

Depression, Anxiety, and Objective Hardship: Examining Prenatal Mental Health During the Covid-19 Pandemic in Canada*

Boxuan Yi

17 April 2024

Abstract

The outbreak of the Covid-19 pandemic was a substantial stressor, especially for pregnant individuals. Since depression and anxiety beyond moderate levels are considered clinically significant, this paper uses logistic regression to evaluate the probability of experiencing at least moderate levels of prenatal depression or anxiety during the pandemic. The analysis indicates that younger age, low levels of education and household income, and a high perception of danger to both oneself and the unborn are associated with higher levels of depression and anxiety.

Table of contents

1	Introduction	2
2	Data	2
2.1	Data Overview and Measurement	2
2.2	Data Analysis	3
3	Model	9
3.1	Model Set-up	9
3.2	Model Justification	9
4	Results	10
4.1	Depression	10
4.2	Anxiety	11
5	Discussion	13
5.1	Depression and Anxiety	13
5.2	Treatment	14
5.3	Birth Weight/Length Related to Prenatal Mental Health	14
5.4	Bias, Weakness, and Limitation	15
5.5	Next step	15
6	Appendix	16
6.1	Depression and Anxiety by Education and Income	16
6.2	Answers to Question 2 and 3	16
6.3	Data cleaning	17
	References	18

*Code and data in this analysis is available at: https://github.com/Elaineyi1/Prenatal_Mental_Health

1 Introduction

While pregnancy and childbirth are often moments of joy, they can also bring about distress as mothers navigate responsibilities and physical changes. In the 12 months before childbirth, 12.5% of women in Canada reported that most days were very stressful, and 7.5% reported depressive or anxious symptoms (GovernmentOfCanada). These figures were likely to increase during the COVID-19 pandemic due to heightened uncertainty and panic. Maternal depression and anxiety during pregnancy are associated with adverse neurodevelopmental outcomes for the offspring, such as hyperactivity disorder, autism, poor cognitive or emotional development (Sunaina Seth 2015), which emphasizes the importance of prenatal mental health for both mothers and children. In light of this, I utilize data from the Open Science Framework to explore factors contributing to maternal depression and anxiety during the pandemic, along with associated birth outcomes. This analysis could also provide insight into mothers' mental health during other objective hardships or the general effects of prenatal distress.

Considering that moderate depression and anxiety can affect daily functioning, this paper distinguishes between levels of distress and uses logistic regression to estimate the likelihood of pregnant individuals experiencing at least moderate levels of depression and anxiety in Canada during the pandemic. Predictors include age, education, household income, language preference, and perceived threat to oneself and the unborn baby. Although the dataset used in this paper provides valuable information on pregnant participants' demographic information, basic birth outcomes, and mental health data, it does not include any information on newborns' health. Consequently, this paper mainly focuses on maternal well-being and its effects on mothers.

The estimand being explored is whether pregnant individuals, during the pandemic, would experience at least moderate levels of depression or anxiety, as self-reported using the Edinburgh Postnatal Depression Scale and the Patient-Reported Outcomes Measurement Information System Scales in the survey. The results indicate that young pregnant individuals with lower education and household income, as well as a high perception of danger to both themselves and their unborn child, are more likely to experience at least moderate depression and anxiety. Furthermore, participants who completed the survey in French demonstrate a lower probability of having mental distress compared to those who responded in English.

This paper is constructed as follows: The data utilized for analysis is included in Section 2. Following that, two models, one for depression and one for anxiety, are introduced in Section 3. Section 4 then talks about the results derived from the models. Lastly, I will discuss the findings in a broader context and address limitations of this paper as well as the future explorations in Section 5. This paper uses the programming language R (R Core Team 2022). The analysis, the model and the visualizations use the following packages: `rstanarm` (Goodrich et al. 2024), `modelsummary` (Arel-Bundock 2022), `ggplot2` (Wickham 2016), `dplyr` (Wickham et al. 2023), `readr` (Wickham, Hester, and Bryan 2024), `janitor` (Firke 2023), `arrow` (Richardson et al. 2024), `here` (Müller 2020), `broom` (Robinson, Hayes, and Couch 2023), and `knitr` (Xie 2014).

2 Data

2.1 Data Overview and Measurement

The prenatal mental health dataset sourced from the Open Science Framework was designed to investigate the relationship between exposure to objective hardship caused by the Covid-19 pandemic and psychological distress among pregnant individuals (Gerald Giesbrecht 2023). The population is pregnant individuals aged 17 or older, with gestation periods not exceeding 35 weeks, residing in Canada. Data collection spanned from May 2020 to December 2021, containing individual-level demographic information, mental health data and basic birth outcomes (Catherine Lebel 2023). For this paper, I will only use data collected with delivery month from May to December in 2020 to analyze the prenatal mental health during the initial phase of the outbreak, a period highly marked by panic and adversity. Participants were recruited through pregnancy organizations, care providers, social media, and paid ads on Facebook and Instagram, with the chance to win a 500-dollar gift card. Some of the advertisements were specifically targeted to geographic regions and sociodemographic groups with lower representation to reduce underrepresentation (Catherine Lebel 2023).

Surveys were available in either English or French. Prenatal data, including age, household income in Canadian dollars for the year 2019, and education level were collected as part of the national Pregnancy during the COVID-19 Pandemic (PdP) project using online questionnaires through REDCap. Birth data were also acquired using parents reports (Catherine Lebel 2023).

Depression symptoms were self-assessed using the Edinburgh Postnatal Depression Scale (EPDS), comprising ten questions and each scored from 0 to 3, with possible scores ranging from 0 to 30 (J. L. Cox 1987). Anxiety symptoms were self-evaluated using the Patient-Reported Outcomes Measurement Information System (PROMIS), consisting of 7 questions scored from 1 to 5, with possible total scores ranging from 7 to 35 (PHO 2013). Higher scores on both scales indicate more severe depression or anxiety symptoms. To standardize the scale in this analysis, EPDS scores were divided by 30, and PROMIS scores were adjusted by subtracting 7 from the original scores and then dividing by 35, making the levels of depression and anxiety between 0 and 1.

This paper distinguishes between levels of mental health using the term ‘moderate’, for the following reasons: 1. symptoms of moderate depression may become severe enough to impact daily life (Cherney); 2. While mild anxiety may not always meet clinical significance criteria, anxiety reaching a moderate level is considered significant (BetterHelp 2024). Moreover, given the higher likelihood of experiencing depression or anxiety symptoms during the pandemic, particularly among pregnant individuals, the focus here will be on estimating at least moderate depression or anxiety.

Two binary variables named **depression** and **anxiety** were created. Participants scoring above 12 on the EPDS scale, representing 40%, were likely to be experiencing depression and advised to seek medical attention (J. L. Cox 1987). Accordingly, the variable **depression** was assigned a value of 1 if the EPDS score was greater than or equal to 0.4, and 0 otherwise. For the PROMIS scale, a score exceeding 20 indicated at least moderate anxiety. Therefore, the variable **anxiety** was assigned to 1 if the PROMIS score was greater than or equal to 0.464, and 0 if it was less than 0.464, as 20 on a scale from 7 to 35 represents 46.4%. In this analysis, “depression” refers to being at least moderately depressed, while “no depression” indicates not reaching the level of moderate depression; “anxiety” refers to being at least moderately anxious, while “no anxiety” means not reaching the level of moderate anxiety.

A total of 10,772 participants’ data were available. After excluding observations with missing values and setting the delivery month from May 2020 to December 2020, 3266 observations remained. Further details regarding data cleaning are provided in Section 6.3. All participants in this study provided informed consent.

2.2 Data Analysis

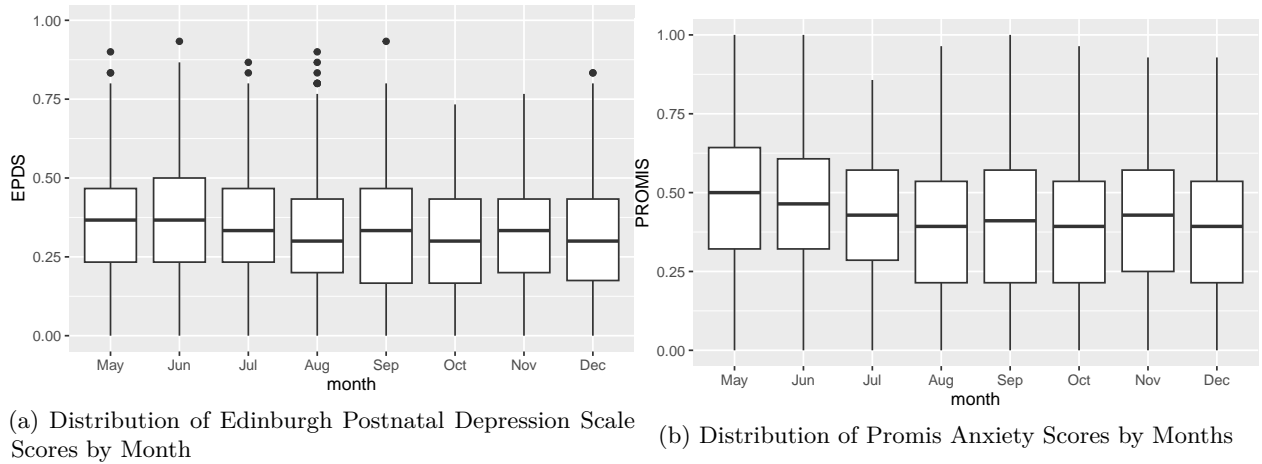


Figure 1: The Distribution of Levels of Depression and Anxiety by Month

Firstly, Figure 1 provides an overview of the levels of depression and anxiety with delivery months spanning from May to December. Overall, a decreasing trend is observed in both scales with the onset of the pandemic. The level of anxiety tends to be slightly higher than that of depression, with the majority experiencing depression levels below 0.5. However, depression exhibits more outliers towards higher values, implying that some individuals experienced significantly severe depression symptoms. Mothers scoring above 0.4 in depression and 0.464 in anxiety are experiencing at least moderate distress. The distributions in Figure 1 indicate a considerable number of pregnant individuals may be experiencing distress, given that the means fall within the range of 0.3 to 0.5.

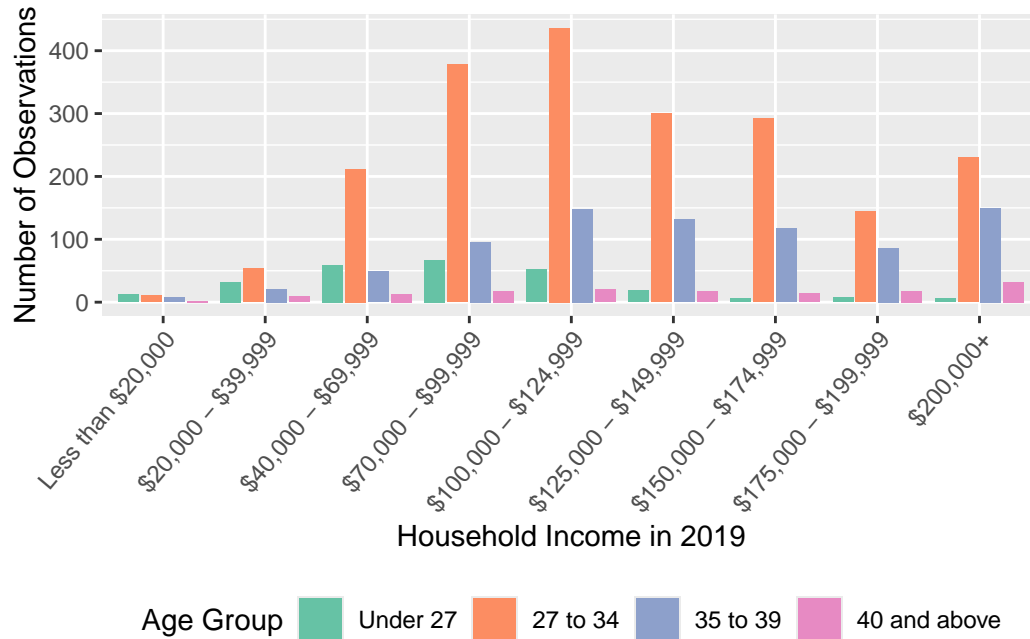


Figure 2: The Distribution of Age Groups and Household Income for Pregnant Participants

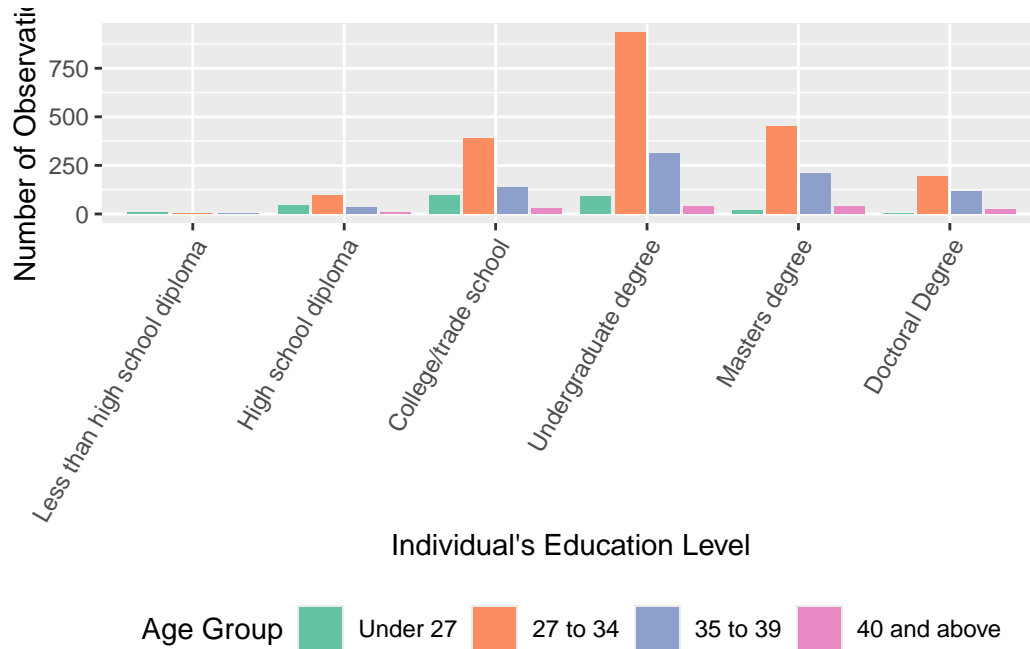


Figure 3: The Distribution of Age Groups and Level of Education for Pregnant Participants

In Canada, the mean age of mothers at delivery is approximately 31 (StatisticsCanada 2023). The dataset contains maternal ages ranging from 18.5 to 49, and because 35 and above is categorized as advanced maternal age (Patricia A. Cavazos-Rehg 2016), I have grouped the ages as follows: Under 27, 27 to 34, 35 to 39, and 40 and above. The distribution of pregnant individuals' ages and household incomes is illustrated in Figure 2, and the relationship between age and education is depicted in Figure 3. Both graphs show that a significant proportion of participants fall within the 27 to 34 age group, followed by those aged 35 to 39. Surprisingly, the number of participants under 27 is very low, almost comparable to those aged 40 and above.

A significant proportion of respondents reported incomes ranging from 70,000 to 149,999, as indicated in Figure 2. There is a notable presence of households with incomes exceeding 200,000, while very few reported incomes below 40,000. For reference, the median after-tax income of Canadian households was 73,000 in 2020, and 11.1% of Canadians were in the low-income group (StatisticsCanada 2022b). Figure 3 demonstrates that the majority of pregnant individuals in the survey hold undergraduate degrees, with some having completed college/trade school or earned Master's degrees. Very few respondents reported having less than a high school diploma. According to Statistics Canada, in 2021, 26.3% of women+ aged 15 and above held a high school diploma, 21.2% had a college, CEGEP, or other non-university certificate or diploma. 58.4% held a postsecondary certificate, while 5.9% completed a Master's Degree (StatisticsCanada 2022a). The participants have a relatively higher income and education distribution than average.

Regarding age and language, Figure 4 presents the proportions of participants experiencing less than moderate levels of depression/anxiety and those experiencing at least moderate depression/anxiety, categorized by age and language. Darker colours represent a more severe level of depression or anxiety. From Figure 4 (a) and (c), younger participants under 27 are more prone to feeling depressed and anxious, with the difference in depression being more noticeable. Figure 4 (b) and (d) reveal that participants who completed the survey in French have lower levels of distress. Given that French speakers are concentrated in Quebec, which was one of the provinces most affected by the pandemic in 2020 (COVID19Tracker), I consider the language, potentially indicating the region of residence, as a factor influencing the probability of significant distress among pregnant individuals during the Covid-19 pandemic.

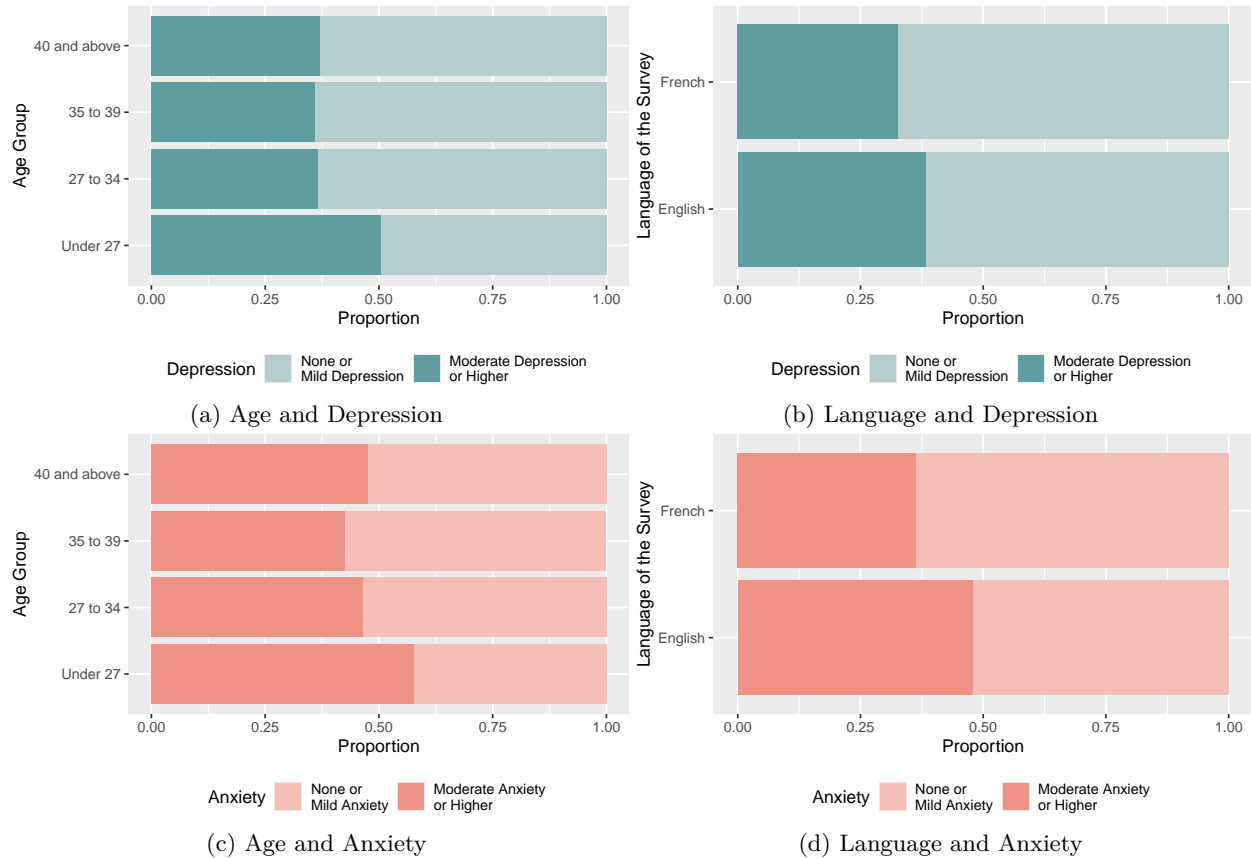


Figure 4: Levels of Depression and Anxiety Among Pregnant Individuals Grouped By Age and Language Used to Complete the Survey

Figure 5 displays the proportions of participants with less than moderate levels of depression/anxiety and those with at least moderate depression/anxiety, categorized by household income in 2019 and education. There is a correlation between higher education and higher household income with lower levels of both depression and anxiety. Conversely, individuals with lower education and income levels are more likely to experience at least moderate depression or anxiety. Comparing Figure 5 (a) and (c), and Figure 5 (b) and (d), we observe that a larger proportion of people experience anxiety compared to depression. More details can be found in Section 6.1.

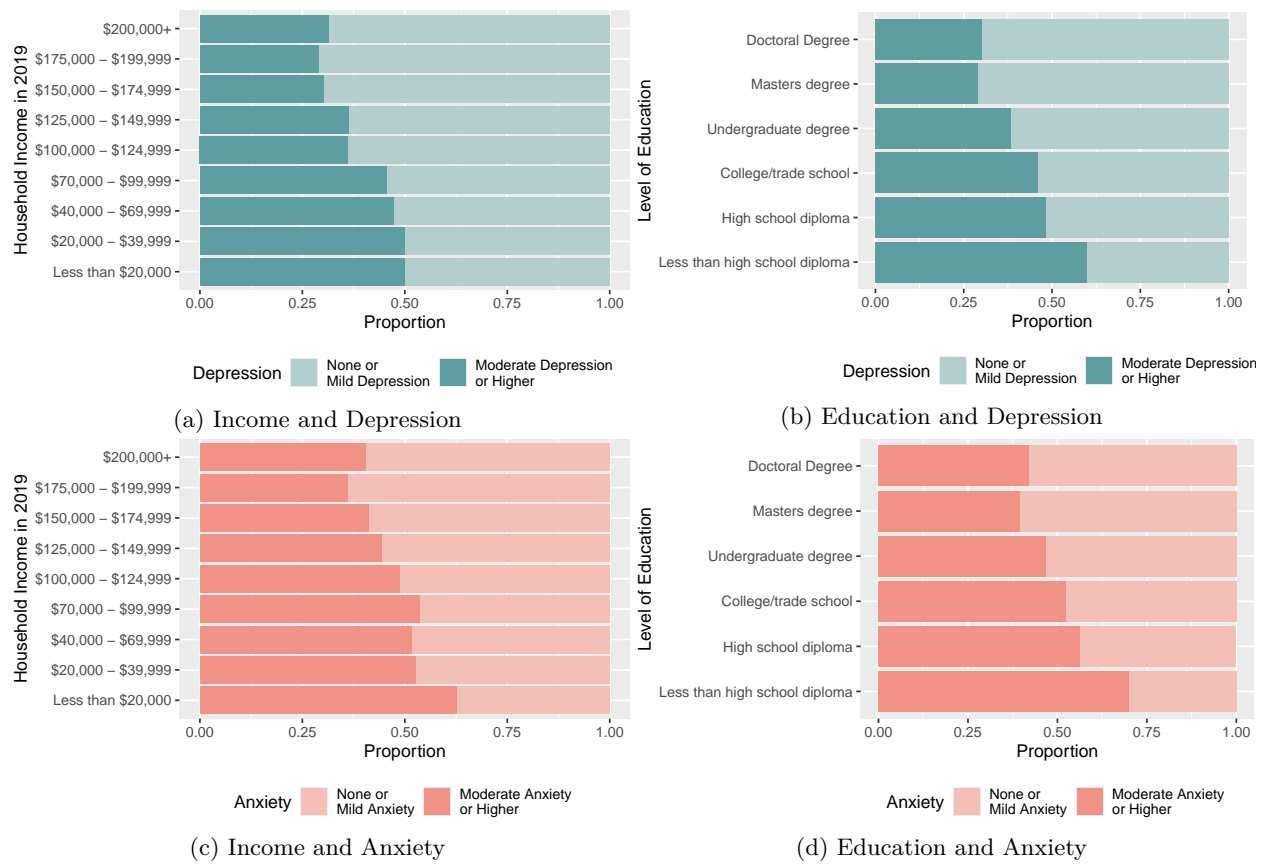


Figure 5: Levels of Depression and Anxiety Among Pregnant Individuals Grouped By Household Income and Education

Three questions specific to fears of COVID-19 were asked in the survey. Answers were on a numeric scale from 0 (not at all) to 100 (very much so), with 50 representing ‘somewhat’ (Catherine Lebel 2023).

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 in danger during the COVID-19 pandemic?
3. How much are you worried that exposure to the COVID-19 virus will harm your unborn baby?

Given the similarity between questions 1 and 2, which respectively focus on self-perceived danger and danger perceived towards the unborn, I will analyze the responses to these two questions, while the relationship between questions 2 and 3 concerning the baby will be presented in Section 6.2. Scores are divided by 100, resulting in a range from 0 to 1. The relationship between the perceived level of danger, both towards self and the unborn, and prenatal mental health is visualized in Figure 6.

Figure 6 (a) and (b) reveal that compared to the perceived level of the unborn baby, a higher perceived level of danger to oneself tends to lead to a higher level of depression. From Figure 6 (c) and (d), it appears that the perceived level of danger to both oneself and the unborn baby have similar impacts on anxiety. Again, the average level of distress among French speakers is lower than that among English speakers, but participants who speak French have a higher variation.

Therefore, the predictors I choose to estimate prenatal mental health are maternal age groups, household income, education, the perceived danger to oneself, and the perceived danger to the unborn baby.

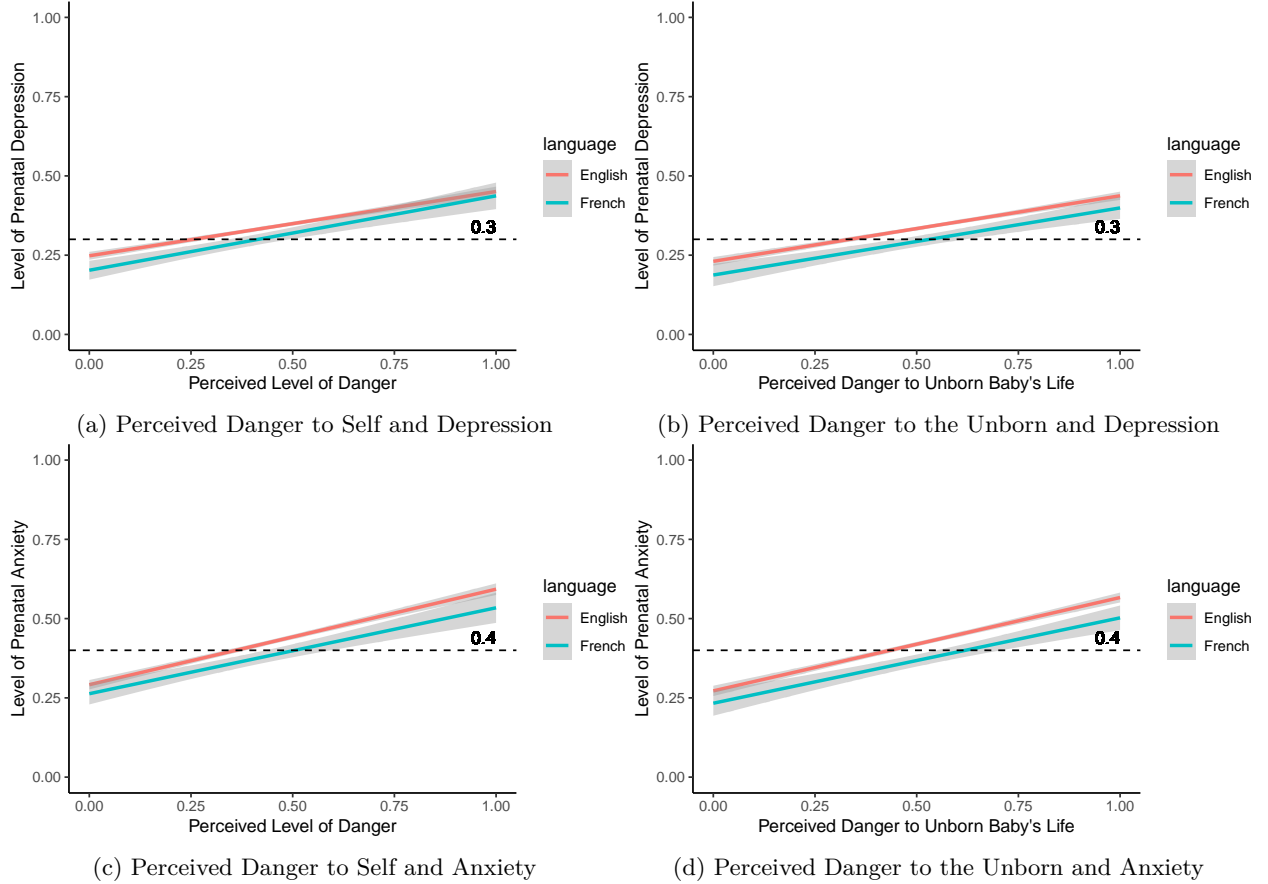


Figure 6: Relationship between Perceived Level of Danger and Prenatal Mental Health

3 Model

3.1 Model Set-up

To estimate whether pregnant individuals will experience depression or anxiety beyond moderate levels, I will utilize logistic regression to create separate models for each psychological distress, using the `stan_glm()` function from the `rstanarm` package (Goodrich et al. 2024). The predictors are age group, education, household income, language, the perceived level of danger to oneself, and the perceived level of danger to the unborn baby. The parameters in the models are considered random variables, each with its own associated probability distribution. It is important to recognize that a model is not, and cannot be, a true representation of reality (Alexander 2023). The purpose of a model is to find patterns in the data and make estimations, so models are not guaranteed to be 100% accurate.

Logistic regression is well-suited when the outcome variable is binary. For these two models, the outcome variables **depression** and **anxiety** are assigned to 1 if participants exhibit at least moderate symptoms and 0 otherwise. The logistic regression equation for both models can be expressed as follows:

$$\begin{aligned} y_i | \pi_i &\sim \text{Bern}(\pi_i) \\ \text{logit}(\pi_i) &= \beta_0 + \beta_1 \times \text{Age}_i + \beta_2 \times \text{Education}_i + \beta_3 \times \text{HouseholdIncome}_i + \beta_4 \times \text{Language}_i \\ &\quad + \beta_5 \times \text{DangerToSelf}_i + \beta_6 \times \text{DangerToBaby}_i \\ \beta_0 &\sim \text{Normal}(0, 2.5) \\ \beta_1 &\sim \text{Normal}(0, 2.5) \\ \beta_2 &\sim \text{Normal}(0, 2.5) \\ \beta_3 &\sim \text{Normal}(0, 2.5) \\ \beta_4 &\sim \text{Normal}(0, 2.5) \\ \beta_5 &\sim \text{Normal}(0, 2.5) \\ \beta_6 &\sim \text{Normal}(0, 2.5) \end{aligned}$$

where:

- y_i is the dependent variable, representing the probability of a pregnant individual experiencing at least moderate level of depression or anxiety
- β_0 is the intercept term, representing the value if all the predictors are zero. It has a prior distribution that is normal with a mean of 0 and a standard deviation of 2.5
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are the coefficients corresponding to the predictor variables, each with a prior distribution that is normal with mean 0 and standard deviation 2.5

3.2 Model Justification

For the depression model, I expect to see a positive relationship between experiencing depression and age under 27, low levels of education (e.g. less than high school diploma), low income household in 2019 (e.g. less than \$20,000), and a preference of using English. This expectation is based on Section 2. Moreover, at the onset of the pandemic, when everything was uncertain, it is reasonable that participants with lower income would worry more about the pregnancy, because financial strain may lead to limited access to resources such as healthcare. Younger individuals or those with lower levels of education may experience increased depression due to limited life experience or reduced access to information. Pregnant individuals who perceive a higher level of threat to themselves or their unborn baby are also expected to experience heightened stress levels, because our bodies activate the stress response system when perceiving threats, leading to the release of stress hormones (Brianna Chu 2022).

For the anxiety model, I also expect a positive relationship between experiencing anxiety and age under 27, low levels of education and income, a preference of speaking English, and a high perception of danger to both self and unborn baby. This is based on Section 2 and the reasons listed in the above paragraph.

Table 1: Estimating Prenatal Depression given Age, Household Income, Education Level and Choice of Language

	Depression
(Intercept)	−0.669
age_group27 to 34	−0.305
age_group35 to 39	−0.274
age_group40 and above	−0.286
household_income\$20,000 - \$39,999	0.207
household_income\$40,000 - \$69,999	0.140
household_income\$70,000 - \$99,999	0.148
household_income\$100,000 - \$124,999	−0.200
household_income\$125,000 - \$149,999	−0.136
household_income\$150,000 - \$174,999	−0.417
household_income\$175,000 - \$199,999	−0.437
household_income\$200,000+	−0.251
languageFrench	−0.327
maternal_educationHigh school diploma	−0.239
maternal_educationCollege/trade school	−0.337
maternal_educationUndergraduate degree	−0.478
maternal_educationMasters degree	−0.787
maternal_educationDoctoral Degree	−0.696
threaten_life	1.253
threaten_baby_danger	1.053
Num.Obs.	3266
R2	0.095
Log.Lik.	−2010.355
ELPD	−2030.7
ELPD s.e.	21.2
LOOIC	4061.3
LOOIC s.e.	42.5
WAIC	4061.2
RMSE	0.46

4 Results

4.1 Depression

The coefficients from the logistic regression model, presented in Table 1, show the impact of various predictors on whether a pregnant individual would experience at least moderate depression. Age groups 27 to 34, 35 to 39, and 40 and above all exhibit negative coefficients, suggesting a lower likelihood of depression in individuals aged 27 and above. The general trend in income is that a higher household income positively correlates with a lower probability of depression, 200,000 and above, shows a slightly higher coefficient than the second higher income range of 175,000 to 199,999. Similarly, higher levels of education are associated with lower depression levels, with the highest level, the Doctoral Degree holders, having slightly larger coefficients than those with the second highest degree, the Master’s degree. Individuals who use French have a negative coefficient, implying a smaller likelihood of depression. The perceived threats to oneself and the unborn baby exhibit large positive coefficients. The threat to life has a larger coefficient than the threat to the baby, meaning that feeling the threat to life can lead to more severe depression.

A participant with a Master’s Degree, a household income of 175,000 to 199,999, aged 27 to 34, who speaks French, and reports a low perceived threat is least likely to feel depressed. Conversely, a participant with less than a high school diploma, a household income between 20,000 to 39,999, aged under 27, who speaks

English, and reports a high perception of danger is the most likely to experience depression.

To provide intuitive insights into the model, I visualize the coefficients from Table 1 in Figure 7 along with their 95% confidence intervals. The age, the language, and threats variables have small confidence intervals. The intercept and the education variables display relatively large confidence intervals, suggesting lower precision in these estimates.

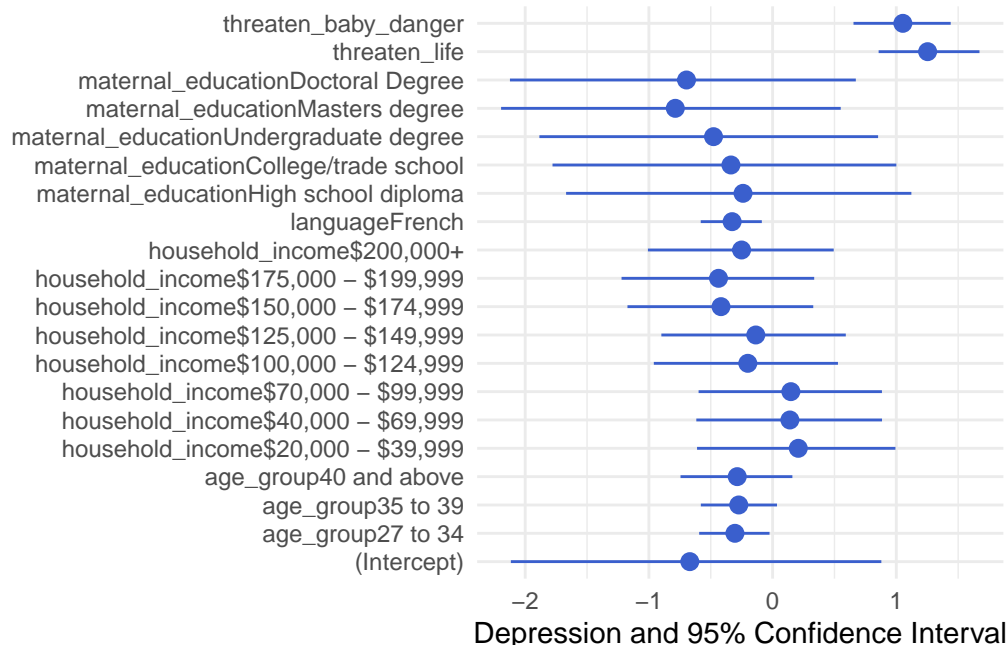


Figure 7: The Coefficients and Confidence Interval in the Depression Model

4.2 Anxiety

The coefficients from the logistic regression model for anxiety, presented in Table 2, indicate the influence of predictor variables on whether a pregnant individual would experience at least moderate anxiety. Age groups 27 to 34, 35 to 39, and 40 and above have negative coefficients from Table 2, suggesting a smaller likelihood of anxiety in individuals aged 27 and above, particularly in the 35 to 39 age group. Higher household income is associated with a lower probability of anxiety, with the income range of 175,000 to 199,999 showing the lowest coefficient. While higher levels of education correspond to lower anxiety, the differences are less evident compared to the depression model. To be more specific, the highest degree Doctoral Degree has a coefficient of -0.695, which falls between the coefficients of College/trade school and Undergraduate degree, with coefficients of -0.642 and -0.705 respectively. Pregnant individuals who speak French have a negative coefficient, which implies a lower likelihood of anxiety as well. The perceived threats to oneself and the unborn baby have large positive coefficients, and they are larger than the coefficients in the depression model. The two values are similar, 1.505 and 1.555, respectively. The perception of threat to the baby leads to more severe anxiety symptoms.

A participant with a Master's Degree, a household income of 175,000 to 199,999, aged 35 to 39, who speaks French, and reports a low perceived threat is least likely to experience anxiety. Conversely, a participant with less than a high school diploma, a household income below 20,000, aged under 27, who speaks English, and who reports a high perception of danger is the most likely to feel anxious.

Figure 8 visualizes the coefficients and 95% confidence intervals from Table 2. As with the depression model, the intercept and education variables display larger confidence intervals, indicating lower precision in these estimates.

Table 2: Estimating Prenatal Anxiety given Age Group, Household Income, Education Level and Choice of Language.

	Anxiety
(Intercept)	−0.227
age_group27 to 34	−0.302
age_group35 to 39	−0.438
age_group40 and above	−0.249
household_income\$20,000 - \$39,999	−0.206
household_income\$40,000 - \$69,999	−0.178
household_income\$70,000 - \$99,999	−0.042
household_income\$100,000 - \$124,999	−0.192
household_income\$125,000 - \$149,999	−0.328
household_income\$150,000 - \$174,999	−0.477
household_income\$175,000 - \$199,999	−0.673
household_income\$200,000+	−0.414
languageFrench	−0.564
maternal_educationHigh school diploma	−0.467
maternal_educationCollege/trade school	−0.642
maternal_educationUndergraduate degree	−0.705
maternal_educationMasters degree	−0.852
maternal_educationDoctoral Degree	−0.695
threaten_life	1.505
threaten_baby_danger	1.555
Num.Obs.	3266
R2	0.132
Log.Lik.	−2037.189
ELPD	−2057.2
ELPD s.e.	20.3
LOOIC	4114.3
LOOIC s.e.	40.5
WAIC	4114.2
RMSE	0.47

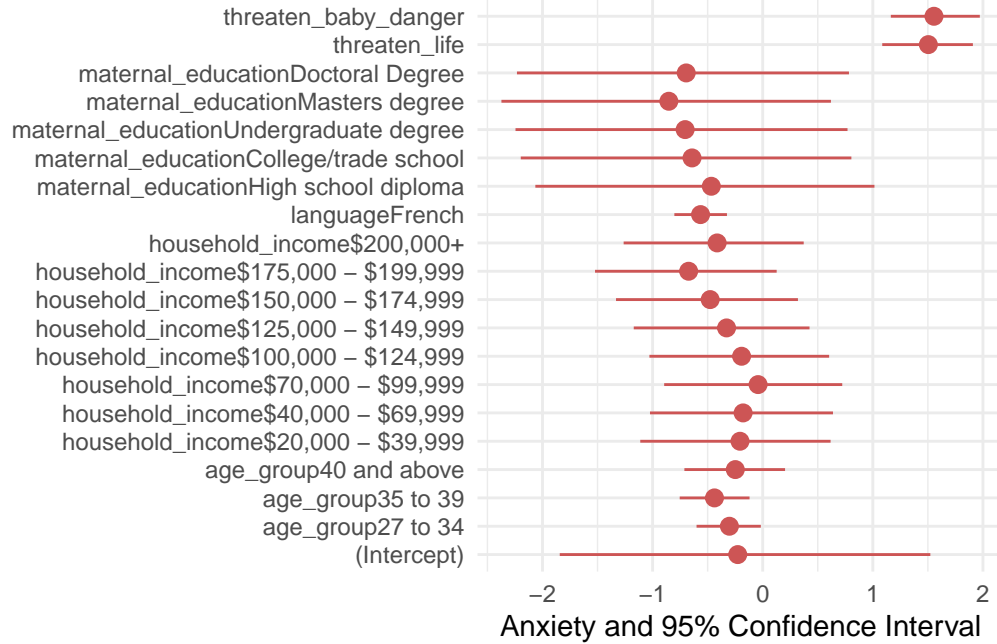


Figure 8: The Coefficients and Confidence Interval in the Anxiety Model

5 Discussion

5.1 Depression and Anxiety

As demonstrated in Section 4, lower household income is associated with higher levels of depression and anxiety, as financial strain can greatly impact individuals' access to essential resources, including healthcare, particularly during uncertain times. Low education has been linked to a lack of a sense of control and resilience, as well as exposure to day-to-day stressors (Williams 2023). These negative factors have been strongly correlated with the onset of depression and anxiety (Mauro Percudani 2022). In contrast, education is shown to be a clear indicator of life outcomes such as employment, income, and social status, and hence, highly-educated participants are prone to having fewer symptoms (Mauro Percudani 2022).

It is observed that pregnant individuals under 27 are more likely to experience depression and anxiety. This could be attributed to the fact that younger mothers have a higher likelihood of experiencing their first pregnancy compared to older mothers, and older mothers have a greater chance of having previously given birth. Young individuals often face various socioeconomic challenges, including lower income and limited time to complete their education, which can lead to lower educational attainment levels. These factors can contribute to a higher likelihood of experiencing depression and anxiety.

When individuals perceive a threat, their bodies activate the stress response system, which involves an activation of stress hormones that produce physiological changes (Brianna Chu 2022). More than this, individuals who perceive threats may engage in rumination and experience a decreased sense of control, continuously dwelling on their fears and anxieties. Thus, a high perception of threat to oneself and the baby may lead to physiological disorders.

The differences in language preference are often related to the regions. Most people who prefer to speak French reside in Quebec. Despite Quebec being one of the provinces with the highest number of COVID-19 cases in 2020 (COVID19Tracker), the reason behind French speakers having a low level of depression and anxiety remains uncertain. It could potentially be attributed to lifestyle and cultural attitudes prevalent among Quebecers. Further research is needed to better understand the underlying factors.

5.2 Treatment

Only one-third of pregnant women with depression would consider taking anti-depression treatment (Alexander Jarde 2016). Hence, it is critical to raise awareness of depression as a health issue and encourage individuals to seek professional help.

Research has shown that pregnant individuals with untreated depression face significantly increased infant risks compared to those without depression, particularly in terms of preterm birth and small infant size. However, treating depression with antidepressants has also been found to be associated with higher risks of preterm birth and low birth weight (Alexander Jarde 2016). Considering these findings, non-pharmacological therapies may be more acceptable for pregnant individuals, and they usually provide a more personalized treatment for individuals.

5.3 Birth Weight/Length Related to Prenatal Mental Health

Studies have shown that maternal distress may contribute to reduced birthweight, and complications related to preterm birth and low birth weight are leading causes of infant morbidity and mortality (Alexander Jarde 2016). The dataset used in this paper, from the Open Science Framework (Gerald Giesbrecht 2023), also demonstrates a correlation between poor mental health and reduced birth weight and birth length. As illustrated in Figure 9, there is a clear association between higher levels of depression or anxiety and lower birth weight and length, categorized by delivery mode, with Caesarean-section babies having a larger average length and weight compared to vaginally delivered babies. These findings, once again, emphasize the importance of addressing maternal mental health during pregnancy to support fetal growth and development.

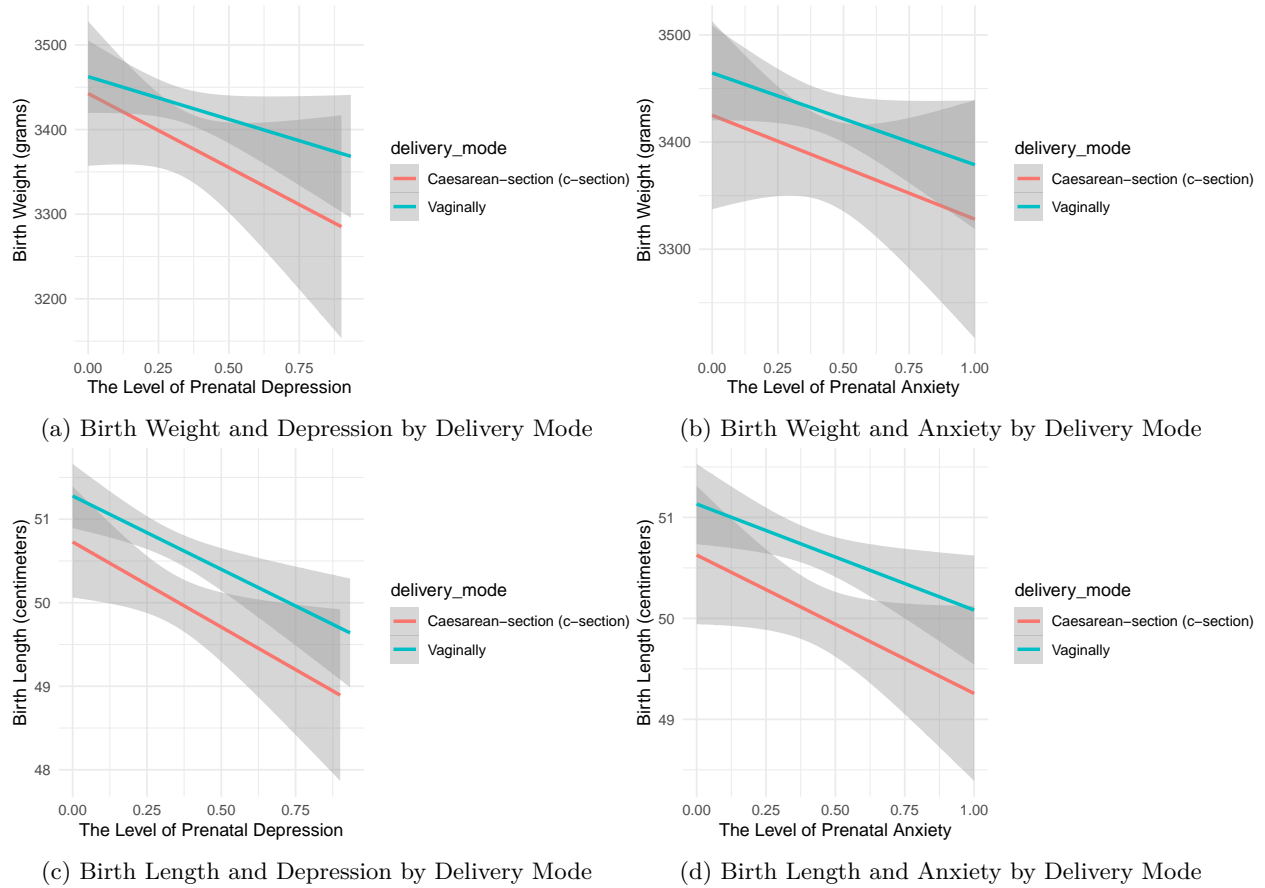


Figure 9: Distribution of Birth Weight and Length and Prenatal Mental Health by Delivery Mode

5.4 Bias, Weakness, and Limitation

Participants in the study were pregnant individuals aged 17 years or older, with gestation periods of up to 35 weeks. However, during the COVID-19 outbreak, potential biases in the data may occur, such as more severe depression or anxiety symptoms among young mothers under 17 years old and participants with more than 35 weeks of gestation. This sampling bias could result in an underestimation of mental distress levels. As demonstrated in Section 4, younger mothers tend to experience higher levels of depression and anxiety, and they are less likely to be financially stable compared to adults. Consequently, it is also important to understand the mental health of mothers under 17 years old.

In the survey, depression and anxiety levels were assessed through self-reported measures using the Edinburgh Postnatal Depression Scale and Promis Anxiety Scale, while birth length and weight were reported by parents. This reliance on self-reporting and parental reporting introduces biases and potential ethical implications that may limit the accuracy of data.

Based on Figure 2 and Figure 3, it appears that the proportion of individuals with lower income and education levels is smaller than expected compared to the actual education (StatisticsCanada 2022a) and income distribution (StatisticsCanada 2022b) in Canada. Individuals from lower socioeconomic backgrounds may face limited access to networks and healthcare services, which could hinder their participation in surveys or online platforms, thus skewing the results. They may also be too stressed to look at their phone or engage with social media, and then miss the survey advertisements. It is also possible that self-reporting inaccuracies about low income and education have influenced the data. Regardless of the reason, the underrepresentation has resulted in bias.

One weakness of the dataset is its lack of information on other mental disorders besides depression and anxiety, like psychosis, and geographical data. Considering that regions with different population densities may experience varying levels of panic during the pandemic, the analysis could benefit from including relevant regional data for better precision. Moreover, some surveys were collected through social media platforms like Facebook and Instagram Ads. These platforms may not be perceived as formal or serious compared to surveys conducted by established survey companies, meaning that respondents may not have provided accurate or complete information, potentially affecting the reliability and validity of the data collected.

While several rounds of surveys were conducted, the complete dataset containing additional information was not publicly accessible. Consequently, this paper only utilized one survey and could not analyze changes in mental distress over time or assess newborn health outcomes, and this is a limitation of the study.

5.5 Next step

Given the challenges posed by the COVID-19 pandemic and the escalation of conflicts and crises worldwide, understanding prenatal mental health amidst such objective hardships is both useful and necessary. I recommend that researchers focus on investigating how distress during pregnancy impacts birth outcomes, including the health outcomes and language development of newborns during social isolation, as well as postnatal mental health. Future research can explore deeper into subjective factors, such as the prolonged duration of staying at home and the behaviours of family members, in order to fully assess maternal well-being.

The models generated from this analysis serve as a foundation for advancing discussions on resource allocation, clinical interventions, and the role of familial support in caring pregnant individuals. By identifying the multifaceted factors influencing maternal well-being and mental health outcomes, policymakers and healthcare providers can make informed decisions regarding resource allocation and targeted treatments to provide support for pregnant individuals through hardships.

6 Appendix

6.1 Depression and Anxiety by Education and Income

Figure 10 illustrates the detailed distribution of levels of depression and anxiety by education and household income. Generally, participants with higher education levels and higher household income exhibit lower levels of depression and anxiety. Focusing on the lowest education and lowest income groups, individuals with less than high school diploma are more easily to experience anxiety, with an average score of 0.529, compared to 0.499 among those with household incomes less than 20,000. Conversely, individuals with household incomes less than 20,000 tend to feel depressed, with an average score of 0.423, compared to 0.407 among those with less than a high school diploma.

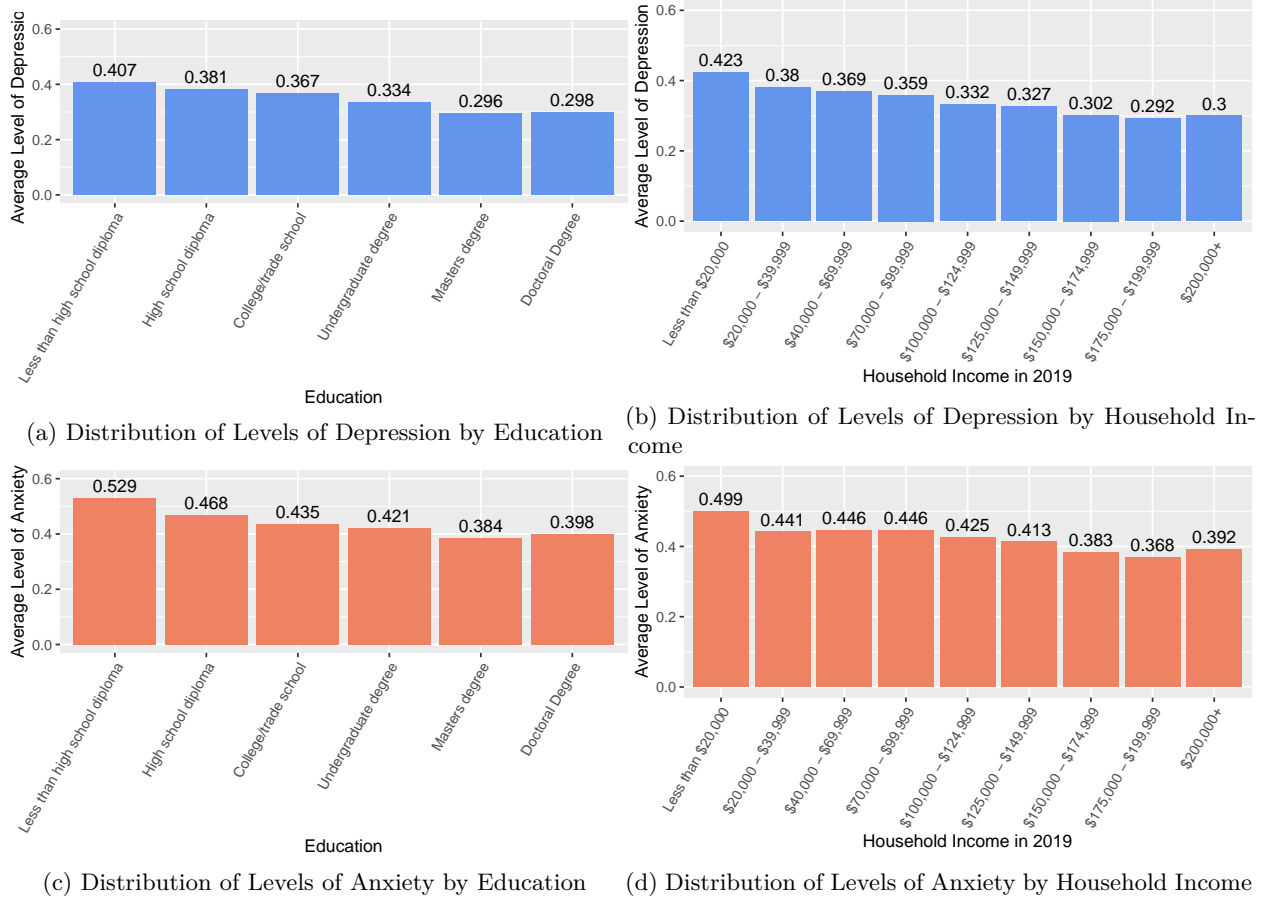


Figure 10: Distribution of Levels of Depression and Anxiety by Education and Household Income

6.2 Answers to Question 2 and 3

Figure 11 displays the relationship between the answers to question 2 and question 3 in Section 2.

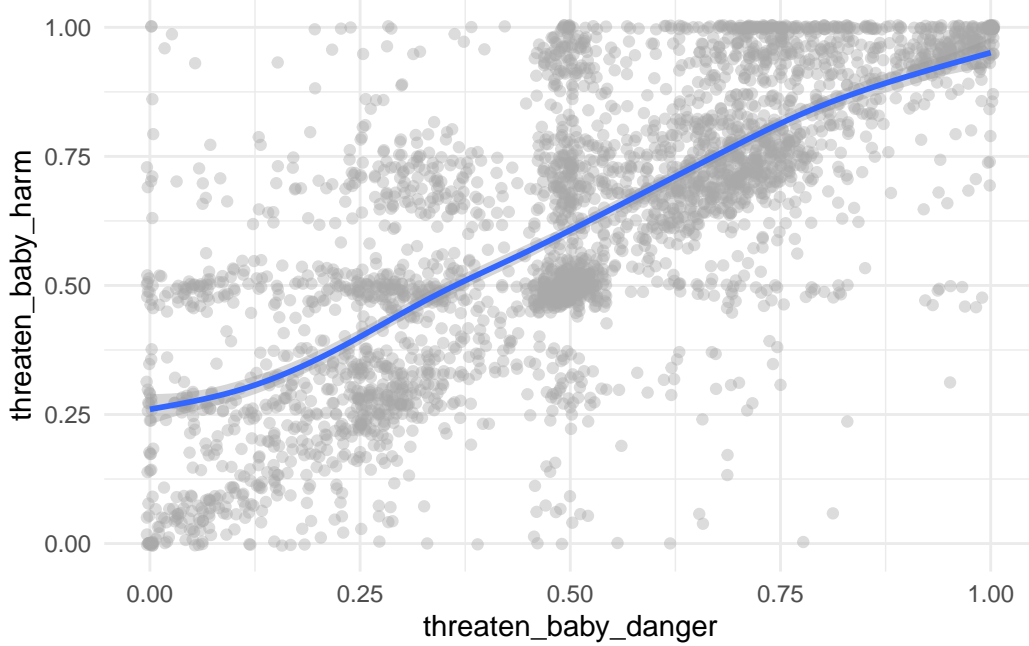


Figure 11: Distribution of the Perceived Danger to Baby and Perceived Potential Harm to Baby

6.3 Data cleaning

After obtaining the original raw dataset, I select the following variables: `maternal_age`, `household_income`, `edinburgh_postnatal_depression_scale`, `promis_anxiety`, `delivery_date_converted_to_month_and_year`, `birth_length`, `birth_weight`, `maternal_education`, `delivery_mode`, `language`, `threaten_life`, `threaten_baby_danger`, `threaten_baby_harm`. I exclude those observations with missing values and create two new variables, `month` and `year`, derived from `delivery_date_converted_to_month_and_year`, representing the delivery month and year respectively. Additionally, I categorized maternal age into four groups: under 27, 27 to 34, 35 to 39, and 40 and above, creating a variable called `age_group`. I then convert `edinburgh_postnatal_depression_scale` and `promis_anxiety` to percentages ranging from 0 to 1, named EPDS and PROMIS as specified in Section 2. I scale `threaten_life`, `threaten_baby_danger` and `threaten_baby_harm` by dividing each by 100 to ensure they range from 0 to 1.

Subsequently, I filtered the dataset to retain only observations from the year 2020, excluding those with a delivery month of April, considering that the surveys were conducted from May 2020 onwards. Finally, two variables named `depression` and `anxiety` are created based on the criteria stated in Section 2: `depression` is set to 1 if EPDS is greater than or equal to 0.4, and 0 otherwise; similarly, `anxiety` is assigned to 1 if PROMIS is not less than 0.464, and 0 if it is smaller than 0.464.

References

- Alexander Jarde, Dawn Kingston, Michelle Morais. 2016. “Neonatal Outcomes in Women With Untreated Antenatal Depression Compared With Women Without Depression.” <https://doi.org/10.1001/jamapsychiatry.2016.0934>.
- Alexander, Rohan. 2023. “Telling Stories with Data - 12 Linear Models.” <https://tellingstorieswithdata.com/12-ijalm.html>.
- Arel-Bundock, Vincent. 2022. “modelsummary: Data and Model Summaries in R.” *Journal of Statistical Software* 103 (1): 1–23. <https://doi.org/10.18637/jss.v103.i01>.
- BetterHelp. 2024. “What Are The Different Stages of Anxiety? | BetterHelp.” <https://www.betterhelp.com/advice/anxiety/are-there-different-levels-of-anxiety/#>.
- Brianna Chu, Terrence Sanvictores, Komal Marwaha. 2022. “Physiology, Stress Reaction.” <https://www.ncbi.nlm.nih.gov/books/NBK541120/>.
- Catherine Lebel, Gerald Giesbrecht, Lianne Tomfohr-Madsen. 2023. “Prenatal Mental Health Data and Birth Outcomes in the Pregnancy During the COVID-19 Pandemic Dataset.” <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10339202/>.
- Cherney, Kristeen. “Mild, Moderate, or Severe Depression? How to Tell the Difference.” <https://www.healthline.com/health/depression/mild-depression#moderate-depression>.
- COVID19Tracker. “COVID-19 Tracker Canada.” <https://covid19tracker.ca/>.
- Firke, Sam. 2023. *Janitor: Simple Tools for Examining and Cleaning Dirty Data*. <https://github.com/sfirke/janitor>.
- Gerald Giesbrecht, Lianne Tomfohr-Madsen, Catherine Lebel. 2023. “Pregnancy During the COVID-19 Pandemic Study.” <https://osf.io/ha5dp/>.
- Goodrich, Ben, Jonah Gabry, Imad Ali, and Sam Brilleman. 2024. “Rstanarm: Bayesian Applied Regression Modeling via Stan.” <https://mc-stan.org/rstanarm/>.
- GovernmentOfCanada. “Pregnancy and Women’s Mental Health in Canada - Canada.ca — Canada.ca.” <https://www.canada.ca/en/public-health/services/publications/healthy-living/pregnancy-women-mental-health-canada.html>.
- J. L. Cox, R Sagovsky, J. M. Holden. 1987. “Med.stanford.edu.” https://med.stanford.edu/content/dam/sm/ppc/documents/DBP/EDPS_text_added.pdf.
- Mauro Percudani, Valeria Brenna, Alessandra Bramante. 2022. “Key Topics in Perinatal Mental Health.” <https://link-springer-com.myaccess.library.utoronto.ca/book/10.1007/978-3-030-91832-3>.
- Müller, Kirill. 2020. *Here: A Simpler Way to Find Your Files*. <https://here.r-lib.org/>.
- Patricia A. Cavazos-Rehg, Edward L. Spitznagel, Melissa J. Krauss. 2016. “Maternal Age and Risk of Labor and Delivery Complications.” <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4418963/>.
- PHO. 2013. “Psychiatry.org.” <https://www.psychiatry.org/getmedia/f284f967-ed9e-4754-99fc-b32765b1c4a0/APA-DSM5TR-Level2AnxietyAdult.pdf>.
- R Core Team. 2022. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Richardson, Neal, Ian Cook, Nic Crane, Dewey Dunnington, Romain François, Jonathan Keane, Dragoş Moldovan-Grünfeld, Jeroen Ooms, Jacob Wujciak-Jens, and Apache Arrow. 2024. *Arrow: Integration to ‘Apache’ ‘Arrow’*. <https://github.com/apache/arrow/>.
- Robinson, David, Alex Hayes, and Simon Couch. 2023. *Broom: Convert Statistical Objects into Tidy Tibbles*. <https://broom.tidymodels.org/>.
- StatisticsCanada. 2022a. “Highest Level of Education by Census Year: Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations.” <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810038401&pickMembers%5B0%5D=1.1&pickMembers%5B1%5D=2.1&pick%0AMember%5B2%5D=4.3&pickMembers%5B3%5D=3.1>.
- . 2022b. “Income in Canada, 2020.” <https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2022040-eng.htm#>.
- . 2023. “Mean Age of Mother at Time of Delivery (Live Births).” <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310041701>.
- Sunaina Seth, Richard Saffery, Andrew James Lewis. 2015. “Maternal Prenatal Mental Health and Placental 11 Beta-HSD2 Gene Expression: Initial Findings from the Mercy Pregnancy and Emotional Wellbeing

- Study.” https://mdpi-res.com/ijms/ijms-16-26034/article_deploy/ijms-16-26034.pdf?version=1447757720.
- Wickham, Hadley. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. <https://ggplot2.tidyverse.org>.
- Wickham, Hadley, Romain François, Lionel Henry, Kirill Müller, and Davis Vaughan. 2023. *Dplyr: A Grammar of Data Manipulation*. <https://dplyr.tidyverse.org>.
- Wickham, Hadley, Jim Hester, and Jennifer Bryan. 2024. *Readr: Read Rectangular Text Data*. <https://readr.tidyverse.org>.
- Williams, Nicola. 2023. “How Does Education Affect Mental Health?” <https://www.news-medical.net/health/How-does-Education-Affect-Mental-Health.aspx>.
- Xie, Yihui. 2014. “Knitr: A Comprehensive Tool for Reproducible Research in R.” In *Implementing Reproducible Computational Research*, edited by Victoria Stodden, Friedrich Leisch, and Roger D. Peng. Chapman; Hall/CRC. <http://www.crcpress.com/product/isbn/9781466561595>.