaded on a secure server at CHU Sainte-Justine, Montréal. All data collected are in a centralized database at CHU Sainte-Justine. For this study on SARS-CoV-2 vaccination, we included CONCEPTION study participants between Apr. 20, 2021, and Feb. 8, 2022. Participants were pregnant and resided in Canada at the time of recruitment; they were also 18 years of age or older, and able to read French, English, Spanish, Mandarin or Portuguese.

Recruitment

The CONCEPTION study uses diverse recruitment methodologies based on the WHO's recent efforts to reach younger people where they get their information, namely social media.[23] Recruitment is done on social media and the Internet, but also through obstetrics and gynecology departments in the Centre hospitalier universitaire (CHU) Sainte-Justine. Furthermore, recruitment is done in person in a community association of recent immigrants through the Montreal Diet Dispensary in Montréal, Quebec, which allows for the recruitment of individuals of lower socioeconomic status. Computer terminals are also made available to pregnant people at in-person recruitment sites. Finally, quick response codes are displayed on posters where in-person recruitment is done, in order for individuals to directly access the questionnaire with their mobile device, without having to be members of any of the social media platforms. With regards to our Web-based recruitment of pregnant people, a combination of social media platforms (Facebook, Instagram, Twitter, LinkedIn and TikTok) is used. Recruitment strategies and data intake questionnaires are available in French, English, Mandarin, Spanish and Portuguese, and postings are refreshed regularly (i.e., reposted weekly at the time of recruitment).

Survey design and development

Development of the questionnaire was done in English by J.G., Y.-H.G. and A.B., as well as the international team of collaborators working on the CONCEPTION study, as described previously.[21,22] The questionnaire was translated into French and back-translated into English to ensure validity. The study instrument includes a number of validated questionnaires in all available languages. The questionnaire was pretested with 10 French-speaking and 10 English-speaking pregnant people and took an average of 25 minutes to complete. Participants were not compensated for their time.

To reach a diverse group of pregnant people, 2 team members (J.G. and Y.-H.G.) actively work on promoting the cohort on social media platforms via information segments (all platforms), mother–child and pregnancy support groups, outpatient and community clinics, and established hashtag strategies (Instagram, Twitter, LinkedIn), as well as through communication specialists affiliated with our team's respective universities (all platforms including mainstream media — television, radio, press releases and news interviews). Recruitment via social media combined with in-person recruitment in times of crises is an appropriate methodology given the rapidity with which we need answers to pressing questions, such as how pregnant women are doing during the COVID-19 pandemic.[24] Social media recruitment with anonymized data (survey, cross-sectional samples) has been used in other similar studies.[8,25,26]

Study variables

Maternal characteristics and general medical and peripartum medical history

Variables collected for the CONCEPTION study included age, gestational age, prepregnancy weight and ethnicity; sociodemographic characteristics (education, household annual income and marital status), place of residence (urban, suburban, rural), current employment status (type of work, working from home, still working on site and at what frequency); lifestyle behaviours during pregnancy, including smoking, alcohol, illicit drugs, cannabis products and multivitamin use; health status and medication use, such as prescribed medication use, comorbidity history (asthma, hypertension, diabetes, hyperthyroidism, hypothyroidism, dyslipidemia, depression, anxiety); pregnancy history, including parity; and COVID-19 diagnoses or symptoms (at the time of survey completion).

Vaccine variables

Participants were asked, "If it were available to you, would you accept the COVID-19 vaccine during your pregnancy?" If they said yes, we asked them whether they had been vaccinated against SARS-CoV-2 since the beginning of their pregnancy. Respondents had space to indicate they had booked an appointment and as such were categorized as "intended to be vaccinated." Participants were also asked whether they had received the influenza vaccine during the 2020/21 season, which was analyzed as a proxy for acceptance of prepandemic public health measures. Additionally, participants were asked to assess their knowledge of COVID-19 severity in pregnancy, and of the safety and efficacy of the SARS-CoV-2 vaccine, in general and in pregnancy specifically, on a Likert scale ranging from 1 (no knowledge) to 5 (excellent knowledge). Of note, this is self-reported knowledge, which incorporates personal biases as well as past and present experiences.[27,28] Each participant was further asked about their personal history of COVID-19. Finally, in cases of nonvaccination, the participant stated the reason(s) for their decision. Participants were provided with a list of reasons to select to explain why they were not vaccinated. They also had the option to enter other reasons in free-form text, which were compiled by our team and categorized.

Data analysis

Comparisons were performed according to vaccination status (vaccinated or intention to be vaccinated, which were pooled into 1 group; not vaccinated). Given the use of vaccination during pregnancy in other countries, and in anticipation of the SOGC statement supporting the use of all available and approved SARS-CoV-2 vaccines in Canada during any trimester of pregnancy on Apr. 20, 2021, our survey began capturing vaccination data on this date. The earlier recruits planned to get vaccinated but had not yet been vaccinated at the time of enrolment. As such, those who had the intention to be vaccinated and those who had been vaccinated were pooled together in our primary analyses. For all variables, comparisons using means with standard deviations (SDs) or proportions with

ranges were performed, depending on whether the variables were continuous or categorical, using a Student t test or χ^2 statistic, respectively. Self-reported knowledge scores were compared between groups using a Wilcoxon rank-sum test.

We quantified the determinants of SARS-CoV-2 vaccination during pregnancy with crude and adjusted logistic regression models, considering maternal age, annual household income and years of education as adjustment variables for each determinant. We calculated odds ratios (ORs) and 95% confidence intervals (CIs). We also calculated absolute and marginal risk difference, which were based on the adjusted logistic regressions.[29] All statistical analyses were performed using R statistical software (version 4.1.0).

Ethics approval

This study was approved by the CHU Sainte-Justine's research ethics committee (institutional ethical review approval no. 2021-2973).

Results

We recruited 615 participants into the CONCEPTION study from Apr. 20, 2021, to Feb. 8, 2022. Among these participants, 12 exited the survey without answering the sociodemographic questions. In the CONCEPTION study overall, participants took an average of 24 minutes, 39 seconds to complete the survey. A total of 603 participants were included in the analysis, of which 83.7% (n = 505) were vaccinated or had the intention to be vaccinated, and 16.3% (n = 98) were not vaccinated against SARS-CoV-2 and did not intend to be (Figure 1).
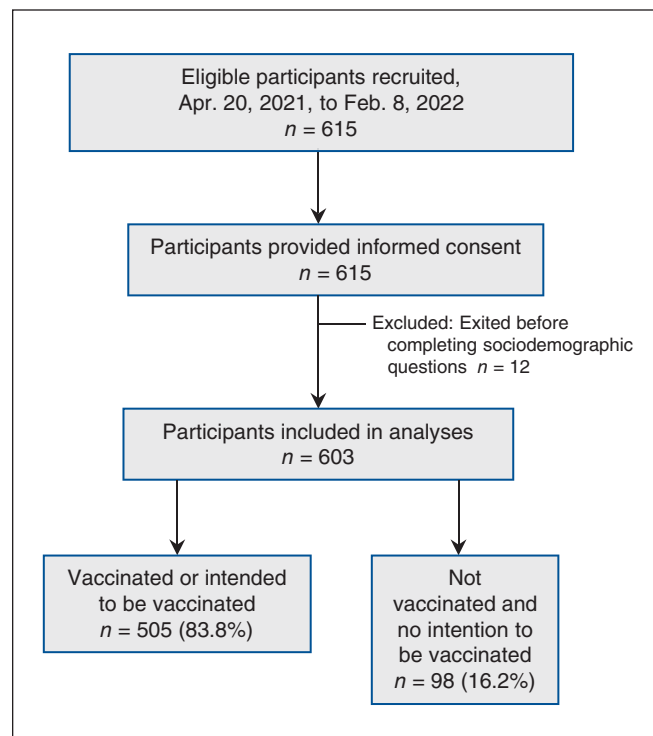

Figure 1: CONCEPTION study flowchart.

Cohort characteristics

The mean age of participants was 33.5 (SD 5.5) years at recruitment (Table 1). The mean gestational age at inclusion was 22.5 (SD 9.3) gestational weeks. Analyses showed significant differences in gestational age at inclusion according to vaccination status. Individuals who were vaccinated or had the intention to be vaccinated were recruited earlier in their pregnancy than nonvaccinated participants (22.0 [SD 9.4] v. 25.7 [SD 8.8] weeks' gestation, $p < 0.001$) (Table 1). The prevalence of influenza vaccination for the 2020/21 season was significantly higher among individuals vaccinated against SARS-CoV-2 and those intending to be vaccinated (40.2%) than among individuals who were not vaccinated (10.2%, $p < 0.001$). Furthermore, vaccinated individuals and those intending to be vaccinated had more years of education than participants who were not vaccinated (17.4 v. 15.0 yr, respectively; $p < 0.001$). Pregnant people who were vaccinated or intended to be vaccinated had higher annual family income than nonvaccinated participants ($p < 0.001$) (Table 1). Sociodemographic data for all groups separately (i.e., intention to be vaccinated, vaccinated and nonvaccinated) are presented in Appendix 2 (available at www.cmajopen.ca/content/10/4/E1034/suppl/DC1).

Self-assessed knowledge of COVID-19 and predictors of vaccination status

Vaccinated participants were more likely to report a higher prevalence of good (4/5) or excellent knowledge (5/5) on COVID-19 severity in pregnancy than nonvaccinated participants ($p < 0.01$, Figure 2A). This was also observed in the self-assessed knowledge of SARS-CoV-2 vaccination in general ($p < 0.01$, Figure 2B) and the self-assessed level of knowledge of SARS-CoV-2 vaccination in pregnancy ($p < 0.01$, Figure 2C). Participants who were not vaccinated reported lower self-assessed knowledge scores overall (Figure 2).

Personal experience with COVID-19 stratified by vaccination status is shown in Table 2. Participants who were vaccinated or intended to be vaccinated reported more frequent testing for SARS-CoV-2 (62.0%) than nonvaccinated participants (55.1%), but this difference was not significant ($p = 0.2$) (Table 2). Receipt of an influenza vaccine within the most recent flu season was a significant predictor of being vaccinated or intention to be vaccinated (marginal risk difference 3.2%, 95% CI 3.0% to 3.3%, and adjusted OR 4.43, 95% CI 2.32 to 9.25) (Table 3). Being employed was significantly associated with being vaccinated or the intention to be vaccinated after adjustment for the other predictors (marginal risk difference 11.2%, 95% CI 10.6% to 11.9%, and adjusted OR 2.17, 95% CI 1.03 to 4.35) when compared with unemployment or receiving welfare support (Table 3). Self-assessed knowledge of COVID-19 severity in pregnancy and of SARS-CoV-2 vaccines in pregnancy and in general were not significant predictors of vaccination status, regardless of the level of self-reported personal knowledge (Table 3).

The main reasons stated for not being vaccinated against SARS-CoV-2 were lack of safety and efficacy data in pregnancy, the speed of vaccine creation and approval, and lack of information on vaccines in pregnancy (Figure 3). Reasons for nonvaccination submitted in free-form text included lack of information on vaccine adverse effects on babies and anxiety. Additionally, respondents also stated that public health officials, or their obstetrician, family doctor or midwife had advised against vaccination (Figure 3).

Interpretation

In this study on SARS-CoV-2 vaccine hesitation and acceptance of SARS-CoV-2 vaccination in a sample of pregnant people in Canada, most individuals (83.7%) were vaccinated or intended to be vaccinated. After adjustment for maternal age, years of education, body mass index and annual household income, we identified that previous influenza vaccination uptake and employment status were significant predictors of SARS-CoV-2 vaccination among participants. The main reasons provided among individuals who were not vaccinated were lack of safety and efficacy data in pregnancy, and hasty approval of the vaccine.

Overall, we identified predictors for vaccination status, such as higher socioeconomic status (e.g., household income, years of education) and having been vaccinated during the last flu season, which is consistent with the literature.[30]

Influenza vaccination acceptance was considered a predictor of SARS-CoV-2 vaccination among the participants. Indeed, the group not vaccinated against SARS-CoV-2 reported lower influenza vaccination during the previous flu season. This result is consistent with vaccine hesitancy, a growing problem in public health over the last decade.[31] In Canada, a vaccination survey tracks coverage every 2 years for all vaccines recommended by the National Advisory Committee on Immunization.[32] Among pregnant people in 2019, only 45% were vaccinated against the flu and 44% against pertussis, and 3%–10% did not know if they had been vaccinated.[19] With a prevalence of SARS-CoV-2 vaccination of 78.6% (474/603), in addition to 5.1% (31/603) who accepted vaccination but had not yet received a vaccine when they completed the survey, and a prevalence of flu vaccination of 35.7% overall, our reported vaccination acceptance is consistent with Canadian and international observations.[33,34] This discrepancy with our results may stem from the fact that vaccination rollout occurred at different times in Canada, with earlier access granted to pregnant people in Quebec than in Ontario.

Underestimation of vaccine efficacy and lack of trust were previously reported as 2 main reasons for vaccine hesitancy.[35,36] In our study, mistrust of the vaccine safety and efficacy were the most frequent reasons for nonvaccination. The population expressing vaccine hesitancy denounced a precipitous approval of vaccines, which suggests a lack of understanding of the approval process, lack of confidence in the procedures for validating vaccination in pregnant people, and a mistrust of national recommendations. The exclusion of pregnant people from vaccine safety trials[37] did not prevent the SOGC from recommending the use of the SARS-CoV-2 vaccine for pregnant people.[8] A recent surveillance review of

Table 1: Characteristics of study participants (recruited Apr. 20, 2021–Feb 8, 2022), stratified by SARS-CoV-2 vaccination status

| Characteristic | No. (%) of participants* | | | p value† |
	Overall n = 603	Vaccinated or intention to vaccinate n = 505	Not vaccinated n = 98	
Age, yr, mean ± SD	33.5 ± 5.5	33.6 ± 5.8	32.9 ± 4.7	> 0.9
Gestational age, wk, mean ± SD	22.5 ± 9.3	22.0 ± 9.4	25.7 ± 8.8	< 0.001
Body mass index,‡ mean ± SD	24.4 ± 5.4	24.3 ± 5.3	25.0 ± 5.9	0.2
Trimester of pregnancy at the time of survey completion				
1st trimester	98 (16.3)	89 (17.6)	9 (9.2)	
2nd trimester	236 (39.1)	203 (40.2)	33 (33.7)	
3rd trimester	269 (44.6)	213 (42.2)	56 (57.1)	0.01
Received influenza vaccine in 2020/21	215 (35.7)	203 (40.2)	10 (10.2)	< 0.001
Health care professional ensuring pregnancy follow-up§				
Family physician	187 (31.0)	158 (31.3)	29 (29.6)	
Obstetrician	388 (64.3)	322 (63.8)	66 (67.3)	
Midwife	56 (9.3)	48 (9.5)	8 (8.2)	
Nurse practitioner	37 (6.1)	32 (6.3)	5 (5.1)	
Years of education, mean ± SD	17.0 ± 3.9	17.4 ± 3.7	15.0 ± 4.7	< 0.001
Employment status				
Employed	451 (74.8)	386 (76.4)	65 (66.3)	
Self-employed	57 (9.5)	50 (9.9)	7 (7.1)	
Student or intern	37 (6.1)	32 (6.3)	5 (5.1)	
Unemployed	22 (3.6)	10 (2.0)	11 (11.2)	
Receiving welfare support	24 (4.0)	19 (3.8)	6 (6.1)	< 0.001
Prefer not to answer	12 (2.0)	8 (1.6)	4 (4.1)	
Ethnic background				
Aboriginal (North American Indians, Métis or Inuit [Inuk])	3 (0.5)	3 (0.6)	–	
Asian	11 (1.8)	7 (1.4)	5 (5.1)	
Black	14 (2.3)	7 (1.4)	7 (7.1)	
White	538 (89.2)	464 (91.9)	74 (75.5)	
Hispanic	13 (2.2)	10 (2.0)	1 (1.0)	
Other	10 (1.7)	10 (2.0)	7 (7.1)	
Prefer not to answer	15 (2.5)	4 (0.8)	4 (4.1)	–
Living situation				
Living alone or single mother	14 (2.3)	12 (2.4)	1 (1.0)	
Living with a partner or married	578 (95.9)	486 (96.2)	92 (93.9)	
Living with parents or family	11 (1.8)	7 (1.4)	5 (5.1)	0.04
Area of residence				
Urban	271 (44.9)	226 (44.8)	45 (45.9)	
Suburban	256 (42.5)	220 (43.6)	36 (36.7)	
Rural	76 (12.6)	59 (11.7)	17 (17.3)	0.2
Household income, $Can				
<60 000	78 (12.9)	52 (10.3)	26 (26.5)	
60 001–90 000	83 (13.8)	68 (13.5)	15 (15.3)	
90 001–120 000	125 (20.7)	110 (21.8)	15 (15.3)	
120 001–150 000	109 (18.1)	95 (18.8)	14 (14.3)	
>150 001	172 (28.5)	157 (31.1)	15 (15.3)	< 0.001
Prefer not to answer	36 (6.0)	23 (4.6)	13 (13.3)	

Note: SD = standard deviation.
*Unless stated otherwise.
†p values compare the 2 vaccination status categories and were considered significant at < 0.05.
‡Measured using prepregnancy weight.
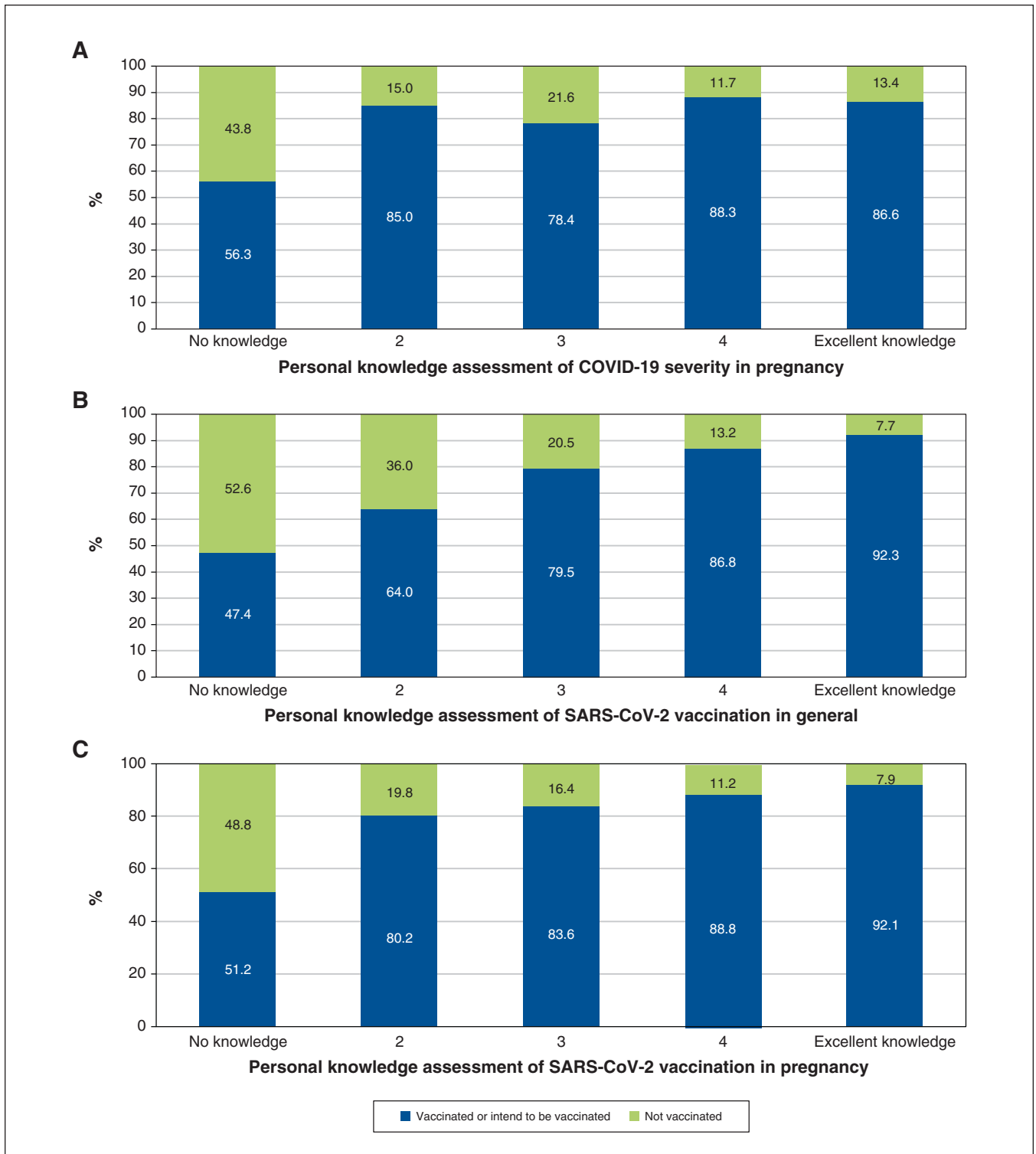§Not mutually exclusive categories.

Figure 2: Personal knowledge assessment of (A) COVID-19 severity in pregnancy, (B) SARS-CoV-2 vaccination in general and (C) SARS-CoV-2 vaccination in pregnancy, stratified by vaccination status. Wilcoxon rank-sum test for differences between groups, $p < 0.01$.

the safety of mRNA SARS-CoV-2 vaccines during pregnancy indicated no significant outcomes among pregnant people who received the vaccine.[38] Nonvaccination associated with a good to excellent self-assessment of knowledge level highlights the priority to address remaining knowledge gaps and

confront the existing misinformation regarding SARS-CoV-2 vaccines. Indeed, while the vaccine validation trials were completed and many studies have provided reassuring SARS-CoV-2 vaccine safety data,[1,38,39] patients mentioned inconsistent arguments to justify their vaccine hesitation, which may

Table 2: Personal experience with COVID-19

Variable	No. (%) of participants		p value*
	Vaccinated or intention to vaccinate n = 505	Not vaccinated n = 98	
Tested for SARS-CoV-2	313 (62.0)	54 (55.1)	0.2
Prevalence of negative test	285 (56.4)	47 (48.0)	0.1
Prevalence of COVID-19	27 (5.3)	7 (7.1)	0.5
Prevalence of positivity among those tested	27 (8.6)	7 (13.0)	0.3
Immediate family members infected with SARS-CoV-2			
None	443 (87.7)	84 (85.7)	
1–5	60 (11.9)	14 (14.3)	
≥ 6	2 (0.4)	–	–
Extended family members and/or friends infected with SARS-CoV-2			
None	250 (49.5)	44 (44.9)	
1–5	211 (41.8)	49 (50.0)	
≥ 6	44 (8.7)	5 (5.1)	0.2

*p values compare the vaccination status categories and were considered significant at < 0.05.

denote the limited access to evidence-based medicine in a constantly evolving and learning science. Additionally, finding 20% of individuals choosing nonvaccination because they perceived their risk of infection to be low highlights the importance of further research to explore context-specific barriers to vaccination in pregnancy.[40]

This study emphasizes the impact of educational strategies on behavioural determinants of health. Our findings suggest that the involvement of the patient in the preventive strategy (namely, vaccination) and the knowledge of the benefits and risks of the therapeutic plan generate better compliance and adherence to national public health recommendations. Since women's health authorities have recommended that pregnant people discuss vaccination decisions with their health care providers,[41,42] these findings emphasize the need for public health messaging and access to educational material (e.g., decisional flowcharts, brief reading material) to improve SARS-CoV-2 vaccination acceptance adapted to each distinct population. Health care providers are the most frequently trusted source of vaccine information and play a key role in shaping maternal attitudes toward vaccination.[43] Although education on the safety of SARS-CoV-2 vaccination in pregnancy is essential, our results show that an alternative approach may be necessary to increase acceptance of SARS-CoV-2 vaccination, especially for those who experience mistrust in the health care system.

This study has several strengths, including a well-established recruitment strategy tailored to our study population and a large sample over an important period during the COVID-19 pandemic.

We measured self-assessed knowledge in lieu of being able to question individuals on their understanding of the vaccines and COVID-19. This parameter is used in the context of understanding personal medical choices, such as vaccination, as it accounts for personal biases and experiences.[27,28] Given that the survey was anonymized, we do not believe this introduced a social-desirability bias.

Data intake was performed electronically, which allowed us to collect data in real time. We ensured the quality of data through complete data cataloguing.

Limitations

Limitations of the study include enrolment, in part, through social media, which may limit generalizability to those less familiar with social media and exclude those with lower socioeconomic status. However, the 2018 Canadian Internet Use Survey showed that more than 80% of Canadian adults aged 18–44 years use social media regularly (and > 90% adults aged 18–34 yr), women predominantly.[44] Additionally, we acknowledge that our participants had higher-than-average household income compared with the Canadian population of the same age. Indeed, in 2019, the median household income for families with children was of $98 690, whereas the median salary bracket of our sample was $120 000–$150 000.[45] As higher household income is thought to be a predictor of vaccine acceptance in the general population, our study population may be more inclined to accept vaccination.[30] However, our recruiting team attempted to provide access to the study to pregnant people across social media groups, as well as through the Montreal Diet Dispensary. Additionally, the high SARS-CoV-2 vaccine uptake in our sample is representative of the vaccination uptake in Canada in the child-bearing age group, which is 88.60% in the 30–39 years age group (at least 1 dose) and 90% in the 18–39 years age group in Quebec.[46]

Table 3: Predictors of vaccination status or intention to be vaccinated

Variable	No. (%) of participants*		Crude OR (95% CI)	Adjusted† OR (95% CI)	Absolute risk difference (95% CI)	Marginal risk difference,‡ % (95% CI)
	Vaccinated or intention to vaccinate n = 505	Not vaccinated n = 98				
Age, yr, mean ± SD	33.6 ± 5.8	32.9 ± 4.7	1.00 (0.97 to 1.05)	0.98 (0.95 to 1.02)	–	–
Prepregnancy BMI, mean ± SD	24.3 ± 5.3	25.0 ± 5.9	0.97 (0.94 to 1.02)	0.99 (0.95 to 1.03)	–	–
Education, yr, mean ± SD	17.4 ± 3.7	15.0 ± 4.7	1.10 (1.05 to 1.16)	1.08 (1.02 to 1.14)	–	–
Household income, Can$						
<60 000	52 (10.3)	26 (26.5)	1.00	1.00	0.00	0.00
60 001–90 000	68 (13.5)	15 (15.3)	2.27 (1.10 to 4.80)	1.94 (0.92 to 4.20)	0.20 (0.03 to 0.37)	8.7 (7.6 to 9.8)
90 001–120 000	110 (21.8)	15 (15.3)	3.06 (1.55 to 6.15)	2.78 (1.39 to 5.66)	0.31 (0.15 to 0.48)	8.7 (7.8 to 9.7)
120 001–150 000	95 (18.8)	14 (14.3)	3.39 (1.65 to 7.22)	2.96 (1.41 to 6.40)	0.30 (0.13 to 0.46)	11.0 (9.8 to 12.2)
>150 001	157 (31.1)	15 (15.3)	5.23 (2.61 to 10.85)	4.32 (2.05 to 9.36)	0.39 (0.23 to 0.54)	10.2 (9.3 to 11.1)
Received an influenza vaccine within the last flu season	203 (40.2)	10 (10.2)	4.90 (2.71 to 9.64)	4.43 (2.32 to 9.25)	0.30 (0.22 to 0.37)	3.2 (3.0 to 3.3)
Area of residence						
Rural	59 (11.7)	17 (17.3)	1.00	1.00	0.00	0.00
Suburban	220 (43.6)	36 (36.7)	1.76 (0.91 to 3.32)	1.45 (0.71 to 2.88)	0.10 (–0.03 to 0.24)	2.5 (2.2 to 2.7)
Urban	226 (44.8)	45 (45.9)	1.47 (0.77 to 2.73)	1.30 (0.64 to 2.52)	0.07 (–0.05 to 0.19)	2.5 (2.2 to 2.8)
Employment status						
Receiving welfare support or unemployed	119 (23.6)	33 (33.7)	1.00	1.00		
Employed	386 (76.4)	65 (66.3)	3.23 (1.68 to 6.03)	2.17 (1.03 to 4.35)	0.10 (0.01 to 0.20)	11.2 (10.6 to 11.9)
Self-assessment of knowledge of COVID-19 severity in pregnancy						
No knowledge	18 (3.6)	14 (14.3)	1.00	1.00	0	0
2	34 (6.7)	6 (6.1)	2.20 (0.64 to 7.82)	1.09 (0.28 to 4.33)	0.35 (0.12 to 0.59)	1.3 (0.9 to 1.7)
3	105 (20.8)	29 (29.6)	1.41 (0.51 to 3.58)	0.80 (0.24 to 2.32)	0.18 (0.03 to 0.33)	–1.1 (–1.7 to –0.6)
4	212 (42.0)	28 (28.6)	2.94 (1.07 to 7.44)	1.51 (0.45 to 4.39)	0.26 (0.11 to 0.40)	3.1 (3.1)
Very knowledgeable	136 (26.9)	21 (21.4)	2.52 (0.89 to 6.58)	1.28 (0.37 to 3.94)	0.28 (0.11 to 0.45)	3.3 (3.2 to 3.4)
Self-assessment of knowledge of SARS-CoV-2 vaccine in general						
No knowledge	9 (1.8)	10 (10.2)	1.00	1.00	0	0
2	16 (3.2)	9 (9.2)	0.99 (0.24 to 3.84)	0.31 (0.04 to 1.71)	0.17 (–0.13 to 0.46)	–8.7 (–11.3 to 6.1)
3	136 (26.9)	35 (35.7)	2.15 (0.63 to 6.67)	0.54 (0.08 to 2.40)	0.16 (0.03 to 0.29)	1.7 (1.5 to 1.8)
4	224 (44.4)	34 (34.7)	3.66 (1.07 to 11.27)	0.92 (0.13 to 4.10)	0.19 (0.06 to 0.32)	4.8 (4.6 to 5.1)
Very knowledgeable	120 (23.8)	10 (10.2)	6.67 (1.78 to 23.57)	1.31 (0.17 to 6.51)	0.43 (0.21 to 0.65)	4.9 (4.6 to 5.2)
Self-assessment of knowledge of SARS-CoV-2 vaccine in pregnancy						
No knowledge	22 (4.4)	21 (21.4)	1.00	1.00	0.00	0.00
2	73 (14.5)	18 (18.4)	2.21 (0.91 to 5.29)	1.02 (0.34 to 2.85)	0.31 (0.13 to 0.49)	9.2 (7.9 to 10.4)
3	153 (30.3)	30 (30.6)	2.78 (1.22 to 6.17)	1.41 (0.49 to 3.71)	0.29 (0.14 to 0.43)	10.2 (9.2 to 11.2)
4	175 (34.7)	22 (22.4)	4.34 (1.86 to 9.92)	2.18 (0.74 to 5.99)	0.38 (0.22 to 0.53)	11.7 (10.5 to 13.0)
Very knowledgeable	82 (16.2)	7 (7.1)	6.39 (2.30 to 19.05)	7.62 (0.75 to 8.66)	0.54 (0.36 to 0.72)	11.5 (10.2 to 12.8)

Note: BMI = body mass index, CI = confidence interval, OR = odds ratio.
*Unless stated otherwise.
†Estimates for each individual variable were adjusted for maternal age, prepregnancy BMI, years of education and annual household income.
‡Marginal risk differences were calculated based on the logistic regression model adjusted for maternal age, prepregnancy BMI, years of education and annual household income.

Lastly, the study design may have biased the selection of participants, preferentially recruiting individuals who were interested in the topic or favourable to vaccination, and who were more concerned about COVID-19; however, our methods did not target influencers, social media groups or news sources that were necessarily more provaccination than others. Of note, most (96.2%) of our study sample was from Quebec. Our study described the vaccine acceptance rate around the time that the mRNA vaccines were promoted.
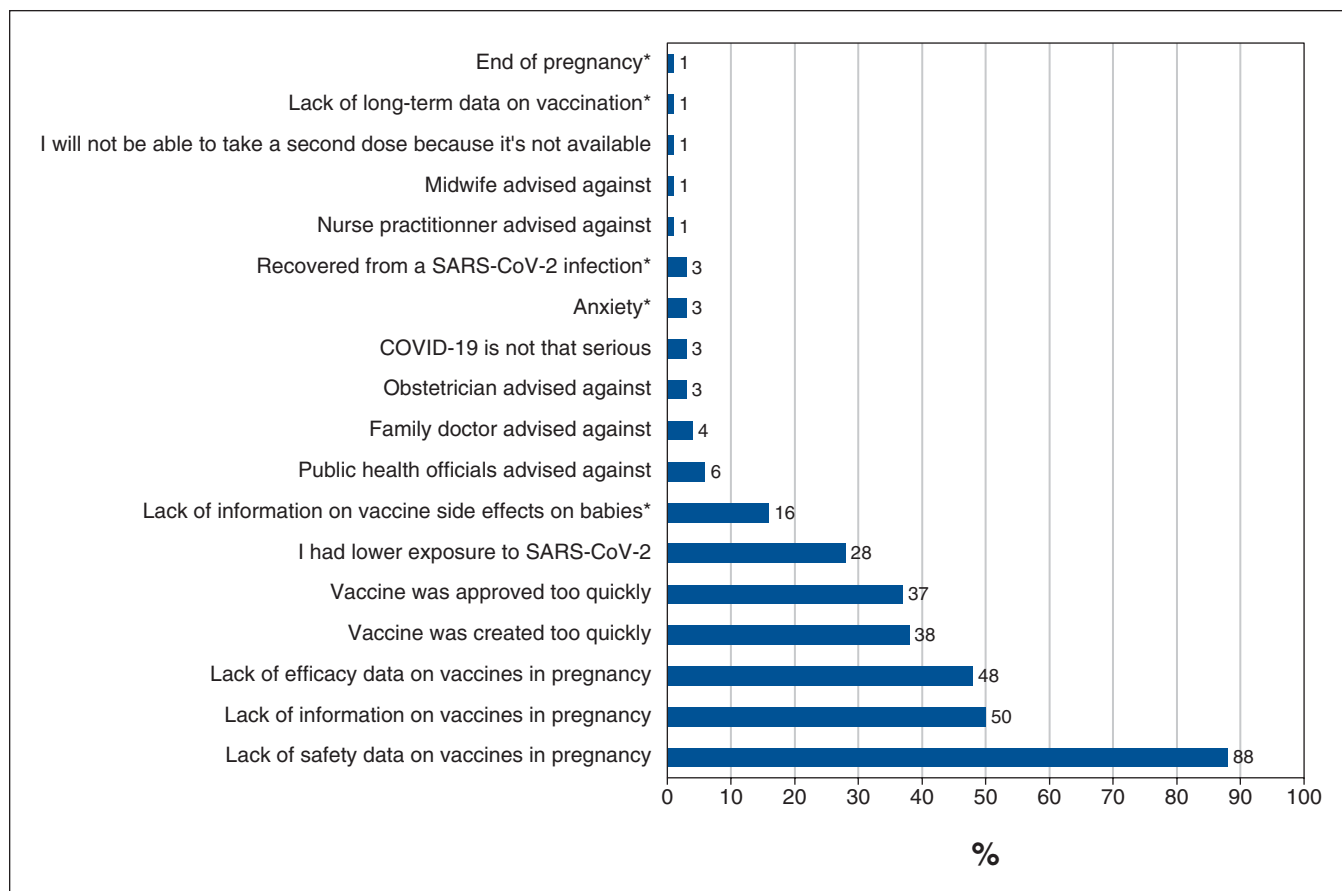
Figure 3: Reasons provided for nonvaccination (*n* = 98). *Reasons reported by participants in addition to those suggested in the survey.

Conclusion

Among the Canadian pregnant people who responded to this study, vaccine uptake against SARS-CoV-2 was high. However, our results underscore the importance of improving knowledge transfer about the efficacy of SARS-CoV-2 vaccines in pregnancy to guide vaccination efforts. Although prolonged monitoring is needed to evaluate late-onset neonatal and childhood outcomes associated with maternal SARS-CoV-2 vaccination, vaccination against SARS-CoV-2 in pregnancy is vital to controlling disease burden and decreasing morbidity in pregnancy. Given the economic, political, social and industrial repercussions, it is essential to consider the epidemiological factors influencing vaccine acceptance and prioritize their impact in public health and knowledge translation strategies. This study highlights the importance of adapted educational approaches to guide public health and research efforts as a key to improve vaccine acceptance in pregnant people. Indeed, the collaborative CONCEPTION study team is working on the development of educational tools and education strategies to reach pregnant people.

References

1. Polack FP, Thomas SJ, Kitchin N, et al.; C4591001 Clinical Trial Group. Safety and efficacy of the BNT162b2 mRNA COVID-19 vaccine. *N Engl J Med* 2020;383:2603-15.
2. Knoll MD, Wonodi C. Oxford-AstraZeneca COVID-19 vaccine efficacy. *Lancet* 2021;397:72-4.
3. Mahase E. COVID-19: Moderna applies for US and EU approval as vaccine trial reports 94.1% efficacy. *BMJ* 2020;371:m4709.
4. Meo SA, Bukhari IA, Akram J, et al. COVID-19 vaccines: comparison of biological, pharmacological characteristics and adverse effects of Pfizer/BioNTech and Moderna vaccines. *Eur Rev Med Pharmacol Sci* 2021;25:1663-9.
5. Krubiner CB, Faden RR, Karron RA, et al. Pregnant women and vaccines against emerging epidemic threats: ethics guidance for preparedness, research, and response. *Vaccine* 2021;39:85-120.
6. Zambrano LD, Ellington S, Strid P, et al.; CDC COVID-19 Response Pregnancy and Infant Linked Outcomes Team. Update: characteristics of symptomatic women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status: United States, January 22–October 3, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1641-7.
7. COVID-19 vaccines and pregnancy: key recommendations and messaging for clinicians. Washington (DC): The American College of Obstetricians and Gynecologists; 2022. Available: https://www.acog.org/-/media/project/acog/acogorg/files/pdfs/clinical-guidance/practice-advisory/covid19vaccine-conversationguide-121520-v2.pdf?la=en&hash=439FFEC1991B7DD3925352A5308C7C42 (accessed 2021 Aug. 6).
8. Poliquin V, Castillo E, Boucoiran I, et al.; Infectious Disease Committee of the Society of Obstetricians and Gynaecologists of Canada. SOGC statement on COVID-19 vaccination in pregnancy. Ottawa: The Society of Obstetricians and Gynaecologists of Canada (SOGC); 2020, revised 2022 Mar. 14. Available: https://sogc.org/common/Uploaded%20files/Latest%20News/SOGC_Statement_COVID-19_Vaccination_in_Pregnancy.pdf (accessed 2021 Aug. 6).
9. Vousden N, Ramakrishnan R, Bunch K, et al. Severity of maternal infection and perinatal outcomes during periods of SARS-CoV-2 wildtype, alpha, and delta variant dominance in the UK: prospective cohort study. *BMJ Med* 202;1:e000053.
10. Infectious Diseases Committee of the SOGC. SOGC statement on the COVID-19 vaccines and rare adverse outcomes of thrombosis associated with low platelets. Ottawa: The Society of Obstetricians and Gynaecologists of Canada (SOGC); 2021. Available: https://www.sogc.org/en/content/featured-news/SOGC_Statement_on_the_COVID-19_vaccines_and_rare_adverse_outcomes_of_%20thrombosis.aspx (accessed 2021 Aug. 6).
11. Recommendations on the use of COVID-19 vaccines. Ottawa: Government of Canada; modified 2022 Jan. 6. Available: https://www.canada.ca/en/public-health/services/immunization/national-advisory-committee-on-immunization-naci/recommendations-use-covid-19-vaccines.html#ap_f (accessed 2021 Aug. 6).

12. COVID-19 ARNm: vaccins à ARN messager contre la COVID-19. Québec: Ministère de la Santé et des Services sociaux; updated 2022 May 11. Available: https://www.msss.gouv.qc.ca/professionnels/vaccination/piq-vaccins/covid-19 -vaccin-a-arn-messager-contre-la-covid-19/ (accessed 2021 Aug. 6).

13. Strategic Advisory Group of Experts on Immunization (SAGE). Report of the SAGE Working Group on vaccine hesitancy. Geneva: World Health Organization; 2014. Available: https://www.asset-scienceinsociety.eu/sites/default/files/sage_ working_group_revised_report_vaccine_hesitancy.pdf (accessed 2021 Aug. 6).

14. Dudley MZ, Limaye RJ, Omer SB, et al. Characterizing the vaccine knowledge, attitudes, beliefs, and intentions of pregnant women in Georgia and Colorado. *Hum Vaccin Immunother* 2020;16:1109-17.

15. Fisher KA, Bloomstone SJ, Walder J, et al. Attitudes toward a potential SARS-CoV-2 vaccine: a survey of U.S. adults. *Ann Intern Med* 2020;173:964-73.

16. Kilich E, Dada S, Francis MR, et al. Factors that influence vaccination decision-making among pregnant women: a systematic review and meta-analysis. *PLoS One* 2020;15:e0234827.

17. King JP, Hanson KE, Donahue JG, et al. Survey of influenza vaccine knowledge, attitudes, and beliefs among pregnant women in the 2016–17 season. *Vaccine* 2020;38:2202-8.

18. Hamel L, Kirzinger A, Muñana C, et al. KFF COVID-19 Vaccine Monitor: December 2020. KFF.org; 2020. Available: https://www.kff.org/coronavirus -covid-19/report/kff-covid-19-vaccine-monitor-december-2020/ (accessed 2021 Aug. 6).

19. Results of the Survey on Vaccination during Pregnancy. Ottawa: Public Health Agency of Canada; modified 2021 Apr. 6. Available: https://www.canada.ca/en/ public-health/services/publications/vaccines-immunization/survey-vaccination -during-pregnancy.html (accessed 2021 Aug. 6).

20. Sulis G, Basta NE, Wolfson C, et al.; Canadian Longitudinal Study on Aging (CLSA) Team. Influenza vaccination uptake among Canadian adults before and during the COVID-19 pandemic: an analysis of the Canadian Longitudinal study on Aging (CLSA). *Vaccine* 2022;40:503-11.

21. Bérard A, Gorgui J, Tchuente V, et al. The COVID-19 pandemic impacted maternal mental health differently depending on pregnancy status and trimester of gestation. *Int J Environ Res Public Health* 2022;19:2926.

22. Pagès N, Gorgui J, Wang C, et al. The impact of COVID-19 on maternal mental health during pregnancy: a comparison between Canada and China within the CONCEPTION cohort. *Int J Environ Res Public Health* 2022;19:12386.

23. Youth-centred digital health interventions: a framework for planning, developing and implementing solutions with and for young people. Geneva: World Health Organization; 2020. Available: https://apps.who.int/iris/bitstream/handle /10665/336223/9789240011717-eng.pdf (accessed 2022 Nov. 10).

24. Ali SH, Foreman J, Capasso A, et al. Social media as a recruitment platform for a nationwide online survey of COVID-19 knowledge, beliefs, and practices in the United States: methodology and feasibility analysis. *BMC Med Res Methodol* 2020;20:116.

25. Ceulemans M, Foulon V, Ngo E, et al. Mental health status of pregnant and breastfeeding women during the COVID-19 pandemic: a multinational cross-sectional study. *Acta Obstet Gynecol Scand* 2021;100:1219-29.

26. Kajdy A, Feduniw S, Ajdacka U, et al. Risk factors for anxiety and depression among pregnant women during the COVID-19 pandemic: a web-based cross-sectional survey. *Medicine (Baltimore)* 2020;99:e21279.

27. Provenzano S, Gentile L, Cuda A, et al. Is there an association between self-reported vaccination knowledge and the immunization behaviour of Health Sciences students. *Ann Ig* 2020;32:223-33.

28. Unadkat MB, Mbuba CK, Ngugi AK, et al. Self-reported knowledge, attitudes, practices and barriers in use of evidence-based medicine among resident physicians in Kenya: a mixed methods study. *BMC Med Educ* 2021;21:537.

29. Estimating a risk difference (and confidence intervals) using logistic regression. Keith Goldfeld; 2021. Available: https://www.rdatagen.net/post/2021 -06-15-estimating-a-risk-difference-using-logistic-regression/ (accessed 2022 June 11).

30. Joshi A, Kaur M, Kaur R, et al. Predictors of COVID-19 vaccine acceptance, intention, and hesitancy: a scoping review. *Front Public Health* 2021;9:698111.

31. Ten threats to global health in 2019. Geneva: World Health Organization. Available: https://www.who.int/news-room/spotlight/ten-threats-to-global -health-in-2019 (accessed 2021 Aug. 6).

32. Vaccination coverage by age, sex, and province or territory. Ottawa: Public Health Agency of Canada; modified 2022 May 30. Available: https://health -infobase.canada.ca/covid-19/vaccination-coverage/#a5 (accessed 2022 Feb. 6).

33. Goncu Ayhan S, Oluklu D, Atalay A, et al. COVID-19 vaccine acceptance in pregnant women. *Int J Gynaecol Obstet* 2021;154:291-6.

34. Levy AT, Singh S, Riley LE, et al. Acceptance of COVID-19 vaccination in pregnancy: a survey study. *Am J Obstet Gynecol MFM* 2021;3:100399.

35. Palamenghi L, Barello S, Boccia S, et al. Mistrust in biomedical research and vaccine hesitancy: the forefront challenge in the battle against COVID-19 in Italy. *Eur J Epidemiol* 2020;35:785-8.

36. Prematunge C, Corace K, McCarthy A, et al. Factors influencing pandemic influenza vaccination of healthcare workers: a systematic review. *Vaccine* 2012;30:4733-43.

37. LaCourse S, John-Stewart G, Adams Waldorf KM. Importance of inclusion of pregnant and breastfeeding women in COVID-19 therapeutic trials. *Clin Infect Dis* 2020;71:879-81.

38. Shimabukuro TT, Kim SY, Myers TR, et al.; CDC v-safe COVID-19 Pregnancy Registry Team. Preliminary findings of mRNA COVID-19 vaccine safety in pregnant persons. *N Engl J Med* 2021;384:2273-82.

39. Male V. Are COVID-19 vaccines safe in pregnancy? *Nat Rev Immunol* 2021; 21:200-1.

40. Qiu X, Bailey H, Thorne C. Barriers and facilitators associated with vaccine acceptance and uptake among pregnant women in high income countries: a mini-review. *Front Immunol* 2021;12:626717.

41. COVID-19 vaccination considerations for obstetric–gynecologic care. Washington (DC): American College of Obstetricians and Gynecologists; 2020. Available: https://www.acog.org/en/clinical/clinical-guidance/practice -advisory/articles/2020/12/covid-19-vaccination-considerations-for-obstetric -gynecologic-care (accessed 2022 June 11).

42. Society for Maternal-Fetal Medicine (SMFM) statement: SARS-CoV-2 vaccination in pregnancy. Washington (DC): SMFM; 2020. Available: https://s3. amazonaws.com/cdn.smfm.org/media/2591/SMFM_Vaccine_Statement_ 12-1-20_(final).pdf (accessed 2021 Aug. 6).

43. Danchin MH, Costa-Pinto J, Attwell K, et al. Vaccine decision-making begins in pregnancy: correlation between vaccine concerns, intentions and maternal vaccination with subsequent childhood vaccine uptake. *Vaccine* 2018;36:6473-9.

44. Schimmele C, Fonberg J, Schellenberg G. Canadians' assessments of social media in their lives. Ottawa: Statistics Canada; modified 2021 Oct. 26. Available: https://www150.statcan.gc.ca/n1/pub/36-28-0001/2021003/article /00004-eng.htm (accessed 2021 Aug. 6).

45. Table 11-10-001201: Distribution of total income by census family type and age of older partner, parent or individual. Ottawa: Statistics Canada; 2021. Available: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1110001201 (accessed 2022 Feb. 8).

46. COVID-19 vaccination in Canada. Ottawa: Public Health Agency of Canada; modified 2022 May 30. Available: https://health-infobase.canada.ca/covid-19/ vaccination-coverage/ (accessed 2022 Feb. 8).

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