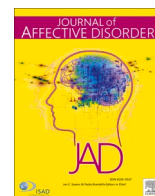




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Fear of COVID-19, mental health, and pregnancy outcomes in the pregnancy during the COVID-19 pandemic study

Fear of COVID-19 and pregnancy outcomes

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ARTICLE INFO

Keywords:

Pregnancy outcomes

COVID-19

Fear

Anxiety

Depression

Birthweight

Pregnancy during the pandemic (PdP)

ABSTRACT

Background: Sustained fear during pregnancy has the potential to increase psychological distress and obstetric risk. This study aimed to (1) identify factors and characteristics associated with fear of COVID-19, (2) investigate the relationship between fear of COVID-19 and maternal anxiety and depression, and (3) determine the relationship between fear of COVID-19 and pregnancy outcomes.

Methods: 9251 pregnant Canadians were recruited between April – December 2020. Participants self-reported (scale of 0–100) the degree of threat they perceived from the SARS-CoV-2 virus in relation to themselves and their unborn baby.

Results: Mean fear scores indicated moderate to elevated concern. In multivariable linear regression, fear of COVID-19 was associated with food insecurity, ethnicity, geographic location, history of anxiety prior to pregnancy, having a chronic health condition, pre-pregnancy BMI, parity, and stage of pregnancy at study enrollment. Higher COVID-19 fear was associated with increased odds of depression, adjusted odds ratio (aOR) = 1.75, $p < 0.001$, 95% CI 1.66–1.85, and anxiety, aOR=2.04, $p < 0.001$, 95% CI 1.94–2.15). Furthermore, fear of COVID-19 was associated with a 192-gram reduction in infant birthweight, and a 6.1-day reduction in gestational age at birth.

Limitations: The sample has higher education compared to the Canadian population and cannot test causal effects.

Conclusion: This study suggests that sociodemographic, health, and obstetric factors may contribute to increased fear of COVID-19 and associated adverse psychological and pregnancy outcomes.

1. Introduction

Outbreaks of infectious diseases, because of their evolving nature and inherent scientific uncertainties, are often accompanied by widespread fear of disease in the general public (Person et al., 2004). Public health countermeasures designed to reduce spread of the disease, such as quarantine, isolation, and physical distancing, may inadvertently heighten fear by increasing the perception of risk (Smith, 2006). Infectious diseases may also generate heightened fear among pregnant individuals because morbidity and mortality are often increased in

pregnant individuals (C. M. Lam et al., 2004), and because recent outbreaks of infectious diseases, such as Zika virus and severe acute respiratory syndrome (SARS), resulted in severe birth defects (Marrs et al., 2016), and poor birth outcomes (e.g., preterm birth; Wong et al., 2004), respectively. During pregnancy, the cardiorespiratory and immune systems undergo significant physiological changes, making pregnant individuals vulnerable to a variety of infections, including COVID-19 (Wastnedge et al., 2021).

Early reports of risks associated with COVID-19 among pregnant individuals suggested that the virus did not pose a more serious threat to

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<https://doi.org/10.1016/j.jad.2021.12.057>

Received 9 August 2021; Received in revised form 19 November 2021; Accepted 18 December 2021

Available online 21 December 2021

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the mother or the fetus compared to non-pregnant individuals (Qiao, 2020). In contrast, more recent reports indicate that although infection rates among pregnant individuals were similar to the general population, infection led to a higher incidence of severe disease (including rates of hospitalization, admission to ICU and the need for mechanical ventilation) in pregnant individuals compared to age matched non-pregnant females (DeBolt et al., 2021; Martinez-Portilla et al., 2021; Sattari et al., 2020). Variants of concern may also play a role in differential risks for pregnant individuals (Funk et al., 2021). Although in utero infection and vertical transmission of COVID-19 appear to be rare (Kotlyar et al., 2020), infection during pregnancy is associated with an increased risk of preeclampsia, preterm birth, stillbirth, and low birth-weight (Mullins et al., 2021; Villar et al., 2021; Wei et al., 2021). As well, co-morbidities such as preeclampsia, gestational diabetes and obesity possibly contributed to an increase in adverse outcomes. These new data suggest that COVID-19 poses a significant health threat to pregnant individuals and their babies.

Pregnancy and birth related fears are relatively common (~25%), with up to 10% of pregnant individuals reporting severe fear that impairs daily activities and the ability to cope with labor and childbirth (Molgora et al., 2018). Fear of childbirth is associated with increased psychological distress and increased risk for poor birth outcomes and less optimal infant development (Ding et al., 2014; Dunkel Schetter and Tanner, 2012; Nilsson et al., 2018; Vismara et al., 2020), yet little is known about the effects of health-related fears, such as fear of COVID-19, on maternal psychological distress or birth outcomes (Ahmad and Vismara, 2021; Ravaldi et al., 2021). This is an important gap because it limits the ability of healthcare providers and health systems to anticipate and rapidly respond to the needs of pregnant individuals when epi- and pandemic infectious diseases arise.

The current COVID-19 pandemic affords a unique opportunity to study fear of infectious disease because of the widespread scope and prolonged duration of the pandemic. However, we anticipate that the lessons learned from the experiences of pregnant individuals during the COVID-19 pandemic will be applicable to future epi- and pandemics. Accordingly, the aims of this study were to (1) identify determinants of COVID-19 fear among pregnant individuals, (2) investigate the relationship between fear of COVID-19 and maternal anxiety and depression symptoms, and (3) determine if fear of COVID-19 is associated with adverse pregnancy outcomes. We hypothesized that fear of COVID-19 would be associated with increased anxiety and/or depression symptoms and increased adverse pregnancy outcomes.

2. Methods

Data from this study come from the Pregnancy During the COVID-19 Pandemic study (PdP), details of which have been previously published (Giesbrecht et al., 2021). The current analysis is based on data collected between April 5, 2020 and December 17, 2020. Briefly, study enrollment, consent, and administration of questionnaires were conducted through Research Electronic Data Capture (REDCap; Harris et al., 2009). At enrollment, participants completed a survey that assessed demographic, socioeconomic, and prior obstetric and health history. Additional measures, as described below, were also completed at this time. This study received ethics approval (REB20–0500) from the University of Calgary Conjoint Health Research Ethics Board on March 26, 2020. All participants were required to voluntarily agree to participate in this study and sign the electronic informed consent form prior to providing any data.

2.1. Participants

Participants were eligible for the PdP study if they were ≥ 17 years, ≤ 35 weeks gestation at study enrollment, living in Canada, and able to read and write in English or French. There were no additional exclusion criteria. Participant recruitment was conducted via social media ads in

both official Canadian languages (French and English).

2.2. Measures

COVID-19 Fear. In the context of pregnancy, the two most salient targets for fear include the pregnant woman herself, because infectious diseases tend to increase morbidity and mortality among pregnant individuals (C. M. Lam et al., 2004), and the fetus, because some recent example of infectious diseases, such as Ebola (Menéndez et al., 2015) and Zika virus (Marrs et al., 2016), had devastating effects on fetal health and survival. Fear of COVID-19 was assessed using the following three items designed to measure the perceived degree of threat to the pregnant participant and the unborn baby: (1) How much do you think your life is in danger during the COVID-19 pandemic?; (2) How much do you think your unborn baby's life is (was) in danger at any time during the COVID-19 pandemic?; and (3) How much are you worried that exposure to the COVID-19 virus will harm your unborn baby? Responses were recorded on a 100-point sliding scale, with the left anchor indicating "Not at all" (0 points), the middle anchor "Somewhat" (50 points), and the right anchor "Very much so" (100 points).

Depression Symptoms. Self-reported depression symptoms within the past 7 days were assessed using the 10-item Edinburgh Postpartum Depression Scale (EPDS; Cox et al., 1987). Each item is scored from 0 to 3, and scores range from 0 to 30 with higher scores indicating more severe symptoms. A cut-off score of ≥ 13 was used to identify women with clinically concerning depression symptoms (Cox et al., 1987). The EPDS is widely used with substantial support for its reliability and validity as a screening measure both during and after pregnancy (Bergink et al., 2011; Kozinsky and Dudas, 2015). Cronbach's alpha in the current study was 0.88.

Anxiety Symptoms. General anxiety symptoms within the past 7 days were assessed using the Patient-Reported Outcomes Measurement Information System (PROMIS®) Anxiety Adult 7-item short form (Pilkonis et al., 2011). As per standard practice, we converted raw scores to T-scores using US general population norms; possible T-scores range from 36.3 to 82.7 with a mean of 50 and a standard deviation of 10. T-scores ≥ 60 indicate elevated anxiety symptoms (Cella et al., 2010; Pilkonis et al., 2011). Cronbach's alpha in the current study was 0.93.

Pregnancy Outcomes. Within two months of delivery, participants were asked to self-report pregnancy outcomes, including birthweight, length, gestational age at birth, delivery mode, whether the delivery resulted in a live birth and whether the infant was admitted to a neonatal intensive care unit (NICU).

Obstetric, health and sociodemographic predictors. Participants self-reported their obstetric history, pre-pregnancy health characteristics, and sociodemographic status in the enrollment survey. Pre-pregnancy BMI was calculated using pre-pregnancy weight and current height. Participants were considered food insecure if, during 2019, they had often or sometimes experienced times that food didn't last and they didn't have money to buy more, or if anyone in the household received food from a food bank, soup kitchen, or other charitable agency in 2019.

2.3. Data analysis

Prior to data analysis, every record was screened to determine that it was a valid record and not produced by a bot or trolls. Records with email addresses that could not be verified, those with unusual responses, and those that provided insufficient data to be considered a participant (must have completed sufficient number of items to calculate at least one outcome measure) were removed from the database. A complete description of screening methods is available by contacting the authors. Data analysis were conducted in SPSS 26.0 software. Descriptive analyses were conducted to characterize the sample. Analysis for Aim 1 used univariable ANOVAs to identify determinants of COVID-19 fear. These individual models were followed by a multivariable ANOVA that included all significant univariate predictors to determine the unique

effects of each predictor.

For Aim 2, univariable and multivariable logistic regression were used to evaluate the contribution of COVID-19 fear to the likelihood of scoring above the established cut-off on measures of anxiety and depression symptoms. We selected covariates *a priori* based upon their potential to confound the association between fear of COVID-19 and anxiety/depression. Specifically, previous studies have shown that individuals with lower income, education, and minority ethnicity experience a greater burden of COVID-19, indicating that COVID-19 is a greater threat to them and may therefore lead to greater fear (Hotz et al., 2020; Sze et al., 2020). At the same time, it is well established that lower income, lower education, and minority ethnicity are also associated with greater psychological distress (J. R. Lam et al., 2019; Williams, 2018). Accordingly, these variables may confound the association between fear of COVID-19 and anxiety/depression. In addition, a history of anxiety and/or depression prior to pregnancy may simultaneously increase perception of threat (i.e., increase self-report of fear) and lead to increased anxiety and/or depression symptoms. Thus, pre-pregnancy history of anxiety/depression was also included in the adjusted model.

For Aim 3, associations between fear of COVID-19 and pregnancy outcomes were investigated using linear regression for continuous outcomes (birthweight, length, gestational age at birth) and logistic regression for categorical outcomes (preterm birth, live birth, delivery mode, being admitted to the neonatal intensive care unit (NICU)). Univariable models were conducted first (fear as the only predictor) to determine the total effect of COVID-19 fear on pregnancy outcomes. This was followed by adjusted analyses which included potential confounders of association between COVID-19 fear and pregnancy outcomes. Lower income, education, and minority ethnicity may simultaneously lead to increased fear of COVID-19 (as indicated above) and to increased adverse pregnancy outcomes (Olson et al., 2010), suggesting that these variables have the potential to confound the association between COVID-19 fear and pregnancy outcomes (Messer et al., 2008; Olson et al., 2010; Parker et al., 1994).

We also conducted sensitivity analyses to determine whether fear of COVID-19 was associated with pregnancy outcomes over and above other factors with known effects on pregnancy outcomes. Sensitivity analysis included the potential confounders noted above (income, education, and ethnicity) along with pre-pregnancy health conditions (including hypertension, asthma, type 1 or type 2 diabetes, and obesity), obstetric factors (including gestational hypertension, preeclampsia, and parity), and mental health factors (including anxiety and depression symptoms during pregnancy), all of which have previously been established as predictors of pregnancy outcomes.

To account for testing multiple outcomes, we controlled the familywise error rate using a Bonferroni correction. Although this approach tends to be very conservative with respect to type-1 error, our sample was sufficiently large to expect that effects of clinical interest would survive this correction. Critical p-values were adjusted as follows: Aim 1 $p < 0.003$, Aim 2 $p < 0.025$, and Aim 3 $p < 0.008$.

3. Results

3.1. Participants

A total of 9251 pregnant individuals provided data for the PdP study between April 5 and December 17, 2020. Data were missing on the fear of COVID-19 items for 736 participants (8%), making the sample size for the Aim 1 and 2 analyses 8515. Analysis of baseline characteristics for those included in the analyses ($n = 8515$) and those not included ($n = 736$) showed that those not included were slightly younger, (31.2y versus 31.9y), had more previous children (0.65 versus 0.55), had less education (college certificate versus university degree), had lower income ($< \$100,000$ versus $> \$100,000$), and fewer had a history of anxiety prior to pregnancy (21% versus 41%), but did not differ on pre-pregnancy BMI, previous pregnancy complications, previous preterm

birth, marital status, or province of residence. For Aim 3 ($n = 2756$), the sample size was necessarily limited to those who had given birth by December 17, 2020. According to their due dates, we expected 6270 deliveries by this date. However, because of the sequencing of questionnaires, some participants did not receive a delivery questionnaire until 1 - 3 months after their baby was born. This affected 2746 individuals with an expected delivery prior to December 17, 2020 but who did not have an opportunity to report their delivery by this date. Analysis of baseline characteristics for those included in Aim 3 ($n = 2756$) compared to the complete sample for Aims 1 and 2 shows strong similarities, see Table 1. Of note, fewer Aim 3 participants were from Quebec and more were White compared to the full sample. In addition, fewer were initially recruited in the first trimester, reflecting the fact that many first trimester individuals had due dates later than December 17, 2020.

Overall, nearly half were primigravida and more than half were nulliparous. Participants were from every province and territory in Canada. The majority were married or cohabitating with a partner. Most participants self-identified as White/Caucasian. Most participants reported completing education beyond high school. Median household before tax income was between \$100,000-\$124,999 CDN/year.

Of the 2756 participants who reported a delivery, 2657 resulted in a live delivery and 99 resulted in miscarriage or neonatal death. Twins ($n = 45$ sets) were not included in birth outcome analysis because data for each twin is not independent of the other twin. The majority of births (92.7%) took place in a hospital, with the remaining at home (5.4%), at a birth center (1.7%), or other (0.2%).

41 participants (in the total sample of 9251) had confirmed COVID-19 infections during pregnancy, 38 of these reporting that infection was confirmed with an official COVID-19 test. An additional 220 pregnant individuals reported suspected but unconfirmed infection.

3.2. Fear of COVID-19

Mean and median scores on the three fear of COVID-19 items fell in the middle portion of the scale, indicating that participants felt 'somewhat' fearful of the coronavirus (see Table 2). Participants reported relatively less fear regarding their own health compared to the health of their baby. The three items had moderately strong inter-correlations ($r = 0.55 - 0.74$) and Cronbach's alpha for the 3 items was 0.85, suggesting that the three items assess a common construct. To further evaluate the factorial composition of the 3 items, we conducted a confirmatory factor analysis in MPlus 8.1 software (Muthén and Muthén, 2017). This analysis confirmed excellent fit for a single factor, indicating that the three items comprise a single construct (see Supplemental Figure 1). Accordingly, we calculated the mean of the three items as a summary measure of COVID-19 fear. To aid with interpretation of the findings, we first standardized (z-score transformed) each item before taking the mean. The resulting variable has a mean of zero and a standard deviation of 1, with scores above zero indicating above average fear and scores below zero indicating below average fear.

3.3. Determinants of COVID-19 fear

SARS CoV-2 infection. Self-reported infection with the SARS CoV-2 virus was not associated with fear of COVID-19, $F(8514, 2) = 0.42$, $p = 0.66$. Likewise, infection of a household member, or someone within the participant's close circle of friends and family was not associated with fear of COVID-19, $F(8514, 1) = 0.06$, $p = 0.81$ and $F(8511, 1) = 2.40$, $p = 0.12$, respectively.

Obstetric characteristics. COVID-19 fear differed by parity, $F(8514, 2) = 5.01$, $p < 0.0001$, with nulliparous participants reporting higher fear ($M = 0.03$) than primiparous ($M = -0.02$) or multiparous ($M = -0.11$) participants. Fear also differed by trimester during which participants completed the enrollment survey, $F(8513, 2) = 16.28$, $p < 0.0001$, with first trimester participants reporting less fear ($M = -0.11$) compared to

Table 1
Participant sociodemographic characteristics.

	Full Sample (Aims 1 & 2) N= 9251		Pregnancy Outcomes Sample (Aim 3) N= 2756	
	M (SD)	Range	M (SD)	Range
Maternal Age (years)	31.8 (4.4)	17.9 – 50.5	32.8 (4.2)	18.6–49.0
Pregnancy Outcomes				
Birthweight (grams)			3418.4 (539.6)	314.7 – 5600
Length at birth (cm)			50.7 (4.6)	18.0 – 70.0
Gestational age at birth (weeks)			38.9 (1.9)	24 - 43
	n	%	n	%
Gravida ^a				
Primigravida	4283	46.3	1164	45.7
Multigravida	4967	53.7	1384	54.3
Parity ^b				
Nulliparous	5257	56.8	1441	56.6
Primiparous	2762	29.9	779	30.6
Multiparous	1211	13.1	324	12.7
Missing	20	0.2	0.2	0.2
Trimester of pregnancy at study enrollment				
First	2055	22.2	173	6.8
Second	4332	46.8	1132	44.4
Third	2861	30.9	1243	48.8
Pre-pregnancy BMI class				
Underweight	283	3.1	71	2.8
Normal weight	4416	47.7	1245	48.9
Overweight	2371	25.6	634	24.9
Obese	2048	22.1	569	22.3
Missing	133	1.4	29	1.1
Marital Status				
Single	345	3.7	60	2.4
Married	5875	63.5	1891	74.2
Cohabiting	2973	32.1	588	23.1
Divorced	17	0.2	5	.2
Widowed	1	0.01	1	.0
Separated	37	0.4	3	.1
Missing	3	0.03	0	0
Education				
Doctoral Degree (PhD, MD, etc.)	680	9.3	275	10.8
Master's Degree	1667	18.0	577	22.6
Bachelor's degree	3641	39.4	1059	41.6
Completed Trade/ Technical Degree	2360	25.5	493	19.3
Completed High School Diploma	789	8.5	138	5.4
Less Than High School Diploma	113	1.2	6	.2
Missing	1	< 0.01	0	0
Ethnicity				
White (Caucasian)	7508	81.2	2191	86.0
Aboriginal (First Nations, Metis, Inuit)	243	2.6	35	1.4
Black	119	1.3	30	1.2
Chinese	129	1.4	37	1.5
Filipino	113	1.2	24	.9
Korean	17	0.2	6	.2
Asian	326	3.5	76	3.0
Hispanic/Latinx	192	2.1	50	2.0
Mixed race or other	443	4.8	99	3.9
Missing	161	1.7	0	0
Annual Household Income				
\$200,000+/Year	902	9.8	326	12.8
\$175,000 – \$199,999/Year	576	6.2	199	7.8
\$150,000 – \$174,999/Year	999	10.8	350	13.7
\$125,000 – \$149,999/Year	1192	12.9	366	14.4
\$100,000 – \$124,999/Year	1718	18.6	507	19.9
\$70,000 – \$99,999/Year	1793	19.4	446	17.5
\$40,000 – \$69,999/Year	1186	12.8	240	9.4
\$20,000 – \$39,999/Year	512	5.5	91	3.6
Less Than \$20,000/Year	215	2.3	23	.9
Missing	158	1.7	0	0
Province/Territory				

Table 1 (continued)

	Full Sample (Aims 1 & 2) N= 9251		Pregnancy Outcomes Sample (Aim 3) N= 2756	
	M (SD)	Range	M (SD)	Range
British Columbia	1347	14.6	409	16.1
Alberta	1926	20.8	690	27.1
Saskatchewan	264	2.9	82	3.2
Manitoba	376	4.1	25	1.0
Ontario	2598	28.1	792	31.1
Quebec	2201	23.8	360	14.1
New Brunswick	135	1.5	25	1.0
Prince Edward Island	38	0.4	8	.3
Nova Scotia	209	2.3	54	2.1
Newfoundland	93	1.0	25	1.0
Yukon	39	0.4	10	.4
Northwest Territories	20	0.2	9	.4
Nunavut	3	0.04	0	0
Missing	2	<0.01	0	0
Delivery Mode				
Vaginal			1787	69.2
Caesarean			795	30.8
Neonatal death/miscarriage			99	3.6
Admission to NICU			245	9.5

^a Primigravida – pregnant for the first time; Multigravida – has been pregnant more than once.

^b Nulliparous – has not given birth previously; primiparous – has given birth once; multiparous – has given birth more than once.

Table 2

Descriptive data for fear variables.

	Mean (SD)	Median	Pearson Correlation		
			1.	2.	3.
1. Threat to own life	42.9 (25.4)	47	–		
2. Threat to baby's life	51.4 (26.5)	50	0.68	–	
3. Harm to baby	62.8 (27.0)	67	0.55	0.74	–

Note: Fear items were measured on a 100-point scale.

participants in the second ($M = 0.03$) or third ($M = 0.04$) trimesters. Previous history of pregnancy complication (miscarriage or preterm birth) was not significantly associated with increased fear, $F(8514, 1) = 3.00, p = 0.08$.

Pre-pregnancy health conditions. Participants with a chronic health condition (e.g., diabetes, hypertension) prior to pregnancy had higher fear scores compared to participants without a chronic condition, $F(8514, 1) = 70.46, p < 0.0001$. History of anxiety prior to the pandemic was associated with increased fear, $F(8514, 1) = 169.70, p < 0.0001$. Pre-pregnancy BMI was associated with fear such that normal weight individuals had the lowest fear ($M = -0.10$) followed by overweight ($M = 0.01$), underweight ($M = 0.12$) and obese ($M = 0.19$) individuals, $F(8402, 3) = 33.97, p < 0.0001$.

Sociodemographic factors. Household income was associated with fear, $F(8514, 8) = 14.03, p < 0.0001$, such that individuals with the lowest household income had the highest fear scores ($M = 0.35$), and there was a linear decrease in fear for each higher income bracket ($M = -0.15$ for the highest income bracket). Likewise, food insecurity was associated with increased fear, $F(8514, 1) = 137.86, p < 0.0001$. Individuals with the least education reported the highest fear ($M = 0.25$ for those without a high school education), and there was a linear decrease in fear for each additional education level such that those with the highest education (professional degrees/doctorates) reported the least fear ($M = -0.15$), $F(8514, 2) = 1520, p < 0.0001$. After Bonferroni correction, marital status was not significantly associated with fear, $F(8514, 2) = 6.51, p = 0.01$. Being an immigrant was associated with increased fear, $F(8514, 1) = 54.29, p < 0.0001$, as was self-identified ethnicity, $F(8514, 12) = 28.01, p < 0.0001$, with White participants reporting the least fear ($M = -0.07$). Geographic location was also associated with fear, $F(8514, 12) = 6.04, p < 0.0001$, with those in Newfoundland, Saskatchewan and Manitoba

reporting the highest levels of fear ($M = 0.11$ to 0.19) and those in the Northern territories (Yukon, Nunavut and Northwest Territories) reporting the least ($M = -0.22$ to -0.56).

Pandemic phase. To estimate differences in fear over time, we binned data into 1-month segments. There was an overall decrease in fear over time with highest fear in April 2020 ($M = 0.07$) and lowest fear in October 2020 ($M = -0.17$) and December 2020 ($M = -0.12$), $F(8514, 6) = 5.04$, $p < 0.0001$. November 2020, corresponding to the start of the second wave of coronavirus infections in Canada, was an exception where levels of fear were significantly higher ($M = 0.02$) compared to both October and December.

Multivariable Linear Regression Analysis. Given that some determinants of fear may explain overlapping variance in COVID-19 fear, we conducted a multivariable analysis including all variables that were significant in univariable analyses. Tests of multicollinearity indicated that the variables were not multicollinear (all variance inflation factors were well below 10). Factors that remained independent predictors of fear included: trimester, parity, pre-pregnancy BMI, chronic health condition, history of anxiety prior to pregnancy, geographic location, food insecurity, ethnicity, and education (see supplementary Table 1 and supplementary Figure 2 for complete results). Factors that did not remain significant (after Bonferroni correction) in the multivariable model included household income, pandemic phase, and being an immigrant to Canada. The multivariable model explained 9% of the variance in fear of COVID-19.

3.4. Associations between fear of COVID-19 and maternal anxiety and depression symptoms

Mean (SD) scores for depression and anxiety symptoms at study enrollment were 10.2 (5.44) and 58.2 (8.32), respectively. 29.5% ($n = 2724$) of participants scored above the cut-off for depression and 41.9% ($n = 3873$) were above the cut-off for anxiety symptoms. Logistic

regression analyses of COVID-19 fear (predictor) in relation to clinically elevated anxiety and depression symptoms (outcomes) indicated significant associations for both outcomes. The odds for clinically elevated depression symptoms were 1.9 times higher for each standard deviation increase in fear of COVID-19, odds ratio (OR) = 1.89, 95% CI 1.80–1.99, $p < 0.001$. The odds for clinically elevated anxiety symptoms were 2.1 times higher for each standard deviation increase in fear of COVID-19, OR = 2.14, 95% CI 2.03–2.25, $p < 0.001$.

In adjusted analysis, we included potential confounders: minority ethnicity, education, income, and history of anxiety or depression prior to pregnancy. The odds for clinically elevated depression symptoms were 1.8 times higher for each standard deviation increase in fear, adjusted odds ratio (aOR) = 1.75, 95% CI 1.66–1.85, $p < 0.001$. Comparing individuals with the highest fear to those with the least fear, there was an 8.4-fold increase in the odds of scoring ≥ 13 on the EPDS. The odds for clinically elevated anxiety symptoms were 2 times higher for each standard deviation increase in fear, aOR=2.04, 95% CI 1.94–2.15, $p < 0.001$. Comparing individuals with the highest fear to those with the least fear, there was a 9.8-fold increase in the odds of scoring above the cut-off on the PROMIS anxiety measure. Increase in classification accuracy for the depression and anxiety models with predictors versus no predictors was 5.1% and 16%, respectively. Complete model results are reported in Supplemental Table 2.

3.5. Associations between fear of COVID-19 and pregnancy outcomes

Univariable (unadjusted) and multivariable (adjusted) models (linear regression for continuous outcomes and logistic regression for binary outcomes) were used to determine the associations between COVID-19 fear and pregnancy outcomes. Covariates for adjusted models were selected *a priori* (as indicated above). Complete model results are reported in Table 3.

Birthweight. Fear of COVID-19 was associated with reduced

Table 3
Unadjusted, adjusted and sensitivity regression model results for pregnancy outcomes.

	Birthweight (g)		Length at birth (cm)		Gestational age at birth (weeks)	
	Unstandardized Coefficient (SE)	Standardized coefficient	Unstandardized Coefficient (SE)	Standardized coefficient	Unstandardized Coefficient (SE)	Standardized coefficient
Unadjusted Models						
Constant	3417.35 (10.7)		50.67 (0.09)		38.95 (0.04)	
Fear	-40.09 (11.0)*	-0.07	-0.28 (0.09)*		-0.18 (0.04)*	-0.09
Model R ²	0.01		0.004		0.01	
Adjusted Models						
Constant	3680.18 (58.5)		51.05 (0.50)		39.21 (0.20)	
Fear	-31.35 (11.2)*	-0.06	-0.22 (0.10)	-0.05	-0.16 (0.04)*	-0.09
Ethnic minority	-191.49 (31.1)*	-0.12	-0.79 (0.27)*	-0.06	-0.27 (0.11)	-0.05
Income	-3.33 (5.7)	-0.01	.08 (0.05)	.03	-0.02 (0.02)	-0.03
Education	-6.34 (11.2)	-0.01	.03 (0.10)	.01	.04 (0.04)	.02
Model R ²	0.02		0.01		0.01	
Sensitivity Models						
Constant	3637.82 (123.4)		51.82 (1.07)		39.79 (0.42)	-0.07
Fear	-21.16 (12.1)	-0.04	-0.13 (0.10)	-0.03	-0.13 (0.04)*	-0.06
Ethnic minority	-188.77 (31.0)*	-0.12	-0.81 (0.27)*	-0.06	-0.30 (0.11)*	-0.03
Income	-3.94 (5.7)	-0.02	.07 (0.05)	.03	-0.03 (0.12)	.01
Education	-3.62 (11.2)	-0.01	.02 (0.10)	.01	.02 (0.04)	-0.06
Chronic health condition	5.26 (26.6)	.004	-0.25 (0.23)	-0.02	-0.27 (0.09)*	-0.11
Obstetric complications	-129.32 (43.1)*	-0.06	-0.60 (0.37)	-0.03	-0.84 (0.15)*	-0.03
Parity	99.35 (15.1)*	.13	.30 (0.13)	.05	-0.08 (0.05)	-0.01
Depression symptoms	-3.23 (3.4)	-0.03	-0.02 (0.03)	-0.02	-0.002 (0.01)	-0.02
Anxiety symptoms	0.28 (2.2)	.004	-0.01 (0.02)	-0.02	-0.004 (0.01)	-0.07
Model R ²	0.04		0.01		0.03	

* $p < 0.008$.

birthweight, $B = -40.09$, $p < 0.001$, indicating a 192-gram reduction in birthweight for individuals with the highest fear compared to those with the lowest fear. In adjusted analysis, COVID-19 fear remained a significant predictor after controlling for potential confounders (education, income, minority ethnicity), $B = -31.35$, $p = 0.005$. In sensitivity analysis, adjusting for additional variables previously established as predictors of pregnancy outcomes (pre-pregnancy health conditions, obstetric factors, and mental health factors as described above), the effect for fear of COVID-19 was reduced, $B = -21.16$, $p = 0.08$, indicating that fear of COVID-19 did not have a unique association after controlling for other known predictors of birthweight. The final model explained 4% of the variance in birthweight.

Length at birth. Fear of COVID-19 was associated with reduced length at birth, $B = -0.28$, $p = 0.003$, indicating a 1.3 cm reduction in birth length for individuals with highest fear compared to individuals with lowest fear. After adjusting for potential confounding by education, income, minority ethnicity, the effect was reduced, $B = -0.22$, $p = 0.02$ (which is no longer statistically significant after Bonferroni correction), and inclusion of pre-pregnancy health conditions, obstetric factors and mental health factors suggested that fear of COVID-19 does not have a unique effect over and above other included variables, $B = -0.13$, $p = 0.23$. The final model explained 1% of the variance in birth length.

Gestational age at birth. Fear of COVID-19 was associated with a reduction in gestational age at birth, $B = -0.18$, $p < 0.001$, indicating a 6.1-day reduction in gestational age at birth for individuals with the highest fear compared to individuals with the least fear. After controlling for potential confounders (education, income, minority ethnicity), the effect was slightly attenuated, but still significant $B = -0.16$, $p < 0.001$. The effect for gestational age also remained significant in sensitivity analyses, $B = -0.13$, $p = 0.002$ controlling for confounders, pre-pregnancy health conditions, obstetric factors, and mental health factors (as described above). The final model explained 3% of the variance in gestational age. A binary logistic regression to determine if fear of COVID-19 increased the odds of delivery at < 37 weeks gestation was not significant, OR 1.15, 95% CI 0.98–1.34, $p = 0.09$.

Live birth. Fear of COVID-19 was not associated with an increase in the odds of neonatal death or miscarriage, OR = 0.98, 95% CI 0.80–1.21, $p = 0.88$. Adjusting for potential confounders yielded essentially the same result aOR = 0.97, 95% CI 0.78–1.20, $p = 0.76$.

Delivery mode. Fear of COVID-19 was not associated with an increase in the odds of cesarean section delivery, OR = 1.07, 95% CI 0.98–1.17, $p = 0.11$. Adjusting for potential confounders yielded essentially the same result aOR = 1.07, 95% CI 0.98–1.17, $p = 0.13$.

NICU. Fear of COVID-19 was not associated with an increase in the odds of NICU hospitalization, OR = 1.12, 95% CI 0.98–1.29, $p = 0.10$. Adjusting for potential confounders yielded essentially the same result aOR = 1.11, 95% CI 0.97–1.28, $p = 0.13$.

4. Discussion

Most pregnant individuals in a pan-Canadian cohort reported moderate to high levels of fear that COVID-19 was a threat to their health and the health of their baby. This finding is consistent with a small previous study reporting moderate to high worry about maternal and fetal health among pregnant individuals during the COVID-19 pandemic (Corbett et al., 2020) and a large population-based study in the United States showing that COVID-19 fear was clearly linked to both depression and anxiety symptomatology (Fitzpatrick et al., 2020). Furthermore, this finding is consistent with generally elevated levels of anxiety and depression previously reported in our cohort (Lebel et al., 2020), and other cohorts (Tomfohr-Madsen et al., 2021), and with the associations between fear of COVID-19 and anxiety and depression symptoms that we observed in the current analysis. Each standard deviation increase in fear of COVID-19 resulted in a 2-fold increase in the odds of scoring above the established clinical cut-offs on the EPDS and PROMIS Anxiety measures. Across the range of the scores observed on the fear of

COVID-19 measure, this represents an 8 to 10-fold increase in the odds of scoring above the clinical cut-offs, indicating the relevance of COVID-19 fear to important mental health outcomes. It is known that sustained fear can act as a stressor that amplifies risk for mental health concerns (Maeng and Milad, 2017).

The potential for significant mental health problems amongst pregnant individuals is an urgent public health concern, not only for the health of pregnant individuals but also for the health of their babies. For example, prenatal anxiety is associated with shorter gestation and has adverse implications for fetal neurodevelopment and child outcomes (Dunkel Schetter and Tanner, 2012). Fear of COVID-19 is therefore a significant long-term public health concern, not only as a function of its mental health consequences for pregnant individuals (which may be short- or long-term) but also because the effects on child development will unfold over the lifespan of the children born during this pandemic (Hagemann et al., 2021; Roseboom et al., 2021).

Our analysis of the factors associated with fear suggests that a broad range of obstetric, sociodemographic, and health characteristics may contribute to increased COVID-19 fear. Lower socioeconomic standing, minority ethnicity and having a chronic health condition were recognized early in the pandemic as relevant to increased risk for infection and severe disease (Garg et al., 2020). Our data may reflect the unintended consequences of public health information about factors that increase the risk for COVID-19 disease because our data show that fear of COVID-19 was highest amongst individuals at greater risk of infection and morbidity. For example, we observed a clear inverse gradient of COVID-19 fear across income and education categories, and positive associations with being an immigrant or a racialized individual (although this effect was not statistically significant after Bonferroni correction). Also consistent with previous studies demonstrating increased risk for more severe disease among individuals with chronic health conditions, pregnant individuals with a chronic health condition had greater fear of COVID-19 than healthy individuals.

Our findings also suggest that, beyond risk factors, optimal health may be a protective factor against COVID-19 fear. For example, being either underweight or overweight prior to pregnancy was associated with higher COVID-19 fear. Surprisingly, direct experience with COVID-19, either through infection of the pregnant participant or close family and friends, was not associated with fear of COVID-19, suggesting that perceived threat was not being driven by proximity to the virus or personal experiences of loss associated with the virus. Note, however, that the sample size of infected individuals in our cohort was small ($n = 44$), suggesting caution when interpreting this result. Taken together, the findings may suggest that public health data related to COVID-19, although essential to formulating an appropriate public health response, may also inadvertently contribute to increased fear among individuals who see themselves as being at greater risk for infection or severe disease. And while increased fear may increase the uptake of appropriate precautionary health-related behavior (Corbett et al., 2020; Pakpour and Griffiths, 2020), it may also increase risk for poor mental health and poor pregnancy outcomes.

Geographic differences in fear cannot easily be explained by the regional severity of the pandemic. By mid-December 2021, the provinces reporting the highest COVID-19 fear, Newfoundland, Saskatchewan and Manitoba, did not have the highest per-capita number of cases or deaths, although Saskatchewan and Manitoba were among the highest. Newfoundland, in contrast, had some of the lowest per-capita number of cases and deaths, although government restrictions in the Maritime provinces were quite stringent. Interestingly, a study in the United States found that rates of COVID-19 fear were highest in the Northeastern states, which are proximally close to the Canadian Maritime provinces (Fitzpatrick et al., 2020). The authors of that study suggested that higher COVID-19 fear in this region might be related to higher number of cases. In our study, Quebec had the highest per-capita cases and deaths by mid-December 2020, yet this province had one of the lowest levels of COVID-19 fear. Further investigation is required to

understand what might be driving these regional differences in COVID-19 fear.

Maternal recall of pregnancy outcomes is excellent within the first few months postpartum and a valid source of information for research purposes (Bat-Erdene et al., 2013). The increased risk for poor pregnancy outcomes we observed in those with elevated COVID-19 fear is consistent with a large body of literature showing that prenatal anxiety is associated with shorter duration of gestation and lower birthweight (Dunkel Schetter and Tanner, 2012; Grigoriadis et al., 2018). This may suggest common pathways by which fear and anxiety increase risk for poor pregnancy outcomes. And while this speculation is consistent with our data, it is important to note that, at least with regard to gestational age at birth, COVID-19 fear remained a significant predictor even after accounting for anxiety and depression and other relevant covariates. This suggests that fear of COVID-19 contributes to adverse birth outcomes over and above the effects attributed to maternal mental health and sociodemographic variables. That is, the mechanisms by which fear of COVID-19 contributes to pregnancy outcomes are at least somewhat distinct from the ways in which maternal mental health and sociodemographic factors contribute to pregnancy outcomes. Previous work on stress and pregnancy-related anxiety suggest that the mechanisms by which fear may alter pregnancy outcomes are complex and multi-level, including neuroendocrine, immune and behavioral pathways (Dunkel Schetter, 2009). Understanding the mechanisms by which health-related fears contribute to adverse pregnancy outcomes is an important area of future investigation.

Fear caused by communicable diseases are a relevant threat to maternal and child health, and as such they deserve focussed attention to support global efforts to improve maternal and child health. Although the effects of COVID-19 fear on pregnancy outcomes in our sample were small, even modest effects can be consequential over time or when widespread in the population. For example, even within the gestational ages that are considered a term pregnancy (≥ 37 weeks) a few days of additional gestational duration is significantly associated with larger brain volumes, which has direct implications for children's neurodevelopment (El Marroun et al., 2020).

Infection in pregnancy, leading to adverse fetal outcomes, is often more concerning when the infection occurs in the first trimester. For example, cytomegalovirus (CMV) or varicella in pregnancy have higher rates of congenital anomalies when the primary infection occurs in the first trimester as compared to the third trimester (Hollier and Grissom, 2005). Early in the pandemic, it was not known whether SARS-CoV-2 was associated with fetal congenital anomalies. Accordingly, practitioners had increased concern about early pregnancy infections. In contrast to the focus of concern in early pregnancy among health-care providers, the reported COVID-19 fear among participants was higher in the second and third trimester. This may reflect participant concerns about labor and delivery, which become increasingly prominent as pregnancy progresses. Anecdotally, according to the clinical members of our research team, concerns about labor and delivery were the most common questions posed by pregnant patients (e.g., "Will I have to be alone, or can my partner still come to the delivery" or "Will I have to wear a mask while I'm pushing?"). Maternity patients found the constant change in restrictions and regulations very unsettling. The findings of our study, coupled with our clinical experience, suggest that fear of health consequences related to COVID-19 are only part of the concern for pregnant individuals, to which are added concerns about giving birth during the time of a pandemic.

Despite the undesirable outcomes associated with increased COVID-19 fear, it is important to recognize that fear is an adaptive emotion with the goal of protecting against potential threats. Fear in this adaptive sense may increase willingness to engage in health behaviors that contribute to decreases in the spread of the coronavirus (e.g., regular handwashing, conscientious physical distancing; Corbett et al., 2020; Pakpour and Griffiths, 2020). As such, fear of COVID-19 may also contribute to positive health outcomes, and to the extent that fear of

COVID-19 fear is highest in the most vulnerable individuals (as is suggested by our data), these high levels of fear may confer the greatest benefit to such individuals. A relevant question for future research is how to maximize the potential health benefits of health-related fears while at the same time decreasing its potential for harm.

5. Strengths and limitations

The study findings are based on a large and diverse pan-Canadian sample of pregnant individuals, including questionnaires in both French and English. Data collection began within 3 weeks after the WHO declared the pandemic and continued over the course of seven months, allowing us to measure changes as the pandemic progressed from its early to later stages, including the impact of a second wave. The longitudinal follow-up of the sample allowed us to examine the associations between COVID-19 fear and pregnancy outcomes. These unique features of the study generate invaluable insights into the effects of the pandemic on pregnant individuals, which provide a basis not only for public health response to the current needs of pregnant and postpartum individuals, but also for planning future responses to a public health emergency.

Despite these strengths, the study has several limitations. First, although we obtained a large and diverse sample, the majority of the sample identified as White, relatively well educated, and with relatively high annual household income. These characteristics limit the application of the study findings to populations with greater sociodemographic risks. Nevertheless, and bearing in mind that females of child-bearing age will differ somewhat from the overall Canadian population characteristics, our sample is similar to the Canadian population as a whole. In Canada, median annual household income is \sim \$90,000 CAD compared to \sim \$100,000 in our sample; 22.6% of individuals are visible minorities compared to 18.8% in our sample, and 40.7% of adult females have a bachelor degree or higher compared to 64.7% in our sample (Statistics Canada, 2016). These comparisons suggest that our sample has higher education than the Canadian population as a whole, but similar income and minority characteristics. Second, our analysis did not include psychological antecedents of COVID-19 fear, such as tolerance of the unknown, general tendencies to worry, and consumption of news media coverage (Mertens et al., 2020). Although it is not necessary to identify the psychological processes by which some individuals develop greater fear than others in order to understand the health consequences of this fear, it can yield additional insight into appropriate public health responses. Our data suggest that a fruitful future endeavor would be to examine whether the psychological antecedents of fear differ as a function of the sociodemographic, health, and obstetric characteristics we identified as relevant to COVID-19 fear among pregnant individuals. Third, there may be residual confounding that was not controlled by the potential confounders we identified and included in our statistical models. The temporal nature of the association between COVID-19 fear and pregnancy outcomes strengthens the potential to infer that COVID-19 fear may have causal effects on pregnancy outcomes, however the fact that our effect sizes were reduced when other explanatory factors were included suggests that fear of COVID-19 may be just one factor within a complex and interrelated set of factors contributing to adverse pregnancy outcomes. And while it is the case that increased anxiety and depression might make one more susceptible to fear, the fact that anxiety and depression symptoms among pregnant individuals have dramatically increased following onset of the pandemic (Tomfohr-Madsen et al., 2021) suggests that fear of COVID-19 is a relevant contributing factor. Nevertheless, it is important to recognize that, to some extent, there is a bi-directional relationship between anxiety/depression and fear.

6. Conclusions

Pregnant individuals are experiencing high levels of COVID-19 fear during the COVID-19 pandemic. This fear is accompanied by increased

risk for clinically elevated symptoms of anxiety and depression and followed by increased adverse pregnancy outcomes. Given the known effects of psychological distress and adverse pregnancy outcomes on pregnant individuals and their infants, there is an urgent need to support women and children during this critical time to mitigate long-term negative outcomes. At the same time, the pandemic has resulted in significant disruption to prenatal care (Groulx et al., 2021), amplifying the need for accessible mental health care, including telehealth (Werner et al., 2020). The need for such support is especially urgent for racialized individuals and families with sociodemographic disadvantage, who not only bear the greatest burden of illness but who also experience the greatest fear of COVID-19. The current pandemic has not so much created health inequities and the psychological vulnerability of some segments of the populations, as it has revealed in stark contrast already existing inequities. Our findings are therefore not only relevant to addressing the circumstances of the current pandemic but also as a means for preventive action for future pandemics.

Contributors

CL, LT-M and GG conceived and designed the study. GG and AM conducted data analyses. GG, SP, LR, and VK wrote the first draft of the manuscript. All authors approved the manuscript and contributed to interpretation of the findings and editing the writing.

Funding

This research was supported by the Alberta Children's Hospital Research Institute and the Owerko centre; the funder had no role in the research.

Declaration of Competing Interest

The authors report no conflicts of interest.

Acknowledgments

We thank Mary Kate Dichoso, Ashley Dhillon, Melinda van Sloten, and Mercedes Bagshawe for their assistance with data collection.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2021.12.057.

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