The Impact of Prenatal Mental Health Disorders on Birth Outcomes before and during the COVID-19 Pandemic in Anhui, China

by

Tianqi Zhao

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Epidemiology

School of Public Health
University of Alberta

Abstract

Adverse birth outcomes, including low birth weight, preterm birth, and small for gestational age are associated with increased neonatal morbidity and mortality globally. In China, adverse birth outcomes remain challenging public health problems. Prenatal depression and anxiety have been found to be associated with these adverse birth outcomes.

In China, there is increasing literature that reported the importance and severity of prenatal depression and anxiety. The severity of the COVID-19 pandemic is likely to exacerbate mental health problems during the prenatal period and increase the risk of adverse birth outcomes, possibly adding further burden to the current healthcare system in China. The aim of this research is to explore the impacts of prenatal mental health issues on birth outcomes before and during the COVID-19 pandemic in Anhui, China. Insights generated through this work will help fill an existing knowledge gap in China and help stakeholders to gain a better understanding of how the pandemic could have impacted perinatal health.

A scoping review methodology was used in Chapter 2 to identify peer-reviewed articles published from late 2019 to the end of July 2021. After removing duplicates, 642 articles were identified, of which two full texts were included for analysis. Both articles highlighted that pregnant women have experienced increasing prenatal mental health issues during the COVID-19 pandemic and, further, increased risk of developing adverse birth outcomes. This scoping review highlighted that there is a lack of research on the impact of prenatal mental health issues on birth outcomes during the pandemic.

Study presented in Chapter 3 found that during the pandemic, the prevalence of prenatal depression and anxiety decreased compared to levels before the pandemic. The prevalence of adverse birth outcomes, including low birth weight, preterm birth and small for gestational age also slightly decreased after the pandemic occurred, but the differences were not significant and could be due to other factors, such as sample differences. Interestingly, this study showed that higher PHQ-9 measured depression scores were significantly associated with higher infant birth weights (β=5.51, 95% CI 0.21 to 10.81, p=0.042) and longer gestation age (β=0.02, 95% CI 0.001 to 0.04, p=0.03). Furthermore, EPDS measured prenatal depression and GAD-7 measured anxiety were not significantly associated with birth outcomes. In addition, findings also provided insights into prenatal mental health disorders and adverse birth outcomes by exploring the sociodemographic risk factors for prenatal depression and anxiety, preterm birth, low birth weight and small for gestational age before and during the pandemic in Anhui.

Preface

This thesis is a complication of an original work by Tianqi Zhao under the supervision of Dr. Shelby Yamamoto, Prof. Gian S. Jhangri and Dr. Shahirose S. Premji. The research presented in this thesis is part of two larger collaborative research projects involving screening and management of perinatal depression within primary care and investigating the impact of the COVID-19 pandemic on maternal and health care providers' psychosocial outcomes in China. Both projects were approved through the Research Ethics Boards of the University of Alberta (ethics numbers: Pro00099276; Pro00087163), University of Calgary (ethics numbers: Pro00099276_AME6; REB19-0336), York University (ethics numbers: 2020-117; 2018-179) and Anhui Medical University (ethics number: 2020H001). All women that participated in the study were offered mental health resources and the study supported those interested in counselling.

Chapter 2 has been published as Zhao, T.; Zuo, H.; Campbell, S.M.; Jhangri, G.S.; Dobson, K.S.; Li, J.Y.; Premji, S.S.; Tao, F.; Zhu, B.; Yamamoto, S.S. The Impacts of Prenatal Mental Health Issues on Birth Outcomes during the COVID-19 Pandemic: A Scoping Review. Int. J. Environ. Res. Public Health 2022, 19, 7670. https://doi.org/10.3390/ijerph19137670. Author contributions are as follows: T.Z., screening, data management, data analysis and manuscript writing; H.Z., screening and manuscript editing; S.M.C., searching, supervision and manuscript editing; G.S.J., supervision and manuscript editing; K.S.D., supervision and manuscript editing; J.Y.L., project administration and manuscript editing; S.S.P., supervision and manuscript editing; F.T., supervision and manuscript editing; B.Z., supervision and manuscript editing and S.S.Y., supervision and manuscript editing.

Acknowledgements

As an international student studying at University of Alberta, I acknowledge that I was situated within and worked towards this MSc on Treaty 6 Territory, a traditional gathering place for diverse Indigenous Peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dené, Ojibway/Saulteaux/Anishinaabe, and Inuit, and many others whose histories, languages, and cultures continue to influence our vibrant community.

My sincerest thanks to my committee, Dr. Shahirose Premji for your guidance and support in my master's thesis journey. Your encouragement, support, suggestion, and feedback have been important and essential in my growth as a researcher.

A special thanks to my two thesis supervisors, Dr. Shelby Yamamoto, and Prof. Gian S. Jhangri. Your endless kindness, support, patience, and encouragement made my master's study one of the most beautiful, joyful, and unforgettable experience in my life. During the study, there were many ups and downs, challenges and difficulties, your unconditional support gave me power when I was lost and gave me faith in myself to do better. I would never achieve what I have achieved today without you.

Thank you to everyone else in the research project, Dr. Keith Dobson, Dr. Fangbiao Tao, Dr. Beibei Zhu, Sandy Campbell, and Jessica Li for your support in the research. I would also like to thank all the participants that took the time to complete the surveys. I wish you and your babies all health and happiness during this critical time.

Thank you everyone in the CHEER Lab. Sammy Lowe, Ishwar Tiwari, Brooke Sidney, Shubham Chandras and Tapagni Chakraborty, thank you for being my collogues and friends through this journey. I enjoyed every moment we spent together in the office, the love and support we gave each other, have not only helped me to accomplish this work but have created such as a friendly, bright and cheerful environment at the CHEER Lab.

Thank you to the staff in the School of Public Health for the support throughout the program. It was a great experience to study here at School of Public Health, University of Alberta.

To the wonderful friends I have met in this journey, Hanxiao Zuo, Yiling Zhou, Haoxiang Wang, and Haofei Sun, it was my greatest pleasure to know you and be friends with you. You helped my survived this journey with your love, support, and encouragement. Your company made me feel like home in a foreign country. Cheers to our friendship!

Eleanor Mataruse, Theashni Gounden, and especially Lopiso Kabiso, the most important parts of my life back home in South Africa. Thank you for being my biggest supporters and gave me unconditional trust, love, and encouragement for many years. I would not have accomplished all these without you.

Grandparents, Mom, Dad, Kayle, Uncle, Aunt and Jialin, my beloved families, thank you so much for your endless love, support, faith in me and thank you for always holding my back unconditionally. You made all my little steps and achievements more meaningful. You are always the reasons that keep me going. I love you all!

Lastly, thanks to my two cute cats, Suancai and Nature, for being emotionally supportive during this journey.

Table of Contents

Abstract ..... **ii**

Preface ..... **iv**

Acknowledgements ..... **v**

List of Tables ..... **x**

List of Figures ..... **xi**

List of Abbreviations ..... **xii**

Chapter 1 Introduction **1**

COVID-19 Pandemic Overview *1*

Mental Health Disorders: The Emerging Concerns in China *1*

Mental Health and the COVID-19 Pandemic in China *2*

Women, Prenatal Mental Health Issues and COVID-19 ..... *2*

Adverse Birth Outcomes, Prenatal Mental Health Issues and COVID-19 ..... *4*

Aim, Objectives, and Outcomes *5*

Reference *6*

Chapter 2: The Impacts of Prenatal Mental Health Issues on Birth Outcomes During the COVID-19 Pandemic: A Scoping Review **11**

Abstract *12*

Introduction *13*

Materials and Methods *14*

Research Aim 14

Methods 14

Results *16*

Discussion *20*
Prenatal Mental Health Issues during the COVID-19 Pandemic 20
Prenatal Mental Health Issues and Adverse Birth Outcomes 21
Limitations 22
Conclusions *22*
Acknowledgements *24*
Supplementary Materials *24*
References *25*
Chapter 3. The Impact of Prenatal Depression and Anxiety on Birth Outcomes before and during the COVID-19 Pandemic in Anhui, China 28
Abstract *28*
Introduction *30*
Methodology *33*
Study Setting, Population and Data Collection 33
Exposures and Outcomes Measurement and Definition 33
Statistical Analysis 35
Ethical Considerations 38
Results *38*
Characteristics of Study Participants 38
Prenatal Depression and Anxiety 40
Birth Outcomes 55
Discussion *63*
Summary of Findings 63
Prevalence of Prenatal Depression and Anxiety 63
Risk factors of Prenatal Depression and Anxiety 65
Prevalence of Adverse Birth Outcomes 66
Impacts of Prenatal Depression and Anxiety on Birth Outcomes 68
Limitations 69

Conclusion *70*

Reference *72*

Chapter 4 Discussion and Conclusion **83**

Summary of Thesis Findings *84*

Contributions, Gaps and Future Directions *85*

Conclusion *86*

Reference *88*

Bibliography **91**

Appendices **112**

Appendix 1 PRISMA-S Checklist *113*

Appendix 2 Scoping Review Protocol *115*

Appendix 3 Detailed Searching Strings *128*

Appendix 4 References for Calculating Small for Gestational Age *136*

Appendix 5 Sub-analyses for Prenatal Depression and Anxiety using Multiple Logistic Regression *137*

List of Tables

Table 2.1 Study Characteristics of the Included Studies. 18

Table 3.1 Demographic Characteristics of Participants in Pre-pandemic Survey (n=1148) and Pandemic Survey (n=2249) 39

Table 3.2 Descriptive Statistics of Prenatal Depression and Anxiety for Pre-pandemic Survey (n=1148) and Pandemic Survey (n=2249) 42

Table 3.3 Univariate Linear RegressionAnalyses of Prenatal Depression and Anxiety for both Pre-pandemic and Pandemic Cohorts 43

Table 3.4 Multivariable Linear Regression Analyses of Prenatal Depression and Anxiety for both Pre-pandemic and Pandemic Cohorts 52

Table 3.5 Descriptive Statistics of Birth Outcomes for Pre-pandemic Survey (n=1148) and Pandemic Survey (n=2249) 55

Table 3.6 Univariate Analyses of Birth Outcomes for both Pre-pandemic and Pandemic Cohorts 57

Table 3.7 Multivariable Analyses of Birth Outcomes for both Pre-pandemic and Pandemic Cohorts 61

List of Figures

Figure 2.1 PRISMA flow diagram.....15
Figure 3.1 Psychosocial, biological, and behavioral model.....32
Figure 3.2 Chronic stress, types of stressors.....32

List of Abbreviations

95% CI	95% Confidence Interval
BMI	Body Mass Index
COVID-19	Coronavirus Disease 2019
DALYs	Disability-Adjusted Life-Years
EPDS	Edinburgh Postnatal Depression Scale
GAD-7	General Anxiety Disorder-7
GDP	Gross domestic product
ICSI	Intracytoplasmic Sperm Injection
IQR	Interquartile Range
IVF	In Vitro Fertilization
JBI	Joanna Briggs Institute
OR	Odds Ratio
PHQ-9	Patient Health Questionnaire-9
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SD	Standard Deviation
SGA	Small for Gestational Age
USA	United States of America
WHO	World Health Organization
YLDs	Years Lived with Disabilities

Chapter 1 Introduction

COVID-19 Pandemic Overview

On December 31, 2019, the World Health Organization (WHO) reported a cluster of "pneumonia of unknown cause" cases in Wuhan, Hubei province, China (1). Later on January 9, 2020, the WHO reported that Chinese authorities found that the outbreak was caused by a novel coronavirus, which was further named as "COVID-19" on February 11, 2020 (1). Since that time, COVID-19 has heavily impacted many other provinces of China, and has spread to 222 countries, areas, and territories (2). On March 11, 2020, WHO declared COVID-19 as a pandemic, relevant responses and strategic actions thereafter have been developed and mobilized to guide the world in combating the COVID-19 crisis (1). As of August 9, 2022, the cumulative infection cases were over 580 million, with nearly 6.5 million deaths globally (2). There were more than 5.8 million cumulative cases in China with more than 24,000 deaths (3). Anhui, a landlocked province in the East China region, boarded with Hubei province, the epicenter of the COVID-19 pandemic in China. As of August 7, 2022, Anhui has reported 1504 confirmed cases, with 6 deaths (4).

Mental Health Disorders: The Emerging Concerns in China

Mental health disorders are characterized by clinically significant disturbance in an individual's cognition, emotional regulation, or behavior (5). Mental health disorders, including depression and anxiety, are increasingly a global health priority (6). In 2017, approximately 792 million people suffered from some type of mental disorder (7). As of 2017, the prevalence of mental health disorders increased by 13%, compared to the past decade (8). More than 360 million people experience depressive symptoms or disorders and approximately 300 million people suffer from anxiety symptoms (7,9). Mental health disorders exert significant health, social and economic burdens, which has continued to grow over the years (5). More than 32% of years lived with disability (YLDs) and 13% of disability-adjusted life-years (DALYs) were attributed to mental health disorders (10). Depression and anxiety, the two most common mental health disorders, cost the global economy US$ 1 trillion every year (8).

In China, depression and anxiety are the two most prevalent mental health disorders, which have been increasing rapidly (11). This is a significant disease burden since China has almost one-fifth of the world's population (12). Studies showed a weighted lifetime prevalence of any mental disorder of 16.6%, and 7.4% for mood disorders, and the incidence of depressive disorders is 3.6% in China (11,12). WHO estimated that approximately 54 million people in China have depression and 41 million have anxiety disorders (5). Furthermore, in 2013 mental health disorders expenditures in China were 15% of total health expenditures, which is equivalent to 1.1% of China's Gross Domestic Product (GDP) (13). Despite the high burden of the disease, mental health is also a stigmatized topic in China (12). People consider mental health disorders as untreatable conditions, and there is often inadequate social support available in the community (14). People with such issues are concerned about sharing their feelings and would even feel ashamed of having mental health disorders, further preventing them from utilizing medical services and treatment to improve their mental health (12).

Mental Health and the COVID-19 Pandemic in China

Previous studies have shown that disasters and infectious disease outbreaks raise the risk of developing depression and anxiety (15). During the COVID-19 outbreak, the fear and anxiety about the new virus, uncertainty, and the unpredictability of the pandemic, as well as the implementation of lockdown and social distancing have resulted in increased psychosocial problems (16). In China, according to Wang et al., among 1210 participants from 194 cities, more than 50% of participants reported moderate or severe mental health issues due to the COVID-19 crisis (17). The overall prevalence of anxiety and depression was 35.1% and 20.1%, respectively (18). Another study conducted in Wuhan, the epicentre in China, reported that the prevalence of depression, anxiety and combination of depression and anxiety was 48.3%, 22.6% and 19.4%, respectively (19).

Women, Prenatal Mental Health Issues and COVID-19

Women, on average compared to men, experience 1.3 to 1.5 times higher odds of developing mental health disorders, especially mood and anxiety disorders (20). Pregnancy, a critical time for women, leads them into the motherhood stage of their lives. During pregnancy, women face different changes, including biological, psychological, and status transitions in family and society.

These changes can be overwhelming and lead to some types of mental health symptoms and disorders (21). Depression and anxiety are the common causes of morbidity among pregnant women (22). Postnatal mental health disorders have been largely studied, while fewer studies have focused on prenatal mental health issues (21,23). There is growing evidence highlighting the importance of prenatal mental health issues, with some literature reporting that the prevalence of prenatal mental health disorders is higher compared to during postnatal periods (24,25). Globally, the prevalence of anxiety and depression during pregnancy is approximately 18.2%-24.6% and 7.4%-12.8%, respectively (24). In China, the prevalence of prenatal depression has been reported as 3.6%-40.2% and prenatal anxiety was 1.8%-42.1% (21). This is also the highest among other countries (14). A meta-analysis including 95 studies among 23 regions in mainland China reported that Anhui province had the highest prevalence of perinatal depression (33%) (14,26). Furthermore, prenatal depression influences health care utilization, including increased non-scheduled prenatal care and emergency pregnancy-related care (26,27). These could further lead to higher burdens in the Chinese health care system.

During the COVID-19 pandemic, pregnant women may at higher risk of experiencing mental health disorders (15). For instance, a survey conducted in Belgium among 5866 participants reported that the prevalence of depressive symptoms among pregnant women during the COVID-19 crisis was 25.3%, compared to 8.0-11.1% before the pandemic (28,29). In China, one study suggested that the level of depression among pregnant women has increased significantly compared to the period before the COVID-19 crisis (30). This study also showed that the proportion of depression among pregnant women was estimated at around 50.6% during the pandemic, with nearly 27% of the pregnant women experiencing moderate to severe depression (30). However, there were also some studies that reported contradictory results. For instance, a longitudinal study conducted in China reported non-significant differences in anxiety and depression during the pandemic (17). In other countries, a reduction in the rates of prenatal depression and anxiety had also been reported (31,32). Therefore, these inconclusive results highlighted the needs for further investigation on how prenatal mental disorders have changed since the pandemic occurred.

Adverse Birth Outcomes, Prenatal Mental Health Issues and COVID-19

Adverse birth outcomes, including low birth weight, preterm birth, and small for gestational age are the leading causes of infant morbidity and mortality (33). These adverse birth outcomes increase the risks of developing neurological damage, respiratory diseases, visual and hearing impairment, as well as later life morbidities, such as stunting, mental retardation and even cerebral palsy (34). Preterm birth refers to live birth that occurs before 37 weeks of gestation (35). Globally, approximately 14.9 million preterm births occurred in 2010, which accounts for 11.1% of total live births (36). Preterm birth exerts a critical burden on global health (77 million disability-adjusted life-years), which is comparable to that of HIV and malaria (37). Low birth weight is defined as infants born with a weight under 2500 grams. In 2015, approximately 20.5 million babies were born with low birth weight globally (38). Low birth weight is also associated with an increased risk of infant mortality and morbidity (39). In China, a retrospective study conducted in 2011, involving 39 hospitals across 14 provinces and regions reported an incidence rate of 7.2% for low birth weight (40). Small for gestational age infants are the ones born with weights that are below the 10th percentile for infants of the same gestational age (33). In 2010, approximately 32.4 million infants were born small for gestational age in low- and middle-income countries (37). A study conducted in Guangdong involving nearly 3 million live births reported that the estimated rate of preterm birth, low birth weight and small for gestational age was 4.2%, 4.1% and 12.9%, respectively (40).

Prenatal depression and anxiety are associated with adverse birth outcomes, including preterm birth, low birth weight, and small for gestational age (21). According to Ding et al., women who have experienced maternal anxiety have 1.5 times higher risk of preterm birth and are 1.8 times more likely to have low birth weight infants (39). Stressful events and conditions can compound the risk of adverse birth outcomes, including preterm birth and low birth weight (41). Dancause et al. suggested that during disasters, an increase in adverse birth outcomes could be potentially due to stress-related pathways (42). For instance, the 9/11 attack was a particularly stressful event for many people (41). After the event, there were increases in both very low birth weight (<1500g) and low birth weight (<2500g) infants in New York City (43). Thus, since the COVID-19 pandemic is also a serious public health crisis, pregnant women might be at higher risk of experiencing adverse birth outcomes.

Overall, the rate of prenatal mental health disorders and related adverse pregnancy outcomes are likely to change during the pandemic in China, possibly adding further burdens to the current healthcare system in China. However, there are few and inconsistent results around how prenatal mental disorders and birth outcomes might have changed since the pandemic. Furthermore, to our knowledge, the impact of prenatal mental health issues on adverse birth outcomes during the COVID-19 pandemic in China has also not been well explored. Therefore, it is important to carry out research on exploring the differences in prenatal mental disorders and adverse birth outcomes between pre-pandemic and pandemic periods, and to study the impacts of those mental disorders on birth outcomes in China.

Aim, Objectives, and Outcomes

Research Aim: This thesis is part of larger collaborative research that was focused on perinatal mental health and started pre-pandemic. When the pandemic occurred, we realized that assessing and addressing the psychosocial impacts of COVD-19 among pregnant women was necessary to include in this research. The aim of this study is to explore the impacts of prenatal mental health issues on birth outcomes before and during the COVID-19 pandemic in Ma'anshan, Anhui, China.

Research Questions:

1. What are the risk factors associated with prenatal mental health issues (depression and anxiety) before and during the COVID-19 pandemic in Ma'anshan, Anhui, China?
2. What are the impacts of prenatal mental health issues on birth outcomes before and during the COVID-19 pandemic in Ma'anshan, Anhui, China?

Research Objectives:

1. To assess and compare the prevalence of perinatal depression and anxiety among mothers in Ma'anshan, Anhui, China before and during the pandemic, and further explore associated variables.
2. To investigate the association between prenatal depression and anxiety and birth outcomes before and during the pandemic in Ma'anshan, Anhui, China.

Reference

1. World Health Orgnasiztion. Timeline: WHO's COVID-19 response [Internet]. [cited 2022 Feb 7]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

2. World Health Orgnasiztion. WHO Coronavirus (COVID-19) Dashboard [Internet]. [cited 2022 Feb 7]. Available from: https://covid19.who.int

3. China: WHO Coronavirus Disease (COVID-19) Dashboard With Vaccination Data [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

4. Coronavirus COVID-19 (2019-nCoV) [Internet]. [cited 2022 Aug 9]. Available from: https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6

5. World Health Orgnasiztion. Mental disorders [Internet]. [cited 2021 Jul 25]. Available from: https://www.who.int/news-room/fact-sheets/detail/mental-disorders

6. Mental Health - PAHO/WHO | Pan American Health Organization [Internet]. [cited 2022 Aug 9]. Available from: https://www.paho.org/en/topics/mental-health

7. Hannah Ritchie, Max Roser. Mental Health - Our World in Data [Internet]. [cited 2021 Jul 25]. Available from: https://ourworldindata.org/mental-health

8. Mental health [Internet]. [cited 2022 Aug 9]. Available from: https://www.who.int/health-topics/mental-health

9. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018 Nov 10;392(10159):1789–858.

10. Vigo D, Thornicroft G, Atun R. Estimating the true global burden of mental illness. The Lancet Psychiatry. 2016 Feb;3(2):171–8.

11. Huang Y, Wang Y, Wang H, Liu Z, Yu X, Yan J, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. The Lancet Psychiatry. 2019 Mar 1;6(3):211–24.

12. Yang F, Yang BX, Stone TE, Wang XQ, Zhou Y, Zhang J, et al. Stigma towards depression in a community-based sample in China. Comprehensive Psychiatry. 2020 Feb 1;97:152152.

13. Xu J, Wang J, Wimo A, Qiu C. The economic burden of mental disorders in China, 2005–2013: implications for health policy. BMC Psychiatry. 2016 May 11;16(1):137.

14. Nisar A, Yin J, Waqas A, Bai X, Wang D, Rahman A, et al. Prevalence of perinatal depression and its determinants in Mainland China: A systematic review and meta-analysis. Journal of Affective Disorders. 2020 Dec 1;277:1022–37.

15. Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. Journal of Affective Disorders. 2020 Aug;273:5–13.

16. Moreno C, Wykes T, Galderisi S, Nordentoft M, Crossley N, Jones N, et al. How mental health care should change as a consequence of the COVID-19 pandemic. Lancet Psychiatry. 2020 Sep;7(9):813–24.

17. Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. Int J Environ Res Public Health. 2020 Mar 6;17(5):E1729.

18. Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. Psychiatry Research. 2020 Jun 1;288:112954.

19. Gao J, Zheng P, Jia Y, Chen H, Mao Y, Chen S, et al. Mental health problems and social media exposure during COVID-19 outbreak. PLOS ONE. 2020 Apr 16;15(4):e0231924.

20. Eaton NR, Keyes KM, Krueger RF, Balsis S, Skodol AE, Markon KE, et al. An invariant dimensional liability model of gender differences in mental disorder prevalence: Evidence from a national sample. Journal of Abnormal Psychology. 2012;121(1):282–8.

21. Tang X, Lu Z, Hu D, Zhong X. Influencing factors for prenatal Stress, anxiety and depression in early pregnancy among women in Chongqing, China. Journal of Affective Disorders. 2019 Jun 15;253:292–302.

22. Woody CA, Ferrari AJ, Siskind DJ, Whiteford HA, Harris MG. A systematic review and meta-regression of the prevalence and incidence of perinatal depression. J Affect Disord. 2017 Sep;219:86–92.

23. Howard LM, Molyneaux E, Dennis CL, Rochat T, Stein A, Milgrom J. Non-psychotic mental disorders in the perinatal period. The Lancet. 2014 Nov 15;384(9956):1775–88.

24. Dennis CL, Falah-Hassani K, Shiri R. Prevalence of antenatal and postnatal anxiety: Systematic review and meta-analysis. The British Journal of Psychiatry. 2017 May;210(5):315–23.

25. Sidebottom AC, Hellerstedt WL, Harrison PA, Hennrikus D. An examination of prenatal and postpartum depressive symptoms among women served by urban community health centers. Arch Womens Ment Health. 2014 Feb 1;17(1):27–40.

26. Premji SS, Dobson KS, Prashad A, Yamamoto S, Tao F, Zhu B, et al. What stakeholders think: perceptions of perinatal depression and screening in China's primary care system. BMC Pregnancy and Childbirth. 2021 Jan 6;21(1):15.

27. CGHE. Perinatal Depression Screening in China [Internet]. GACD. [cited 2022 Aug 15]. Available from: https://www.gacd.org/community/research-network/projects/mh09

28. Ceulemans M, Hompes T, Foulon V. Mental health status of pregnant and breastfeeding women during the COVID-19 pandemic: A call for action. International Journal of Gynecology & Obstetrics. 2020;151(1):146–7.

29. Hompes T, Izzi B, Gellens E, Morreels M, Fieuws S, Pexsters A, et al. Investigating the influence of maternal cortisol and emotional state during pregnancy on the DNA methylation status of the glucocorticoid receptor gene (NR3C1) promoter region in cord blood. Journal of Psychiatric Research. 2013 Jul 1;47(7):880–91.

30. Dong H, Hu R, Huang G, Zhang M, Lu C, Huang D, et al. Investigation on the mental health status of pregnant women in China during the Pandemic of COVID-19. Arch Gynecol Obstet. 2021;303(2):463–9.

31. Ayaz R, Hocaoğlu M, Günay T, Yardımcı O devrim, Turgut A, Karateke A. Anxiety and depression symptoms in the same pregnant women before and during the COVID-19 pandemic. Journal of Perinatal Medicine. 2020 Nov;48(9):965–70.

32. Overbeck G, Rasmussen IS, Siersma V, Andersen JH, Kragstrup J, Wilson P, et al. Depression and anxiety symptoms in pregnant women in Denmark during COVID-19. Scand J Public Health. 2021 Nov;49(7):721–9.

33. Ngo TV, Gammeltoft T, Nguyen HTT, Meyrowitsch DW, Rasch V. Antenatal depressive symptoms and adverse birth outcomes in Hanoi, Vietnam. PLOS ONE. 2018 Nov 2;13(11):e0206650.

34. Lin L, Lu C, Chen W, Li C, Guo VY. Parity and the risks of adverse birth outcomes: a retrospective study among Chinese. BMC Pregnancy and Childbirth. 2021 Mar 26;21(1):257.

35. Preterm birth [Internet]. [cited 2022 Feb 15]. Available from: https://www.who.int/news-room/fact-sheets/detail/preterm-birth

36. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal R, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012 Jun 9;379(9832):2162–72.

37. Lee ACC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, et al. National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. Lancet Glob Health. 2013 Jul;1(1):e26-36.

38. Low birthweight [Internet]. UNICEF DATA. [cited 2021 Nov 24]. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/

39. Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

40. Miao H, Li B, Li W, Yao F, Chen Y, Chen R, et al. Adverse birth outcomes in Guangdong province, China, 2014–2017: a spatiotemporal analysis of 2.9 million births. BMJ Open. 2019 Nov;9(11):e030629.

41. Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, et al. The Effects of the World Trade Center Event on Birth Outcomes among Term Deliveries at Three Lower Manhattan Hospitals. Environ Health Perspect. 2004 Dec;112(17):1772–8.

42. Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

43. Harville E, Xiong X, Buekens P. Disasters and Perinatal Health: A Systematic Review. Obstet Gynecol Surv. 2010 Nov;65(11):713–28.

Chapter 2: The Impacts of Prenatal Mental Health Issues on Birth Outcomes During the COVID-19 Pandemic: A Scoping Review

Tianqi Zhao [1], Hanxiao Zuo [1], Sandra M. Campbell [1], Gian S. Jhangri [1], Keith S. Dobson [2], Jessica Yijia Li [2], Shahirose S. Premji [3], Fangbiao Tao [4], Beibei Zhu [4] and Shelby S. Yamamoto [1]

Int. J. Environ. Res. Public Health **2022**, *19*(13), 7670; **https://doi.org/10.3390/ijerph19137670**

Received: 2 May 2022 / Revised: 17 June 2022 / Accepted: 21 June 2022 / Published: 23 June 2022

[1] School of Public Health, University of Alberta, Edmonton, AB T6G 1C9, Canada

[2] Department of Psychology, Faculty of Arts, University of Calgary, Calgary, AB T2N 1N4, Canada

[3] School of Nursing, Faculty of Health, York University, Toronto, ON M3J 1P3, Canada

[4] Department of Maternal, Child and Adolescent Health, School of Public Health, Anhui Medical University, Hefei, 230038, China

Abstract

Background: The severity of the COVID-19 pandemic is likely to exacerbate mental health problems during the prenatal period and increase the risk of adverse birth outcomes. This review assessed the published literature related to the impacts of prenatal mental health issues on birth outcomes during the COVID-19 pandemic.

Methods: This scoping review was conducted using PROSPERO, Cochrane Library, OVID Medline, Ovid EMBASE, OVID PsycInfo, EBSCO CINAHL, and SCOPUS. The search was conducted using controlled vocabulary and keywords representing the concepts "COVID19", "mental health" and "birth outcomes". The main inclusion criteria were peer-reviewed published articles from late 2019 to the end of July 2021.

Results and Discussion: After removing duplicates, 642 articles were identified, of which two full texts were included for analysis. Both articles highlighted that pregnant women have experienced increasing prenatal mental health issues during the COVID-19 pandemic and, further, increased the risk of developing adverse births. This scoping review highlighted that there is a lack of research on the impact of prenatal mental health issues on birth outcomes during the pandemic.

Conclusion: Given the severity of the COVID-19 pandemic and the burdens of prenatal mental health issues and adverse birth outcomes, there is an urgent need to conduct further research.

Keywords: *prenatal mental health; depression; anxiety; birth outcomes; preterm birth; low birth weight; small for gestational age; COVID-19*

Introduction

Adverse birth outcomes, including low birth weight, preterm birth and small for gestational age, are the leading causes of infant morbidity and mortality (1). Worldwide, 75% of neonatal mortality and morbidity is due to adverse birth outcomes (2). Prenatal depression and anxiety increase the risk of adverse birth outcomes, such as preterm birth, low birth weight and small for gestational age (3). According to Ding et al., women who have experienced maternal anxiety are 1.50 times more at risk of preterm birth and 1.76 times more likely to have low birth weight infants (4).

On 11 March 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) outbreak as a public health emergency of international concern (5). As of January 11, 2021, the WHO reported that the cumulative infection cases worldwide have reached nearly 309 million people, with a total of more than 5 million deaths (6). Studies have shown that infectious disease outbreaks raise the risk of developing depression and anxiety (3). A survey conducted in Belgium among 5866 participants reported that the prevalence of depressive symptoms among pregnant women during the COVID-19 crisis was 25.3%, and this number had increased dramatically from 8.0% to 11.1% before the pandemic (7,8). Such stressful events and conditions may also have negative impacts on birth outcomes, including preterm birth and low birth weight, and this could be due to stress-related physiological pathways during disasters (9,10).

The severity of the COVID-19 pandemic is likely to be an added burden to prenatal mental health problems and, thus, increase the risk of adverse birth outcomes. In order to address potential burdens, it is important to explore the potential impacts of prenatal mental health issues on birth outcomes during the COVID-19 pandemic. However, since the declaration of the COVID-19 pandemic, there have been limited reviews focused on prenatal mental health and its impact on adverse birth outcomes during the COVID-19 pandemic.

Materials and Methods

Research Aim

Purpose: This scoping review was developed to map the current literature linking prenatal mental health issues and adverse birth outcomes during the COVID-19 pandemic and to inform the relevant research and policy development.

Guiding questions: What are the impacts of prenatal mental health issues on birth outcomes during the COVID-19 pandemic?

Objective: To assess the published literature related to the impacts of prenatal mental health issues, which include symptoms of stress, anxiety and depression during pregnancy, on the adverse birth outcomes of preterm birth, low birth weight, small for gestational age, birth defects and macrosomia during the COVID-19 pandemic.

Methods

Search Strategy

An expert health sciences librarian (SC) from the University of Alberta developed our search strategy and executed the final search. Seven databases were searched, including PROSPERO, Cochrane Library (CDSR and Central Register of Controlled Trials), OVID Medline, OVID EMBASE, OVID PsycInfo, EBSCO CINAHL and SCOPUS. The search was conducted using controlled vocabulary (e.g., MeSH, Emtree, etc.) and keywords representing the concepts "COVID19" and "mental health" and "birth outcomes". The search included variations of search filters from the John W. Scott Health Sciences Library Search Filters (10–14). All searches were conducted in July 2021 and adjusted appropriately for different databases. The scope was limited to articles from late 2019 to the present to capture the COVID-19 pandemic period. No other limits were applied. Our search identified a total of 894 records. All records were exported to the COVIDENCE systematic review program. We removed 252 duplicates, leaving 642 unique records. The detailed search strategies and results from each database are available in the Supplementary Materials.

Screening

Only peer-reviewed and published articles were included in this review. All titles and abstracts were screened for relevance by two independent reviewers (TZ and HZ). Articles that potentially discussed COVID-19 in relation to mental health, pregnant women who gave birth during the COVID-19 pandemic and birth outcomes were kept for further full-text screening. The title and abstract screening process identified 636 irrelevant records and left 6 records that met all inclusion criteria for full-text reviews.

The full-text screening was conducted by two independent reviewers (TZ and HZ). Articles that clearly discussed the targeted content were included for data extraction. Four studies were excluded at this stage, as they did not focus on our outcomes of interest, leaving two records for data extraction. Snowball searching of the final two eligible studies was also conducted, but no additional eligible studies were discovered. Figure 2.1 presents the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram to show our search strategy and results. Table A1 in Appendix 1 presents the PRISMA-S checklist of this scoping review.

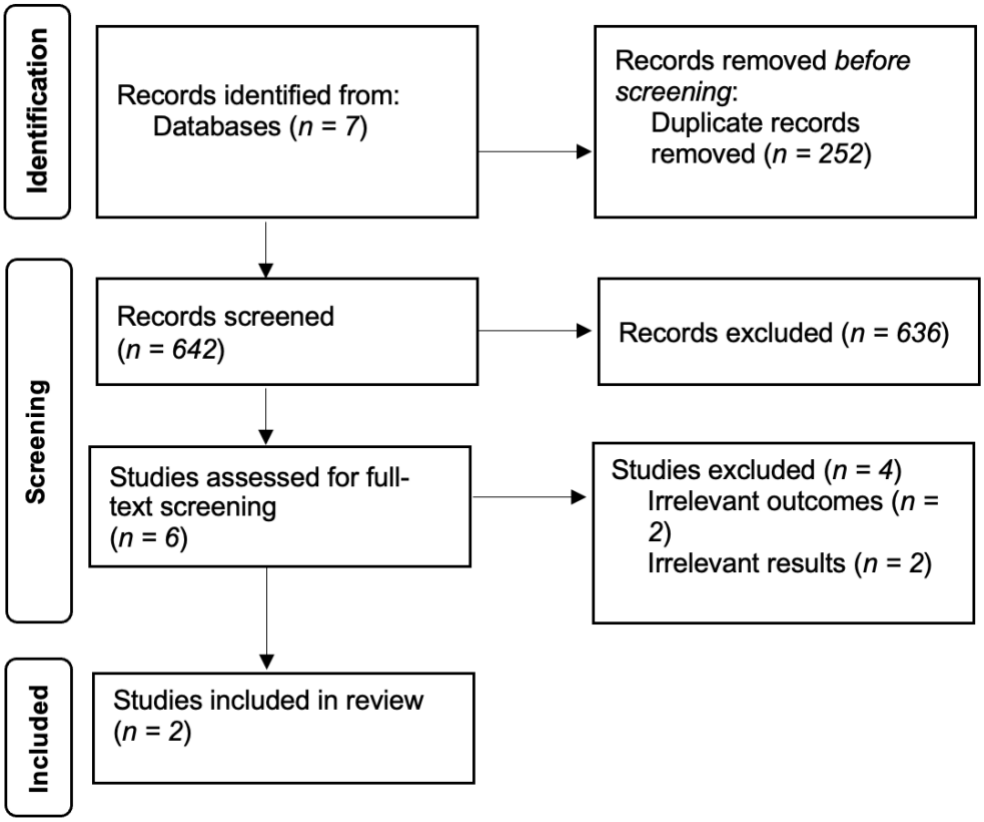


Figure 2.1 PRISMA flow diagram.

Data Extraction

Data extraction was performed following the Joanna Briggs Institute (JBI) recommendations to capture the data. In the data extraction spreadsheet, the information extracted included authors, year of publication, country of origin, study aims, study design, population and sample size, methods, outcomes and key findings that related to the scoping review questions.

Results

We identified two relevant articles (see Table 2.1). Preis et al. conducted a study in 2020 using a prospective cohort design (15). They focused on pregnant women across the USA aged 18 years and above. Wdowiak et al. conducted a study in Poland in 2020, where longitudinal data was used, with the target population being pregnant women who received care from medical facilities in the city of Lublin (16). Both articles found that, during the COVID-19 pandemic, there was an association between prenatal mental health disorders and adverse birth outcomes, but they approached the research from different perspectives. Whether or not such associations differed from the pre-pandemic period was not mentioned. In addition, macrosomia and birth defects were not found in this review.

Preis et al. investigated whether experiencing stress during pregnancy at the beginning of the pandemic was associated with a higher prevalence of adverse prenatal outcomes (see Table 2.1) (15). This study showed that preterm birth was predicted by elevated prenatal maternal stress (15). In this study, prenatal maternal stress was measured using the Revised Prenatal Distress Questionnaire (15). The risk of preterm birth increased by 40% with experiences of prenatal maternal stress (15). Overall, 1% of the variance in preterm birth and 3% in small for gestational age were attributed to elevated stress over and above other relevant maternal sociodemographic and medical characteristics (15). Preparedness stress was found to be another factor that affected birth outcomes (15). Preparedness stress refers to stressful feelings of not being prepared for birth or postpartum, as a result of the pandemic. It was measured using the Pandemic-Related Pregnancy Stress Scale (15). This study shows that the risk of delivering a small gestational age infant was 66% higher among women who reported higher preparedness stress (15).

Wdowiak et al. focused on evaluating the effect of the COVID-19 pandemic on depression and whether the course of pregnancy and infant well-being would be affected by depression and the COVID-19 pandemic (see Table 2.1) (16). The study used the Beck Depression Inventory (the second edition) twice during the pregnancy (first between weeks 11 and 14, and then on week 32) among the same population to assess the depressive symptoms (16). The study showed that the severity of depression during weeks 10–13 (i.e., first trimester) and week 32 (i.e., third trimester) were significantly different from the depression severity in the second trimester, which also correlated with the COVID-19 pandemic (16). Additionally, the severity of depression was also dependent on the interaction between the pre-pregnancy Body Mass Index (BMI) and the COVID-19 pandemic (16). Moreover, the depression severity was negatively associated with gestational age and birth weight (16). More severe depression and higher pre-pregnancy BMI were associated with lower gestational age at birth and lower birth weight (16). Wdowiak et al. reported that the average birth weight and gestational age at birth were lower during the COVID-19 pandemic compared to the pre-pandemic measures: women who experienced the COVID-19 pandemic, on average, had 0.87 weeks less gestational age at delivery ($p = 0.001$), and their infants, on average, were 184.7 g lighter ($p = 0.01$), compared to infants born before the pandemic (16).

Table 2.1 Study Characteristics of the Included Studies.

Citation	Study Setting	Study Date	Mental Health Measure	Outcome Measure	Study Sample	Study Design	Main Results	Other Relevant Results
Preis, Mahaffey, Pati, Heiselman, & Lobel (2021) [15]	The USA	April–August, 2020	Pandemic-Related Pregnancy Stress (preparedness stress and perinatal infection stress) were measured using the Pandemic-Related Pregnancy Stress Scale; Scores calculated as mean response to items on a scale of 1 (very little) to 5 (very much) Prenatal maternal stress was assessed using the Revised Prenatal Distress Questionnaire; Scores calculated as mean response to items on a scale of 0 (not at all) to 2 (very much) General Anxiety Symptoms were assessed using the Generalized Anxiety Disorder-7; Scores calculated as the summing up scores of the responses. The cut-offs are: 0–4 minimal anxiety; 5–9 mild anxiety; 10–14 moderate anxiety; 15–21 severe anxiety	Preterm birth: gestational age at delivery less than 37 weeks. Small for gestational age: new-born weight less than 10th percentile for gestational age at delivery referring to WHO standards.	Pregnant women across the USA aged 18 years old and above N = 1367	Prospective cohort study	More than half (58.0%) of the participants reported canceled or altered appointments due to the pandemic; 40.5% experienced pandemic-related income loss; 30.3% experienced major life events during the pregnancy. Preterm birth rate among the participants: 7.1% (n = 97). Rate of delivering SGA infants: 8.6% (n = 252). Prenatal maternal stress increased the risk of preterm delivery by 40%, and explained 1% of the variance in preterm birth. Stress explained 3% of variance in SGA, and giving birth to an SGA infant was 66% greater among mothers who reported high preparedness stress.	Women who had an SGA infant are more likely to report stress than the ones who did not have an SGA infant. Outcomes were significantly related to the COVID-19 diagnosis, sociodemographic factors and medical risk factors. SGA was more than 5 times higher among women who were diagnosed with COVID-19. Anxiety symptoms, infection stress, discrimination and income loss were not related to adverse birth outcomes from the univariate analyses.

Wdowiak et al. (2021) (16)	Lublin, Poland	Longitudinal data were obtained between 1 January 2019 and 15 March 2019; 1 January 2020 and 15 March 2020	Depressive symptoms were assessed using Beck depression inventory second edition. It consists of 21 self-report questions scored from 0 to 3, the summing up score used to measure the severity of depression. The cut-offs are: 0–11 score (lack of depression); 12–19 score (mild depression); 20–25 score (severe depression	Birth outcomes were assessed using the following variables: gestational age at delivery, fetal weight and APGAR score	N = 280 (100 women with normal weight, 100 overweight women, 50 with Class 1 obesity and 30 with Class 2 obesity).	Longitudinal Study	The severity of depression was significantly higher during than before the pandemic. Women who experienced the COVID-19 pandemic on average had 0.87 week less on gestational age at delivery (p-value: 0.001) and their infants on average were 184.72 g lighter (p-value: 0.01) compared to those before the pandemic. Pre-pregnancy BMI and severity of depression in week 32 are associated with lower birth weight. The higher the pre-pregnancy BMI and the severity of depression, the lower the gestational age at delivery;	During the pandemic, pre-pregnancy BMI was positively correlated with level of depression in weeks 10–13 ($r = 0.526$, $p < 0.001$) and week 32 ($r = 0.539$, $p < 0.001$). The odds of lower APGAR (5 or 6) were significantly higher during COVID-19 pandemic than before it (OR:3.18. p-value: 0.009). Women with higher pre-pregnancy BMI and higher severity of depression during pregnancy have higher odds of lower APGAR.

Discussion

This scoping review assessed the state of the literature on prenatal mental health disorders' impacts on adverse birth outcomes during the COVID-19 pandemic. After reviewing the identified articles, we found that very few studies explored the association between prenatal mental health issues and adverse birth outcomes during the COVID-19 pandemic. This limited literature may be due to timing. The pandemic began early in 2020, but for prenatal mental health issues to develop and to study the impacts on adverse birth outcomes require a relatively long follow-up period. Additionally, in order to understand the unique impacts of the pandemic, longitudinal data are often needed for comparison with trends in the previous years. As the onset of the pandemic occurred relatively quickly, there might be little time to collect the longitudinal data; thus, longitudinal studies might not have been a feasible choice to assess the association.

Although limited, the published literature has demonstrated that prenatal mental health issues may have a negative impact on birth outcomes during the COVID-19 pandemic. Both articles highlighted that pregnant women experienced prenatal mental health issues, including stress, depressive symptoms and anxiety during the COVID-19 pandemic. Moreover, both articles reported that experiencing such mental health issues increased the risk of developing adverse birth outcomes, including preterm birth, low birth weight and small for gestational age (15,16).

Prenatal Mental Health Issues during the COVID-19 Pandemic

Pregnant women are likely to experience heightened mental health issues during any stressful events, including the COVID-19 pandemic. As the two studies reported, the average levels of prenatal maternal stress and depression have been higher during the pandemic compared to the levels before the pandemic (15,16). Similarly, a study conducted in Poland reported that the pandemic and related restrictions exaggerated the prevalence of prenatal anxiety from 15% pre-COVID-19 pandemic to 38% during the pandemic (17). There are three potential reasons for the exacerbation of prenatal stressors and mental health issues during the pandemic. Firstly, increasing worries and stress could be related to uncertainty regarding the effects of COVID-19 on maternal–fetal health and pregnancy. Women may feel uncertain about the effect of the virus on themselves, their fetuses and their infants (15). Secondly, higher stress was also likely due to pandemic restrictions. Preis et al. stated that 58.0% of the participants reported canceled or altered

appointments due to the pandemic, which compounded uncertainties around fetal–infant health and delivery (15). Wdowiak et al. also hypothesized that physical distancing guidelines and social isolation would negatively impact mothers' mental health, elevating the depressive symptoms, anxiety, insomnia and stress (16). Furthermore, Preis et al. also reported that 40.5% of their participants experienced a pandemic-related income loss and suggested that pandemic-related financial strain was another factor that negatively affected mothers' health (15). The above results are consistent with other similar studies. For instance, Thayer and Gildner found that 43% of their participants reported financial stress due to the pandemic, which was significantly associated with the elevated depression scores among the pregnant women in their study (18).

Prenatal Mental Health Issues and Adverse Birth Outcomes

Both articles reported significant associations between prenatal mental health issues and adverse birth outcomes during the COVID-19 crisis. Preis et al. reported that pandemic-related stress was significantly associated with higher risks of preterm birth and the delivery of small for gestational age infants and also suggested that being infected with COVID-19 was a strong independent predictor of SGA infants, as infected mothers are more likely to experience higher stress (15). Furthermore, Wdowiak et al. observed that the intensification of prenatal depressive symptoms was positively associated with low-birth-weight infants during the pandemic (16). Such findings are consistent with previous studies, which have suggested that maternal stress exposure is related to preterm birth, as explained by the stress-related hypothesis (19,20). However, in Preis's study, they also found that the overall rate of preterm birth was lower than it was among the U.S. population in 2019 (7.1% and 10.2%, respectively) (15). Preis et al. suggested it could be due to the exclusion of the youths who are under 18 years old in their sample, since younger age is one of the risk factors for preterm birth (15). Similarly, there was some evidence also suggesting a reduction in adverse birth outcomes during the COVID-19 pandemic. For instance, the overall rate of preterm birth and SGA were lower during the COVID-19 pandemic compared to similar time periods in 2017–2019 in Botswana (21). In Ireland, the rate of very low-birth-weight infants also reduced from 8.2 to 2.2 per 1000 live births during the COVID-19 lockdown period, compared to the periods prior to the pandemic (22). This could also be explained by stress-related pathways. Philip et al. suggested that such reductions could contribute to "unparalleled and widespread socioenvironmental alterations to which pregnant women would have responded with appropriate

behavioral and lifestyle modifications" (22). For instance, the lockdown restrictions likely resulted in mothers resting at home and not working, in some instances. Women may also have received more partner and family support during their pregnancy compared to the pre-pandemic periods. These may have reduced their stress anxiety and depression levels of being pregnant, especially during the pandemic, and likely resulted in better infant health (22). On the other hand, pandemic-related stress and anxiety could increase the risk of adverse birth outcomes from increased financial, family or other strains (15). Therefore, the relationship between prenatal mental health with adverse birth outcomes during the pandemic may be a little more nuanced. Despite the association between prenatal mental health issues and adverse birth outcomes, there is a need to further investigate other potential mediators and impact factors beyond mental health issues. Furthermore, the differences in the associations between pandemic and non-pandemic periods were not mentioned in either of the included articles.

Limitations

This review has potential limitations. The two reviewed studies are from high-income countries. The results might not be generalizable to low- and middle-income countries or other population groups. Although Preis et al. suggested that African-American women and other women of color are at higher risk of experiencing higher pandemic-related stress and adverse birth outcomes, it remains unknown if the same trend applies to mothers from other historically disadvantaged groups during the COVID-19 pandemic (15). Furthermore, this review did not observe any changes in the associations between prenatal mental health measures and adverse birth outcomes during the pandemic period compared to pre-pandemic periods. In addition, this review included a study with a relatively small sample size (i.e., 280 participants), so the results might not be generalizable to larger populations.

Conclusions

This scoping review highlighted that the existing knowledge on the impact of prenatal mental health issues on birth outcomes during the COVID-19 pandemic is not yet well-established. Given these early results, which show the negative effects of prenatal mental health issues on birth outcomes during the pandemic, there is an urgent need for continued research exploring and

addressing prenatal mental health issues and related adverse birth outcomes during the COVID-19 pandemic.

Acknowledgements

Author Contributions: T.Z., screening, data management, data analysis and manuscript writing; H.Z., screening and manuscript editing; S.M.C., searching, supervision and manuscript editing; G.S.J., supervision and manuscript editing; K.S.D., supervision and manuscript editing; J.Y.L., project administration and manuscript editing; S.S.P., supervision and manuscript editing; F.T., supervision and manuscript editing; B.Z., supervision and manuscript editing and S.S.Y., supervision and manuscript editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Canadian Institutes of Health Research, grant number RN419823–439880, Alberta Innovates and National Natural Sciences Foundation of China, grant number 81761128034.

Supplementary Materials

The PRISMA checklist (Table A1), scoping review protocol and detailed searching string (Table A2) are available in Appendix 1, Appendix 2 and Appendix 3, respectively.

References

1. Ngo TV, Gammeltoft T, Nguyen HTT, Meyrowitsch DW, Rasch V. Antenatal depressive symptoms and adverse birth outcomes in Hanoi, Vietnam. PLOS ONE. 2018 Nov 2;13(11):e0206650.

2. Tamirat KS, Sisay MM, Tesema GA, Tessema ZT. Determinants of adverse birth outcome in Sub-Saharan Africa: analysis of recent demographic and health surveys. BMC Public Health. 2021 Jun 7;21(1):1092.

3. Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. Journal of Affective Disorders. 2020 Aug;273:5–13.

4. Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

5. World Health Orgnasiztion. Timeline: WHO's COVID-19 response [Internet]. [cited 2022 Feb 7]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

6. World Health Orgnasiztion. WHO Coronavirus (COVID-19) Dashboard [Internet]. [cited 2022 Feb 7]. Available from: https://covid19.who.int

7. Ceulemans M, Foulon V, Ngo E, Panchaud A, Winterfeld U, Pomar L, et al. Mental health status of pregnant and breastfeeding women during the COVID-19 pandemic-A multinational cross-sectional study. Acta Obstet Gynecol Scand. 2021;100(7):1219–29.

8. Hompes T, Izzi B, Gellens E, Morreels M, Fieuws S, Pexsters A, et al. Investigating the influence of maternal cortisol and emotional state during pregnancy on the DNA methylation status of the glucocorticoid receptor gene (NR3C1) promoter region in cord blood. Journal of Psychiatric Research. 2013 Jul 1;47(7):880–91.

9. Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

10. Campbell S. Search Hedge to Retrieve Studies related to COVID-19 from the EBSCO CINAHL Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/17w4RulQkUjJnAeIVyvLalCHPudBqobIlE8Qhtll5qTA/edit?usp=embed_facebook

11. Campbell S. earch Hedge to Retrieve Studies related to COVID-19 from the SCOPUS Database [Internet]. John W. Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/16r1ChRPvy2spv6yZYbJVzQut0r5wr0AolZuFXgw3HIw/edit?usp=embed_facebook

12. Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID EMBASE Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1TEJrJsh1HUKszA5BoGvr8YoeCHlNCA8sw3ekw--ylLQ/edit

13. Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID PsycInfo Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1u2tWwOAlfNjun1bXsc4TUe6A9MMt8Y2Fmj0R49qDXKs/edit

14. Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID MEDLINE Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1VQnOBmBAwAT5fkqQfxtQgvmCbXqC3ZpDtxo-v24yvIQ/edit?usp=embed_facebook

15. Preis H, Mahaffey B, Pati S, Heiselman C, Lobel M. Adverse Perinatal Outcomes Predicted by Prenatal Maternal Stress Among U.S. Women at the COVID-19 Pandemic Onset. Ann Behav Med. 2021;55(3):179–91.

16. Wdowiak A, Makara-Studzinska M, Raczkiewicz D, Janczyk P, Slabuszewska-Jozwiak A, Wdowiak-Filip A, et al. Effect of excessive body weight and emotional disorders on the course of pregnancy and well-being of a newborn before and during covid-19 pandemic. J Clin Med. 2021;10(4):1–16.

17. Nowacka U, Kozlowski S, Issat T, Januszewski M, Jakimiuk A, Sierdzinski J. Covid-19 pandemic-related anxiety in pregnant women. Int J Environ Res Public Health. 2021;18(14):7221.

18. Thayer ZM, Gildner TE. COVID-19-related financial stress associated with higher likelihood of depression among pregnant women living in the United States. American Journal of Human Biology. 2021;33(3):e23508.

19. Smits L, Krabbendam L, de Bie R, Essed G, van Os J. Lower birth weight of Dutch neonates who were in utero at the time of the 9/11 attacks. Journal of Psychosomatic Research. 2006 Nov 1;61(5):715–7.

20. Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, et al. The Effects of the World Trade Center Event on Birth Outcomes among Term Deliveries at Three Lower Manhattan Hospitals. Environ Health Perspect. 2004 Dec;112(17):1772–8.

21. Caniglia EC, Magosi LE, Zash R, Diseko M, Mayondi G, Mabuta J, et al. Modest reduction in adverse birth outcomes following the COVID-19 lockdown. Am J Obstet Gynecol. 2021 Jun;224(6):615.e1-615.e12.

22. Philip RK, Purtill H, Reidy E, Daly M, Imcha M, McGrath D, et al. Unprecedented reduction in births of very low birthweight (VLBW) and extremely low birthweight (ELBW) infants during the COVID-19 lockdown in Ireland: a 'natural experiment' allowing analysis of data from the prior two decades. BMJ Glob Health. 2020 Sep 30;5(9):e003075.

Chapter 3. The Impact of Prenatal Depression and Anxiety on Birth Outcomes before and during the COVID-19 Pandemic in Anhui, China

Abstract

Background: Adverse birth outcomes, including preterm birth, low birth weight, and small for gestational age, remain challenging public health problems in China. Prenatal depression and anxiety have been found to be associated with adverse birth outcomes. There is increasing evidence highlighting the importance and severity of prenatal depression and anxiety in the Chinese context. The COVID-19 pandemic is likely to further exacerbate mental health problems during the prenatal period and increase the risk of adverse birth outcomes. The aim of this research is to explore the impacts of prenatal mental health issues on birth outcomes before and during the COVID-19 pandemic in Ma'anshan, Anhui, China.

Method: This study was conducted in Ma'anshan, Anhui, China. Participants were women who visited local maternity and child healthcare hospitals. Two independent sets of individual maternal data were collected. Prenatal depression and anxiety were measured using Edinburgh Postnatal Depression Scale (EPDS), Patient Health Questionnaire-9 (PHQ-9) and General Anxiety Disorder-7 (GAD-7) via online questionnaires. Adverse birth outcomes were determined using hospital-recorded infants' birth weight and gestational age at delivery. Univariate and multivariable linear and logistic regression were used for the analyses.

Result: During the pandemic, the prevalence of prenatal depression and anxiety decreased compared to levels before the pandemic (prenatal depression,18.6%-48.0% to 14.5%-28.9%; prenatal anxiety 36.3%-26.7%). The prevalence of adverse birth outcomes had slightly decreased

after the pandemic occurred, but the differences were not significant. Interestingly, this study showed that higher PHQ-9 measured depression scores were significantly associated with higher infant birth weights (β=5.51, 95% CI 0.21 to 10.81, p=0.042) and longer gestation age (β=0.02, 95% CI 0.001 to 0.04, p=0.03). Furthermore, EPDS measured prenatal depression and GAD-7 measured anxiety were not significantly associated with birth outcomes. Additionally, findings also provided insights into prenatal mental health disorders and adverse birth outcomes by exploring the sociodemographic factors for prenatal depression and anxiety, preterm birth, low birth weight and small for gestational age before and during the pandemic in Anhui. Unfortunately, due to the differences in the two populations, the changes in risk factors before and during the pandemic need further investigation.

Conclusion: This study highlighted the impacts of prenatal depression and anxiety on birth outcomes before and during the pandemic in Anhui, China. However, it remains unclear why the prevalence of prenatal depression, anxiety and adverse birth outcomes has reduced since the pandemic occurred. Evidence is lacking when it comes to understanding why the association between prenatal mental health disorders and birth outcomes were not significant in some studies but were in others in the Chinese context.

Introduction

On March 11, 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) as a public health emergency of international concern (1). COVID-19 has heavily impacted more than 222 countries, areas, and territories (2). It has become an unprecedented global crisis. As of August 9, 2022, there were more than 580 million cumulative infection cases, with nearly 6.5 million deaths globally (2). China was reported to have more than 5.8 million cumulative cases with more than 24,000 deaths (3).

In China, the weighted lifetime prevalence of any mental health disorder is 16.6% (4). This represents a significant burden of mental health disorders. Depression and anxiety are the two most common mental health issues in China and have been increasing rapidly over the years (5). Despite the high personal burden, not everyone with mental health disorders will obtain professional treatment. This is because stigma toward mental health disorders is a barrier and may prevent people from seeking help (4). A large proportion of Chinese people still hold high levels of stigmatizing attitudes toward mental health issues (4). On average, women experience 1.4 times higher odds of depression compared to men in China (6). During pregnancy, women face biological changes, psychological changes and status transitions in both family and society (7). These lead to a higher risk of prenatal depression and anxiety among pregnant women. Although many studies only focused on postnatal mental health issues, there is increasing research that has reported the importance and severity of prenatal mental health issues in China. China has a high rate of prenatal depression and anxiety among other countries (8). For instance, a study reported that the prevalence of prenatal depression was between 3.6% to 40.2%, and prenatal anxiety was between 1.8% to 42.1% (7) compared to the global average 18.2% to 24.6% for prenatal depression and 7.4% to 12.8 for prenatal anxiety (9). Moreover, prenatal depression also increases the utilization of health care services, including non-scheduled prenatal care and emergency services (10,11), which may increase the burden on China's health care systems during this critical time.

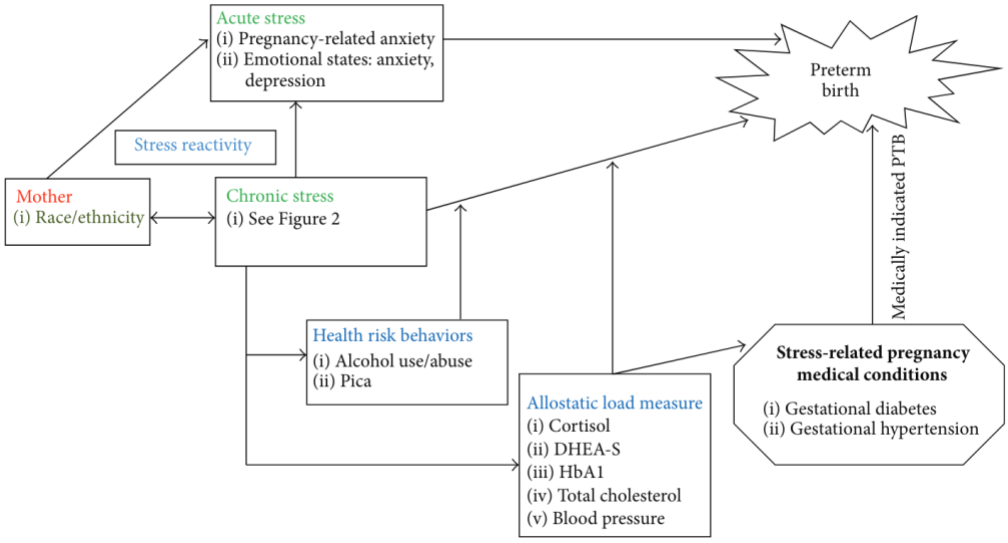
Previous studies have reported that infectious disease outbreaks could increase the risk of developing depression and anxiety. Thus, pregnant women could be at even higher risk of developing prenatal depression and anxiety during the COVID-19 pandemic. In China, a study suggested that the level of depression among pregnant women has significantly increased during

the COVID-19 pandemic (50.6%) compared to the period before the pandemic (3.5% to 8.2%), and nearly 27% of the pregnant women experiencing moderate to severe depression (12). Another study reported the estimated prevalence of prenatal anxiety increased from 15.2% pre-pandemically to 37.0% during the pandemic (13). Both studies highlighted that the rates of prenatal mental health issues have increased since the declaration of the pandemic (12,13).

Preterm birth, low birth weight and small for gestational age are the leading causes of neonatal deaths and under-five mortality (14,15). These adverse birth outcomes increase the risks of developing neurological damage, respiratory diseases, visual and hearing impairment, as well as later life morbidities (16). In China, the overall estimated prevalence of low birth weight was 5.2% in 2013, and the rate of preterm birth was 6.9% in 2014 (17,18). A more recent study conducted in Guangzhou, China reported the prevalence of preterm birth was 4.2%, 4.1% for low birth weight and 12.9% for small for gestational age among 3 million live births (19).

Prenatal depression and anxiety are associated with adverse birth outcomes, including preterm birth, low birth weight, and small for gestational age (7). A study reported that women who have prenatal anxiety experience 1.5 times higher risks of preterm birth and 1.8 times higher risk of delivering low-birth-weight infants (20). Triggers can be stressful events that increase the risk of developing preterm birth and low birth weight (21). For example, Dancause et al. suggested that such increases in adverse birth outcomes during disasters could possibly be due to stress-related pathways (22). The mechanisms of the association between prenatal stress, depression and anxiety and adverse birth outcomes can be complicated. It involves the link between the individual's psychological, biological, and behavioural aspects. According to Premji et al., a psychobiobehavioral model could further explain the association between prenatal depression and anxiety and adverse birth outcomes from four perspectives (23). First, not all women experienced prenatal stress, depression and anxiety will have adverse birth outcomes due to individual differences in stress reactivity (23). Second, "biological response patterns expressed as a cumulative physiologic burden, such as allostatic load (23). Allostatic load is measured using a set of biomarkers, including blood pressure, cholesterols etc. (23). Increased blood pressure, for instance, could increase the risk of developing adverse birth outcomes (23). Moreover, behavioral responses and interactive feedback effects also play important roles in this model explaining the pathways between prenatal mental health issues

and adverse birth outcomes. Overall, pregnant women could be at higher risk of experiencing prenatal depression and anxiety during the pandemic, which would further increase the risk of developing low birth weight, preterm birth and small for gestational age infants. Figure 3.1 shows the psychobiobehavioral model using preterm birth as an example to describe the possible pathways between prenatal mental health issues and adverse birth outcomes. Figure 3.2 shows the chronic stressors that was mentioned in Figure 3.1.



[1]Dehydroepiandrosterone sulfate; [2]hemoglobin subunit alpha 1; [3]Preterm Birth

Figure 3.1 Psychosocial, biological, and behavioral model (23).

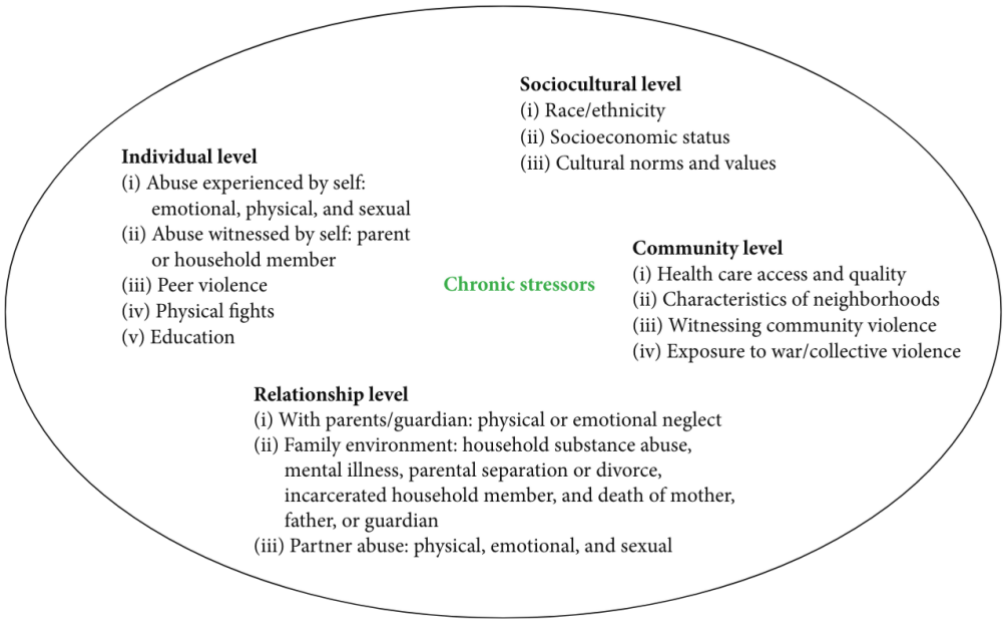


Figure 3.2 Chronic stress, types of stressors (23).

To our knowledge, there was no study simultaneously exploring the impacts of prenatal depression and anxiety on birth outcomes before and during the pandemic in China (24). Thus, this study aims to start to fill this gap. The results from this epidemiological study aim to highlight key research concerning the psychosocial impacts of the COVID-19 pandemic among pregnant women to help mitigate adverse birth outcomes during pandemics.

Methodology

Study Setting, Population and Data Collection

This study was done in Ma'anshan, Anhui, China. Anhui is a landlocked province in the East China region, bordered by Hubei province, the epicentre of the COVID-19 pandemic in China. As of August 7, 2022, Anhui has reported 1504 confirmed cases, with 6 deaths (25). Anhui has the highest prevalence of perinatal depression (33%) in mainland China according to a meta-analysis including 95 studies and 23 regions in China (8,10).

Participants were women who visited local maternity and child healthcare hospitals. Two independent sets of individual maternal data were collected. Pre-pandemic data (n=1148) was collected between May and September 2019, and pandemic data (n=2249) was collected between April and August 2020. This baseline data was collected as part of a larger project focused on implementing a prenatal depression screening and management program. In these two datasets, sociodemographic, prenatal depression and anxiety measures were collected using self-administered questionnaires. All the data was stored on a secure server. Birth outcome measurements were collected through medical records.

Exposures and Outcomes Measurement and Definition

Measurement of Prenatal Mental Health Issues

In both datasets, prenatal depression and anxiety were evaluated using three main tools: Edinburgh Postnatal Depression Scale (EPDS), Patient Health Questionnaire-9 (PHQ-9) and General Anxiety Disorder-7 (GAD-7). These were collected using online questionnaires.

EPDS is the most frequently used screening tool for prenatal depression (26). It is a 10-item self-report questionnaire that measures the emotional expression over the last 7 days. Each question has four options, with a range of 0 to 3 points (0 lowest, 3 highest) based on the seriousness of the symptom. Items 3, and 5 to 10 are reverse scored (0 highest, 3 lowest). EPDS scale has been validated in different cultures including China, and the cut-off value of 9 reflects depressive symptomatology in the Chinese population (sensitivity 80.0%; specificity 83.0%) (27,28). In the study, participants with EPDS scores ≥9 were defined as having depression. The severity of depression was classified by the total scores according to the following: no depression (0-8), mild depression (9-11), moderate depression (12-13), and severe depression (≥14).

PHQ-9 is used to detect major depressive disorders, and this measure has also been used in Chinese population and studies on pregnant women and was found to be reliable to assess depression symptoms and their severity (29). Nine items about typical depression symptoms over the past 2 weeks were measured on a four-point Likert-type scale: 0 = never, 1 = several days, 2 = more than half of the days, and 3 = nearly every day. A cut-off score of 5 or higher was used to define anxiety symptoms in the Chinese population (sensitivity 88.0%; specificity 86.0%) (30). In this study, the severity of depression was classified by the total scores according to the following: no depressive symptoms (0-4), mild (5-9), moderate (10- 14), severe (15-19), and extreme severe (20-27).

GAD-7 is the screening tool to assess patients' anxiety symptoms for the past two weeks (31). It has been confirmed to be a reliable tool to assess anxiety among the Chinese population and pregnant women (32,33). Seven items with typical anxiety symptoms over the past 2 weeks were measured on a 4-point Likert-type scale: 0 = never, 1 = several days, 2 = more than half of the days, and 3 = nearly every day. A cut-off score of 5 or higher was considered to indicate anxiety (34). In this study, the severity of anxiety was classified as follows: mild (5-9), moderate (10-14), and severe (15-21).

Measurement of Birth Outcomes

The main birth outcome measures were birth weight and gestational age at delivery which was extracted from hospital records. These data were used to further determine adverse birth outcomes including low birth weight, preterm birth and small for gestational age as follows:

Low birth weight is defined as infants born with a weight under 2500 grams (35). Moreover, the severity of low birth weight was broken down into low birth weight (birth weight greater or equal to 1500 grams but less than 2500 grams), very low birth weight (birth weight greater or equal to 1000 grams but less than 1500 grams) and extremely low birth weight (birth weight less than 1000 grams) (35).

Small for gestational age infants are those born with a weight that is below the 10th percentile for infants of the same gestational age (36). In this study, small for gestational age was defined based on the newly updated growth standard curves of birth weight, length, and head circumference of Chinese newborns of different gestations (37). As shown in Table A3 (Appendix 4) boys and girls were calculated separately based on their gestational age and the 10^{th} percentile reference weights.

Preterm birth is when the gestational week at delivery is less than the 37th week (38). Infants born with less than 37 gestation weeks were defined as preterm birth. Moreover, the severity of preterm birth was further categorized into moderate to late preterm birth (gestational age greater or equal to 32 weeks but less than 37 weeks), very preterm birth (gestational age greater or equal to 28 weeks but less than 32 weeks), and extreme preterm birth (gestational age less than 28 weeks) (38).

Statistical Analysis

There were four statistical analysis steps in this study, which were descriptive statistics analyses, univariate analyses, analyses of risk factors for prenatal depression and anxiety, and analyses of the relationship between prenatal depression and anxiety and birth outcomes. All statistical analyses were performed using STATA/BE 17.0. A p-value<0.05 was considered statistically significant.

Descriptive Statistics

Descriptive statistics summarized the distribution of socio-demographic characteristics of mothers, mothers' prenatal depression and anxiety, low birth weight, preterm birth and small for gestational age. Categorical sociodemographic characteristics, including ethnicity, residential area, marital status, household income, education, employment, smoking, passive smoking, alcohol

consumption, attitudes toward this pregnancy, how did the pregnancy occur, history of adverse birth outcomes, history of being diagnosed with mental health issues, history of using drugs, whether or not this was the first pregnancy, and whether or not this was the first child, were reported as counts and percentages. Continuous characteristics, including age, body weight before pregnancy, and body mass index (BMI) before pregnancy, were reported as means with standard deviations (SD). Discrete variables, including the number of people in the household and the economic status compared to people around them, were reported as median with an interquartile range. Prenatal depression and anxiety were reported in two ways: 1) the continuous scores of each measurement (EPDS, PHQ-9 and GAD-7) were reported as means and SDs. 2) prenatal depression and anxiety were also further broken down into different levels using the cut-off points described above and were reported as counts and percentages. Birth outcomes were also reported in two different ways: 1) the continuous measurements of body weight and gestational age were normally distributed and reported as means and SDs. 2) low birth weight, preterm birth, and small for gestational age were reported as categorical measurements with counts and percentages. Additionally, t-tests were used to compare the mean EPDS scores, PHQ-9 scores, GAD-7 scores, birth weights and gestational age between the pre-pandemic and pandemic cohorts. Chi-square tests were used to compare the categorical variables between the two cohorts.

Univariate Analysis

Several univariate analyses were performed to examine associations between individual demographic characteristics with prenatal depression and anxiety and birth outcomes for both cohorts. Linear regression was used to analyze the association between scores of prenatal EPDS, PHQ-9 and GAD-7, birth weight and gestational age and risk factors. Logistic regression was used to analyze the association between the binary outcomes (i.e., depression measured by EPDS, PHQ-9; anxiety measured by GAD-7; small for gestational age) and risk factors.

Multivariable Analysis

Multivariable linear regression analysis was used in both cohorts to examine the risk factors associated with prenatal depression and anxiety scores. In addition, sub-analyses were performed using multivariable logistic regression in both datasets to examine the risk factors for prenatal depression and anxiety (binary outcomes) based on the cut-off values discussed above. Results are

as shown in Appendix 5, Table A4 and Table A5. As for birth outcomes, multivariable linear regression analysis was used in both datasets to examine the association between prenatal depression and anxiety and birth outcomes (birth weights and gestational age). Multivariable logistic regression analysis was then performed to examine the association between prenatal depression and anxiety and small for gestational age. Additionally, in the models investigating the association between prenatal depression and anxiety and birth outcomes, prenatal depression measured by EPDS, prenatal depression measured by PHQ-9 and prenatal anxiety were fitted in the model separately.

In both multivariable logistic regression and multivariable linear regression, the first model consisted of potential covariates identified in the univariate analysis (p-values<0.2). A collinearity check was performed using variance inflation factors (VIF). If VIF were greater than 10, the most plausible variable was selected, or if of interest, the variables were analyzed separately. No collinearity was detected in this step. Then the full model was run and variables with the highest p-values≥0.05 were removed one at a time from the model. If a variable was removed from the model due to statistical non-significance, the confounding effect on other risk factors was checked. The examination of confounders was primarily based on the change in regression coefficients. If the change was greater than 15%, the variable was considered a potential confounder. In this study, we also took absolute changes in the coefficients into consideration. In cases where the change in percentage was greater than 15%, but the absolute change was very small (i.e., a change of 0.001 in EPDS scores, which ranged from 0 to 30), we did consider such variables as confounders. Whenever a confounder was confirmed between any two variables, both were retained in the model. Then the variable with the next highest statistically non-significant p-value was considered for elimination. This iterative process of variable elimination and retention persisted until the best main effects model was obtained. Additionally, no significant interactions were relevant to add to the model in this study. Residual analyses were performed to ensure assumptions of linearity, independence, normality, and homoscedasticity were met for the multivariable linear regression model. For logistic regression, the Hosmer-Lemeshow test was used for testing the goodness of fit.

Ethical Considerations

This study falls under the ethics approval of two larger research projects involving screening and management of perinatal depression within primary care and investigating the impact of the COVID-19 pandemic on maternal and healthcare providers' psychosocial outcomes in China. Both projects were approved through the Research Ethics Boards of the University of Alberta (ethics numbers: Pro00099276; Pro00087163), University of Calgary (ethics numbers: Pro00099276_AME6; REB19-0336), York University (ethics numbers: 2020-117; 2018-179) and Anhui Medical University (ethics number: 2020H001). All women that participated in the study were offered mental health resources and the study supported those interested in counselling.

Results

Characteristics of Study Participants

A total of 3438 participants were recruited for the study. Among these participants, 1189 of them were recruited before the pandemic (May to September 2019) with 1148 of them responding to the survey, and 2249 participants were recruited and responded to the survey during the pandemic (April to August 2020). The mean age of the two cohorts was almost the same, 28.2 (SD 4.1) years for pre-pandemic participants and 28.4 (SD 4.4) years among the pandemic participants). However, the pre-pandemic cohort reported a higher rate of not being married (6.4%) than the pandemic cohort (0.9%). Furthermore, the pandemic cohort had a higher rate of unemployment (49.2%) than the pre-pandemic cohort (41.7%). As for education, participants from the pre-pandemic cohort reported a higher rate of obtaining undergraduate degrees or equivalent and higher (i.e., Master's/PhD) (62.9%) than the pandemic cohort (57.7%). All the participants were assessed for their exposures to smoking and passive smoking. Both surveys reported most participants had never smoked (pre-pandemic: n=1097, 95.6%; pandemic: n=1824, 98.8%). However, there was a difference in exposure to passive smoking between the two cohorts. In the pre-pandemic cohort, most of the participants reported they sometimes had been exposed to passive smoking (n=593, 51.7%), while in the pandemic cohort, most of the participants reported they has never been exposed to passive smoking (n=1193, 65.1%). As for alcohol consumption, the pandemic cohort had a much higher rate of drinking (97.2%) compared to the pre-pandemic cohort (86.5%). The demographic characteristics of study participants are presented in Table 3.1.

Table 3.1 Demographic Characteristics of Participants in Pre-pandemic Survey (n=1148) and Pandemic Survey (n=2249)

Characteristics	*Pre-Pandemic (n=1148)*				*Pandemic (n=2249)*				*P-value*
	Mean (SD)	**Median (IQR)**	**Min**	**Max**	**Mean (SD)**	**Median (IQR)**	**Min**	**Max**	
Age (years)	28.2 (4.1)	-	18	42	28.4 (4.4)	-	18	46	0.199
BMI (kg/m2)	21.6 (3.2)	-	15	39	21.9 (3.4)	-	11.8	38	0.013
Socioeconomic Status [1]	-	5 (5-6)	1	10	-	6 (5-7)	1	10	<0.001
Number of People in the Household	-	3 (2-4)	1	10	-	3 (2-4)	1	10	0.001
	n	**%**			**n**	**%**			***P-value***
Ethnicity									
Han	1129	98.8			2210	98.4			0.388
Other (Hui and other ethnicities)	14	1.2			36	1.6			
Residential Area									
Urban	1007	87.7			1549	83.2			0.001
Rural	141	12.3			312	16.8			
Marital Status									
Married	1075	93.6			1837	99.1			<0.001
Not Married (Divorced/Separated/single/cohabit/ widow)	73	6.4			17	0.9			
Household Income (Yuan)									
<50,000	127	11.1			124	7.1			
50,00-100,000	436	38.0			440	25.3			
100,000-200,000	423	36.9			838	48.2			<0.001
200,000-300,000	104	9.1			241	13.9			
>300,000	58	5.1			94	5.4			
Education									
Middle school and lower	198	17.3			356	19.2			
High school or equivalent	228	19.9			429	23.1			0.017
Undergraduate or equivalent and higher	722	62.9			1070	57.7			
Employment									
Unemployed	479	41.7			910	49.2			<0.001
Employed (full-time/part-time/on paid leave)	669	58.3			941	50.8			
Smoking Status									
Never smoke	1097	95.6			1824	98.8			<0.001
Used to or still smoking	51	4.4			23	1.3			
Passive Smoking									
Never	359	31.3			1193	65.1			
Sometimes	593	51.7			488	26.6			<0.001
Almost everyday	196	17.1			152	8.3			
Alcohol consumption									
No [2]	993	86.5			1782	97.2			<0.001
Yes	155	13.5			52	2.8			
Attitude toward this pregnancy									
Acceptable	549	47.8			864	46.9			
Unexpected	255	22.2			453	24.6			0.310
Well-prepared	344	30.0			525	28.5			
Types of conception									
Non-Assisted conception	1071	93.3			1780	96.7			<0.001
Assisted conception (IVF [3] */ICSI* [4] */other)*	77	6.7			61	3.3			
History of adverse pregnancy outcomes [5]									
No	908	79.1			1495	83.6			0.002
Yes	240	20.9			294	16.4			
History of mental health issues									
No	1138	99.1			1803	98.1			0.024
Yes	10	0.9			35	1.9			
History of using drugs									
Never	1131	98.5			1817	99.1			0.123
Used to or still use	17	1.5			16	0.9			
Do you have kids before this pregnancy?									
No	728	63.4			1363	60.6			0.115
Yes	420	36.6			885	39.4			
Number of times being pregnant									
First time pregnant	499	43.5			969	43.1			
Second time	338	29.4			691	30.8			0.738
Third time	188	16.4			340	15.1			
Fourth time and above	123	10.7			247	11.0			

[1]*Economic status compared to people around the participant, with 0 as the lowest and 10 the highest.*

[2]*No alcohol consumption is defined as not more than one drink of either 340ml of beer or 140ml of wine or 43ml of Chinese Baijiu.*

[3]*In vitro fertilization*

[4]*Intracytoplasmic sperm injection*

[5]*Adverse pregnancy outcomes include miscarriage, stillbirth, perinatal mortality, and birth defects.*

Prenatal Depression and Anxiety

Descriptive Statistics

Before the pandemic, the mean EPDS scores and PHQ-9 scores were 5.8 (SD 3.4) and 5.2 (SD 4.0), respectively. During the pandemic, the mean EPDS scores and PHQ-9 scores were 5.4 (SD 3.3) and 3.5 (SD 3.6), respectively, which were significantly lower than the pre-pandemic cohort. The prevalence of prenatal depression was lower across both measures in the pandemic cohort compared to the pre-pandemic cohort. The prevalence of prenatal depression measured by EPDS was 14.5%, which was 4.1% lower than it was in the pre-pandemic cohort (18.6%). PHQ-9 measured depression was 28.9% in the pandemic cohort, which was nearly halved of the pre-pandemic cohort (48.0%). Furthermore, the rates of different levels of depression severities measured by EPDS and PHQ-9 was also lower in the pandemic cohort compared to the pre-pandemic cohort. The detailed breakdown of counts and percentages of different levels of severities are presented in Table 3.2.

As for prenatal anxiety, a similar trend appeared. The mean GAD-7 scores were significantly higher in the pre-pandemic cohort (3.8, SD 3.4) than it was in the pandemic cohort (2.9, SD 2.9). The prevalence of prenatal anxiety measured by GAD-7 was also higher in the pre-pandemic cohort (36.3%) than it was in the pandemic cohort (26.7%). Moreover, the rates of different levels of anxiety severity measured by GAD-7 were also lower in the pandemic cohort compared to the pre-pandemic cohort. The detailed breakdown of counts and percentages of different levels of severities are presented in Table 3.2.

Univariate Analyses of Parental Depression and Anxiety

Before the pandemic occurred, socioeconomic status, marital status, smoking, alcohol consumption, and the attitude toward the pregnancy were significantly associated with prenatal depression in the univariate models. Additionally, history of mental health issues, drug use, number of people in the

household, residential area, income, education, employment, and number of times being pregnant were significantly associated with EPDS measured depression, and passive smoke was associated with PHQ-9 measured depression in the univariate models. Furthermore, marital status, smoking, passive smoking, alcohol consumption and attitude toward the pregnancy were found to be statistically significant associated with prenatal anxiety. The detailed result of the univariate analyses is presented in Table 3.3.

During the pandemic, age, socioeconomic status, number of people in the household, residential area, marital status, education, employment, passive smoking, alcohol consumption, attitude toward the pregnancy, history of mental health issues and number of people in the household were significantly associated with prenatal depression in the univariate models. In addition, the residential area was associated with EPDS measured depression, and smoking was associated with PHQ-9 measured depression in the univariate models. Furthermore, age, socioeconomic status, number of people in the household, marital status, smoking, passive smoking, alcohol consumption, history of adverse pregnancy outcomes, history of mental health issues and whether they had children before the pregnancy was significantly associated with prenatal anxiety. The detailed result of the univariate analyses is presented in Table 3.3.

Table 3.2 Descriptive Statistics of Prenatal Depression and Anxiety for Pre-pandemic Survey (n=1148) and Pandemic Survey (n=2249)

Characteristics	*Pre-Pandemic (n=1148)*			*During-Pandemic (n=2249)*			*P-value*
	Mean (SD)	**Min**	**Max**	**Mean (SD)**	**Min**	**Max**	
EPDS scores	5.8 (3.4)	0	22	5.4 (3.3)	0	30	0.001
PHQ-9 scores	5.2 (4.0)	0	24	3.5 (3.6)	0	27	<0.001
GAD-7 scores	3.8 (3.4)	0	21	2.9 (2.9)	0	21	<0.001
	n		**%**	**n**		**%**	***P-value***
Prenatal Depression Measured by EPDS							
No (0-8)	934		81.4	1923		85.5	0.002
Yes (≥ 9)	214		18.6	326		14.5	
Severity of Prenatal Depression Measured by EPDS							
No (0-8)	934		81.4	1923		85.5	0.020
Mild depression (9-11)	142		12.4	220		9.8	
Moderate depression (12-13)	38		3.3	56		2.5	
Severe depression (≥ 14)	34		3.0	50		2.2	
Prenatal Depression Measured by PHQ-9							
No (0-4)	597		52.0	1599		71.1	<0.001
Yes (≥ 5)	551		48.0	650		28.9	
Severity of Prenatal Depression Measured by PHQ-9							
No (0-4)	597		52.0	1599		71.1	<0.001
Mild depression (5-9)	390		34.0	491		21.8	
Moderate depression (10-14)	125		10.9	122		5.4	
Severe depression (15-19)	28		2.4	27		1.2	
Extreme severe depression (20-27)	8		0.7	10		0.4	
Prenatal Depression Measured by GAD-7							
No (0-4)	731		63.7	1649		73.3	<0.001
Yes (≥ 5)	417		36.3	600		26.7	
Severity of Prenatal Anxiety Measured by GAD-7							
No (0-4)	731		63.7	1649		73.3	<0.001
Mild anxiety (5-9)	358		31.2	550		24.5	
Moderate anxiety (10-14)	44		3.8	40		1.8	
Severe anxiety (15-21)	15		1.3	10		0.4	

Table 3.3 Univariate Linear Regression Analyses of Prenatal Depression and Anxiety for both Pre-pandemic and Pandemic Cohorts

Pre-Pandemic (n=1148)									
	Depression Measured by EPDS			Depression Measured by PHQ-7			Prenatal Anxiety Measured by GAD-7		
Characteristics	*Coeff.*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*
Age (years)	-0.04	(-0.09, 0.003)	0.068	-0.02	(-0.07, 0.04)	0.56	-0.05	(-0.09, 0.001)	0.053
BMI (kg/m2)	-0.03	(-0.09, 0.03)	0.357	-0.02	(-0.09, 0.06)	0.655	-0.04	(-0.10, 0.03)	0.261
Socioeconomic Status[1]	-0.33	(-0.46, -0.19)	<0.001	-0.20	(-0.36, -0.04)	0.015	-0.16	(-0.29, -0.02)	0.200
Number of People in the Household	0.35	(0.18, 0.51)	<0.001	0.17	(-0.03, 0.37)	0.096	0.09	(-0.08, 0.26)	0.305
Ethnicity									
Han		Reference			Reference			Reference	
Other (Hui and other ethnicities)	-0.24	(-2.02, 1.54)	0.794	0.11	(-2.02, 2.24)	0.918	-0.04	(-1.81, 1.73)	0.966
Residential Area									
Urban		Reference			Reference			Reference	
Rural	0.62	(0.02, 1.21)	0.042	0.21	(-0.50, 0.93)	0.554	-0.05	(-0.64, 0.54)	0.863
Marital Status									
Married		Reference			Reference			Reference	
Not Married (Divorced/separated/single/cohabit/widow)	1.79	(1.00, 2.59)	<0.001	1.43	(0.48, 2.39)	0.003	1.46	(0.67, 2.25)	<0.001
Household Income (Yuan)									
<50,000		Reference			Reference			Reference	
50,00-100,000	-0.65	(-1.31, 0.01)	0.055	-0.41	(-1.21, 0.39)	0.314	0.04	(-0.62, 0.71)	0.901
100,000-200,000	-1.04	(-1.71, -0.38)	0.002	-0.60	(-1.40, 0.21)	0.145	-0.13	(-0.79, 0.54)	0.707
200,000-300,000	-0.63	(-1.51, 0.24)	0.153	-0.06	(-1.11, 0.98)	0.908	0.52	(-0.36, 1.39)	0.246
>300,000	-1.55	(-2.59, -0.51)	0.004	-0.87	(-2.12, 0.39)	0.176	-0.29	(-1.34, 0.75)	0.581
Education									
Middle school and lower		Reference			Reference			Reference	
High school or equivalent	-0.24	(-0.88, 0.40)	0.464	0.11	(-0.66, 0.88)	0.777	-0.22	(-0.86, 0.42)	0.496
Undergraduate or equivalent and higher	-1.00	(-1.52, -0.47)	<0.001	-0.18	(-0.82, 0.46)	0.578	-0.11	(-0.64, 0.42)	0.687
Employment									

Unemployed		Reference			Reference			Reference	
Employed (full-time/part-time/on paid leave)	-0.67	(-1.06, -0.27)	0.001	-0.41	(-0.88, 0.07)	0.093	-0.17	(-0.56, 0.23)	0.401
Smoking Status									
Never smoke		Reference			Reference			Reference	
Used to or still smoking	1.42	(0.48, 2.36)	0.003	1.49	(0.36, 2.62)	0.010	1.26	(0.32, 2.21)	0.009
Passive Smoking									
Never		Reference			Reference			Reference	
Sometimes	0.23	(-0.21, 0.67)	0.304	0.61	(0.08, 1.13)	0.023	0.67	(0.23, 1.10)	0.003
Almost everyday	0.54	(-0.04, 1.13)	0.069	1.58	(0.88, 2.28)	<0.001	1.07	(0.49, 1.65)	<0.001
Alcohol consumption									
No[2]		Reference			Reference			Reference	
Yes	1.01	(0.44, 1.57)	0.001	1.83	(1.15, 2.50)	<0.001	0.93	(0.37, 1.50)	0.001
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	
Unexpected	1.11	(0.61, 1.60)	<0.001	1.11	(0.52,1.71)	<0.001	0.75	(0.25, 1.25)	0.003
Well-prepared	-0.38	(-0.83, 0.07)	0.101	-0.07	(-0.61, 0.47)	0.806	0.09	(-0.36, 0.54)	0.705
Types of conception									
Non-Assisted conception		Reference			Reference			Reference	
Assisted conception (IVF/ICSI/other)	-0.59	(-1.37, 0.19)	0.136	-0.54	(-1.47, 0.39)	0.256	-0.38	(-1.16, 0.39)	0.334
History of adverse pregnancy outcomes[3]									
No		Reference			Reference			Reference	
Yes	0.24	(-0.24, 0.72)	0.324	0.45	(-0.13, 1.02)	0.126	0.43	(-0.05, 0.91)	0.079
History of mental health issues									
No		Reference			Reference			Reference	
Yes	3.13	(1.03, 5.22)	0.003	2.25	(-0.26, 4.76)	0.079	1.30	(-0.79, 3.39)	0.223
History of using drugs									
Never		Reference			Reference			Reference	
Used to or still use	2.83	(1.22, 4.44)	0.001	1.62	(-0.31, 3.55)	0.100	0.85	(-0.76, 2.46)	0.302
Do you have kids before this pregnancy?									

No		Reference			Reference			Reference	
Yes	0.32	(-0.08, 0.73)	0.119	-0.10	(-0.59, 0.38)	0.672	-0.27	(-0.67, 0.14)	0.195
Number of times being pregnant									
First time pregnant		Reference			Reference			Reference	
Second time	0.10	(-0.36, 0.57)	0.668	-0.33	(-0.89, 0.22)	0.242	-0.12	(-0.59, 0.34)	0.608
Third time	0.50	(-0.07, 1.06)	0.086	0.32	(-0.36, 1.00)	0.354	0.20	(-0.37, 0.76)	0.495
Fourth time and above	0.73	(0.07, 1.40)	0.031	0.20	(-0.60, 1.00)	0.623	-0.04	(-0.70, 0.62)	0.908
Pandemic (n=2249)									
	Prenatal Depression Measured by EPDS			**Prenatal Depression Measured by PHQ-7**			**Prenatal Anxiety Measured by GAD-7**		
Characteristics	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***
Age (years)	-0.07	(-0.10, -0.04)	<0.001	-0.08	(-0.11, -0.04)	<0.001	-0.05	(-0.08, -0.02)	<0.001
BMI (kg/m2)	0.03	(-0.01, 0.07)	0.209	-0.02	(-0.07, 0.02)	0.353	-0.01	(-0.04, 0.03)	0.618
Socioeconomic Status[1]	-0.27	(-0.37, -0.17)	<0.001	-0.19	(-0.30, -0.08)	0.001	-0.13	(-0.22, -0.04)	0.002
Number of People in the Household	0.24	(0.12, 0.36)	<0.001	0.15	(0.03, 0.28)	0.018	0.11	(0.01, 0.21)	0.030
Ethnicity									
Han		Reference			Reference			Reference	
Other (Hui and other ethnicities)	0.11	(0.99, 1.21)	0.842	-1.11	(-2.31, 0.10)	0.072	-0.38	(-1.32, 0.57)	0.436
Residential Area									
Urban		Reference			Reference			Reference	
Rural	0.51	(0.10, 0.91)	0.014	0.11	(-0.34, 0.55)	0.639	0.23	(-0.12, 0.58)	0.199
Marital Status									
Married		Reference			Reference			Reference	
Not Married (Divorced/separated/single/cohabit/widow)	2.12	(0.53, 3.72)	0.009	2.33	(0.57, 4.08)	0.009	1.52	(0.15, 2.89)	0.030
Household Income (Yuan)									
<50,000		Reference			Reference			Reference	
50,00-100,000	0.20	(-0.46, 0.87)	0.547	-0.39	(-1.12, -0.34)	0.291	0.08	(-0.49, 0.64)	0.794
100,000-200,000	0.01	(-0.62, 0.63)	0.985	-0.49	(-1.18, 0.20)	0.165	0.05	(-0.48, 0.59)	0.843
200,000-300,000	-0.33	(-1.06, 0.39)	0.365	-0.59	(-1.39, 0.20)	0.144	0.1	(-0.51, 0.72)	0.740

>300,000	-0.38	(-1.28, 0.51)	0.402	-0.19	(-1,17, 0.79)	0.699	0.31	(-0.45, 1.08)	0.423
Education									
Middle school and lower		Reference			Reference			Reference	
High school or equivalent	-0.67	(-1.13, -0.20)	0.005	-0.34	(-0.85, 0.18)	0.197	-0.35	(-0.75. 0.06)	0.092
Undergraduate or equivalent and higher	-1.01	(-1.41, -0.61)	<0.001	-0.56	(-1.00, -0.12)	0.012	-0.25	(-0.59, 0.10)	0.156
Employment									
Unemployed		Reference			Reference			Reference	
Employed (full-time/part-time/on paid leave)	-0.46	(-0.76, -0.16)	0.003	-0.47	(-0.81, -0.14)	0.005	-0.19	(-0.45, 0.07)	0.162
Smoking Status									
Never smoke		Reference			Reference			Reference	
Used to or still smoking	0.77	(0.61, 2.14)	0.275	1.90	(0.39, 3.42)	0.013	1.62	(0.44, 2.80)	0.007
Passive Smoking									
Never		Reference			Reference			Reference	
Sometimes	0.41	(0.05, 0.76)	0.024	0.52	(0.13, 0.90)	0.009	0.32	(0.01, 0.62)	0.040
Almost everyday	1.23	(0.67, 1.79)	<0.001	1.11	(0.49, 1.73)	<0.001	0.74	(0.25, 1.22)	0.003
Alcohol consumption									
No[2]		Reference			Reference			Reference	
Yes	1.64	(0.72, 2.56)	<0.001	1.25	(0.24, 2.26)	0.016	0.93	(0.14, 1.72)	0.021
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	
Unexpected	0.67	(0.29, 1.05)	0.001	0.55	(0.14, 0.97)	0.009	0.27	(-0.06, 0.60)	0.106
Well-prepared	-0.14	(-0.50, 0.22)	0.443	-0.28	(-0.68, 0.12)	0.168	-0.22	(-0.54, 0.09)	0.158
Types of conception									
Non-Assisted conception		Reference			Reference			Reference	
Assisted conception (IVF[3]*/ICSI*[4]*/other)*	0.46	(-0.40, 1.31)	0.297	0.27	(-0.67, 1.21)	0.571	0.43	(-0.30, 1.17)	0.246
History of adverse pregnancy outcomes[5]									
No		Reference			Reference			Reference	
Yes	0.37	(-0.05, 0.79)	0.088	0.15	(-0.31, 0.61)	0.529	0.43	(0.07, 0.79)	0.021
History of mental health issues									

No		Reference			Reference			Reference	
Yes	2.92	(1.82, 4.04)	<0.001	3.22	(2.00, 4.45)	<0.001	2.82	(1.87, 3.78)	<0.001
History of using drugs									
Never		Reference			Reference			Reference	
Used to or still use	1.57	(-0.08, 3.22)	0.062	1.36	(-0.45, 3.18)	0.141	1.35	(-0.06, 2.77)	0.061
Do you have kids before this pregnancy?									
No		Reference			Reference			Reference	
Yes	-0.03	(-0.31, 0.25)	0.821	-0.28	(-0.59, 0.03)	0.075	-0.3	(-0.54, -0.05)	0.017
Number of times being pregnant									
First time pregnant		Reference			Reference			Reference	
Second time	0.08	(-0.24, 0.41)	0.620	-0.16	(-0.52, 0.20)	0.376	-0.01	(-0,29, 0.27)	0.967
Third time	-0.11	(-0.52, 0.30)	0.611	-0.34	(-0.79, 0.12)	0.145	-0.26	(-0.61, 0.10)	0.152
Fourth time and above	0.58	(0.11, 1.04)	0.015	0.70	(0.18, 1.21)	0.008	0.38	(-0.02, 0.78)	0.061

[1]*Economic status compared to people around the participant, with 0 as the lowest and 10 the highest.*

[2]*No alcohol consumption is defined as not more than one drink of either 340ml of beer or 140ml of wine or 43ml of Chinese Baijiu.*

[3]*In vitro fertilization*

[4]*Intracytoplasmic sperm injection*

[5]*Adverse pregnancy outcomes include miscarriage, stillbirth, perinatal mortality, and birth defects.*

Multivariable Analyses of Parental Depression and Anxiety

EPDS scores

Before the pandemic occurred, socioeconomic status (β=-0.3, 95% CI -0.44 to -0.17, p<0.001) and number of people in the household (β=0.27, 95% CI 0.11 to 0.44, p=0.001) were significantly associated with EPDS scores in the Multivariable linear regression (Table 3.4). Furthermore, participants who were divorced, separated, single, cohabiting or widowed had 1.27 scores (95% CI 0.46 to 2.08, p=0.002) higher in the mean EPDS score compared to the ones who were married. The mean EPDS score among the participants who smoked was 1.03 scores higher (95% CI 0.09, 1.97, p=0.032) compared to the ones who never smoked. Moreover, participants who reported that this pregnancy was unexpected had 0.93 scores (95% CI 0.43 to 1.43, p<0.001) higher in the mean EPDS scores compared to the ones who reported the pregnancy was acceptable. Additionally, we also found that women who were employed (OR=0.68, 95% CI 0.49 to 0.93, p=0.018), had history of mental health issues (OR=12.20, 95% CI 2.94, 50.63, p=0.001) had higher odds of developing prenatal depression measured by EPDS in the sub-analyses using logistic regression (Table A5). However, these were not significant in the multivariable linear regression models.

During the pandemic, in the Multivariable linear regression (Table 3.4), age (β=-0.07, 95% CI -0.10 to -0.03, p<0.001), socioeconomic status (β=-0.21, 95% CI -0.31 to -0.11, p<0.001) and number of people in the household (β=0.2, 95% CI 0.06 to 0.33, p<0.001) were significantly associated with EPDS scores, after adjusting for other variables. Participants who obtained high school or equivalent degrees and who had undergraduate or equivalent or higher degrees both had lower mean EPDS scores (β=-0.67, 95% CI -1.15 to -0.18, p=0.007; β=-0.67 95% CI -1.09 to -0.24, p=0.002, respectively) compared to the ones with middle school or lower degrees, after adjusting for other variables. Participants who reported being exposed to passive smoke almost every day had 0.77 scores (95% 0.19 to 1.36, p=0.009) higher in the mean EPDS score compared to those who were never exposed. The mean EPDS score among participants who consumed alcohol were 1.49 scores (95% CI 0.58, 2.40, p=0.001) higher than those who did not. Furthermore, the mean EPDS scores among the participants who reported they did not expect this pregnancy were 0.45 scores (95% CI 0.06 to 0.84, p=0.022) higher compared to the ones who reported the pregnancy was accepted. Mental health was the other significant variable. Participants who reported having a

history of being diagnosed with mental health issues had 2.85 scores (95% CI 1.73 to 3.98, p<0.001) higher in the mean EPDS scores.

PHQ-9 scores

Before the COVID-19 pandemic occurred, passive smoking, alcohol assumption and attitude toward pregnancy were significant in both univariate and Multivariable linear regressions (Table 3.4). Participants who reported sometimes being exposed to passive smoking had 0.61 scores higher PHQ-9 mean scores (95% CI 0.08 to 1.12, p=0.023) compared to the ones who were never exposed to passive smoking. Participants who were exposed to passive smoking almost every day had 1.39 scores higher PHQ-9 mean score (95% CI 0.70 to 1.09, p<0.001) compared to the ones who were never exposed to passive smoking. Furthermore, participants who reported drinking had higher PHQ-9 scores compared to the ones who did not drink. (Multivariable linear regression: β=1.61, 95% CI 0.93 to 2.28, p<0.001). As for attitudes toward pregnancy, participants who reported that they did not expect their pregnancies had 0.85 scores (95% CI 0.25 to 1.44, p=0.005) higher PHQ-9 mean scores than those who reported their pregnancies as acceptable.

During the pandemic, age (β=-0.05, 95% CI -0.10 to -0.005, p=0.030), socioeconomic status (β=-0.14, 95% CI -0.25 to -0.02, p=0.017), and the number of people in the households (β=0.2, 95% CI 0.05 to 0.36, p=0.011) were statistically significant associated with PHQ-9 scores (Table 3.4). Participants who were sometimes exposed to passive smoking had 0.4 scores (95% CI 0.01 to 0.79, p=0.043) higher PHQ-9 mean scores compared to the ones who were never exposed to passive smoking. However, in the sub-analyses, we found that sometimes being exposed to passive smoking and prenatal depression were not significantly associated. Participants who reported exposure to passive smoking almost every day had 0.73 scores (95% CI 0.08 to 1.37, p=0.027) higher PHQ-9 mean scores compared to those who were never exposed to passive smoking. The participants who reported that their pregnancies were unexpected had higher PHQ-9 mean scores compared to the ones reported their pregnancies were acceptable (β=0.49, 95% CI 0.05 to 0.92, p=0.028). The PHQ-9 mean scores among participants who reported a history of being diagnosed with mental health issues was 2.99 scores higher (95% CI 1.75 to 4.24, p<0.001) compared to the ones who did not. Participants who had children before had lower PHQ-9 mean scores compared to the ones who did not (β =-0.75, 95% CI -1.31 to -0.20, p=0.008). Furthermore, participants who

reported being pregnant more than four times before had higher PHQ-9 mean scores compared to the ones who were pregnant for the first time (β=1.41, 95% CI 0.66 to 2.15, p<0.001).

GAD-7 scores

Before the pandemic, the Multivariable linear regression (Table 3.4) showed that the GAD-7 mean score decreased by 0.05 (95% CI -0.1, -0.004, p=0.031) for every year of age change. Participants who were not married (divorced, single, separated, cohabiting, and widowed) had higher GAD-7 mean scores compared to the ones who were married (β=1.03, 95% CI 0.21 to 1.84, p=0.014). Participants who reported sometimes being exposed to passive smoking (β=0.66, 95% CI 0.23 to 1.10, p=0.003) and those who were exposed almost every day (β=0.96, 95% CI 0.38 to 1.54, p<0.001) had higher GAD-7 mean scores compared to those who were never exposed to passive smoking. Participants who reported drinking had higher GAD-7 mean scores compared to the ones who did not drink in the adjusted model (β=0.75, 95% CI 0.18 to 1.32, p=0.01). The participants who reported that their pregnancies were unexpected had higher GAD-7 mean scores (β=0.51, 95% CI 0.01 to 1.02, p=0.045) compared to those who reported their pregnancies were acceptable. Moreover, there was an increase of 0.52 (95% CI 0.04 to 1.00, p=0.034) in the GAD-7 mean score among the participants who reported having experienced adverse pregnancy outcomes compared to the ones who did not experience such in the Multivariable linear regression. Additionally, the sub-analyses found that higher economic status was associated with lower odds of developing prenatal anxiety (OR 0.86, 95%CI 0.78 to 0.94, p=0.001) (Table A5), but this was not significant in the multivariable linear regression analysis.

During the pandemic, age (β=-0.04, 95% CI -0.07 to -0.01, p=0.008), socioeconomic status (β=-0.12, 95% CI -0.21 to -0.04, p=0.005), and the number of people in the households (β=0.12, 95% CI 0.01 to 0.23, p=0.032) were statistically significant in the Multivariable linear regression (Table 3.4). There was an increase of 1.38 (95% CI 0.19 to 2.58, p=0.024) GAD-7 mean score among the participants who smoked compared to the ones who did not smoke in the multivariable linear regression. Furthermore, participants who reported being diagnosed with mental health issues previously had higher GAD-7 mean scores (β=2.73, 95% CI 1.75 to 3.72, p<0.001). In addition, the sub-analyses reported that participants who had history of mental health issues had 4.67 times

(95% CI 2.26 to 9.66, $p<0.001$) higher odds of developing prenatal anxiety than those who did not have.

Table 3.4 Multivariable Linear Regression Analyses of Prenatal Depression and Anxiety for both Pre-pandemic and Pandemic Cohorts

Pre-Pandemic (n=1148)									
	Depression Measured by EPDS			**Depression Measured by PHQ-9**			**Anxiety Measured by GAD-7**		
Characteristics	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***
Age (years)							-0.05	(-0.1, -0.004)	0.031
BMI (kg/m2)									
Socioeconomic Status[1]	-0.30	(-0.44, -0.17)	<0.001						
Number of People in the Household	0.27	(0.11, 0.44)	0.001						
Marital Status									
Married		Reference						Reference	
Not Married (Divorced/Separated/single/cohabit/widow)	1.27	(0.46, 2.08)	0.002				1.03	(0.21, 1.84)	0.014
Smoking Status									
Never smoke		Reference						Reference	
Used to or still smoking	1.03	(0.09, 1.97)	0.032						
Passive Smoking									
Never					Reference			Reference	
Sometimes				0.60	(0.08, 1.12)	0.023	0.66	(0.23, 1.10)	0.003
Almost everyday				1.39	(0.70, 1.09)	<0.001	0.96	(0.38, 1.54)	0.001
Alcohol consumption									
No[2]					Reference			Reference	
Yes				1.61	(0.93, 2.28)	<0.001	0.75	(0.18, 1.32)	0.010
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	
Unexpected	0.93	(0.43, 1.43)	<0.001	0.85	(0.25, 1.44)	0.005	0.51	(0.01, 1.02)	0.045
Well-prepared	-0.12	(-0.57, 0.34)	0.607	-0.02	(-0.55, 0.52)	0.952	0.09	(-0.36, 0.54)	0.691
History of adverse pregnancy outcomes[3]									
No								Reference	

Yes							0.52	(0.04, 1.00)	0.034
Pandemic (n=2249)									
	Prenatal Depression Measured by EPDS			**Depression Measured by PHQ-9**			**Prenatal Anxiety Measured by GAD-7**		
Characteristics	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***
Age (years)	-0.07	(-0.10, -0.03)	<0.001	-0.05	(-0.10, -0.004)	0.030	-0.04	(-0.07, 0.01)	0.008
BMI (kg/m2)									
Socioeconomic Status[1]	-0.21	(-0.31, -0.11)	<0.001	-0.14	(-0.25, -0.02)	0.017	-0.12	(-0.21, -0.04)	0.005
Number of People in the Household	0.20	(0.06, 0.33)	<0.001	0.20	(0.05, 0.36)	0.011	0.12	(0.01, 0.23)	0.032
Education									
Middle school and lower		Reference							
High school or equivalent	-0.67	(-1.15, -0.18)	0.007						
Undergraduate or equivalent and higher	-0.67	(-1.09, -0.24)	0.002						
Smoking Status									
Never smoke								Reference	
Used to or still smoking							1.38	(0.19, 2.58)	0.024
Passive Smoking									
Never		Reference			Reference				
Sometimes	0.29	(-0.06, 0.65)	0.101	0.4	(0.01, 0.79)	0.043			
Almost everyday	0.77	(0.19, 1.36)	0.009	0.73	(0.08, 1.37)	0.027			
Alcohol consumption									
No[2]		Reference							
Yes	1.49	(0.58, 2.40)	0.001						
Attitude toward this pregnancy									
Acceptable		Reference			Reference				
Unexpected	0.45	(0.06, 0.84)	0.022	0.49	(0.05, 0.92)	0.028			
Well-prepared	-0.02	(-0.39, 0.34)	0.902	-0.25	(-0.66, 0.15)	0.220			
History of mental health issues									
No		Reference			Reference			Reference	
Yes	2.85	(1.73, 3.98)	<0.001	2.99	(1.75, 4.24)	<0.001	2.73	(1.75, 3.72)	<0.001

Do you have kids before this pregnancy?					
No			Reference		
Yes		-0.75	(-1.31, -0.20)	0.008	
Number of times being pregnant					
First time pregnant			Reference		
Second time		0.23	(-0.26, 0.72)	0.356	
Third time		0.30	(-0.35, 0.96)	0.358	
Fourth time and above		1.41	(0.66, 2.15)	<0.001	

[1]*Economic status compared to people around the participant, with 0 as the lowest and 10 the highest.*

[2]*No alcohol consumption is defined as not more than one drink of either 340ml of beer or 140ml of wine or 43ml of Chinese Baijiu.*

[3]*Adverse pregnancy outcomes include miscarriage, stillbirth, perinatal mortality, and birth defects.*

Birth Outcomes

Descriptive Statistics

There was no significant difference in the mean birth weight of infants between the pre-pandemic cohort (3370.9g, SD 470.0) and the pandemic cohort (3373.5g, SD 453.9). The prevalence of low birth weight in the pre-pandemic period was 3.2% and was 2.8% in the pandemic period, however the difference was not significant. Small for gestational age was 6.2% in the pre-pandemic cohort compared to 5.8% in the pandemic cohort, though the difference was not significant. Furthermore, there was no significant difference in the mean gestational age between the two cohorts (pre-pandemic: 39.5, SD 1.6; pandemic: 39.5, SD 1.5). The prevalence of preterm birth was the same in both time periods (4.3%). However, infants who were further classified as "moderate low birth weight" was 3.1% in the pre-pandemic period and 2.6% in the pandemic period, although the difference was not significant. Infants who were further classified as "very low birth weight" was 0.1% in the pre-pandemic period and 0.2% in the pandemic period, but the difference was not significant. The detailed breakdown of counts and percentages of different levels of severities are presented in Table 3.5.

Table 3.5 Descriptive Statistics of Birth Outcomes for Pre-pandemic Survey (n=1148) and Pandemic Survey (n=2249)

Characteristics	***Pre-Pandemic (n=1148)***			***During-Pandemic (n=2249)***			***P-value***
	Mean (SD)	**Min**	**Max**	**Mean (SD)**	**Min**	**Max**	
Birth Weight (grams)	3370.9 (470)	1450	5180	3373.5 (453.9)	1190	5000	0.879
Gestation Weeks (weeks)	39.5 (1.6)	29.7	44.1	39.5 (1.5)	30	42	1.000
	n		**%**	**n**		**%**	***P-value***
Low Birth Weight							
No (≥2500g)	1080		96.8	2186		97.2	0.493
Yes (<2500g)	36		3.2	63		2.8	
Severity of Low Birth Weight							
No (≥2500g)	1080		96.8	2186		97.2	
Moderate Low birth weight (1500g-2500g)	35		3.1	58		2.6	0.452
Very low birth weight (1000g-1500g)	1		0.1	5		0.2	
Preterm Birth							
No (≥37 weeks)	1070		95.7	2152		95.7	0.979
Yes (<37 weeks)	48		4.3	97		4.3	
Severity of Preterm Birth							
No (≥37 weeks)	1070		95.7	2152		95.7	
Moderate to late preterm birth (32-37 weeks)	40		3.6	91		4.1	0.133
Very preterm birth (28-32 weeks)	8		0.7	6		0.3	
Small for Gestational Age							
No	1036		93.8	1952		94.2	0.607
Yes	69		6.2	120		5.8	

Univariate and Multivariable Analyses of Birth Outcomes

In both univariate and multivariable linear and logistic regression analyses, birth weight, gestational age or small for gestational age were not significantly associated with any mental health assessment scores during the pre-pandemic periods (Table 3.6 and Table 3.7). However, during the COVID-19 pandemic, both birth weight and gestational age increased as the PHQ-9 scores increased (β=5.51, 95% CI 0.21 to 10.81, p=0.042; β=0.02, 95% CI 0.001 to 0.04, p=0.03, respectively) in the multivariable linear regressions.

During the pre-pandemic period, participants' Pre-pregnancy BMI, marital status, household income, and types of conception were significantly associated with infants' birth weight in the multivariable linear regression. As for gestational age, participants' age, types of conception and whether they had children before were statistically significant in the multivariable linear regression. Moreover, participants' pre-pregnancy BMI, number of people in the household, education, and whether they had children before were significantly associated with small for gestational age. During the pandemic, whether they had children before was significantly associated with infants' birth weight, gestational age and small for gestational age. Furthermore, participants' pre-pregnancy BMI was associated with infants' birth weight, and participants' age was associated with infants' gestational age. The statistics of univariate analyses and other significant variables in the multivariable analyses are presented in Table 3.6 and Table 3.7, respectively.

Table 3.6 Univariate Analyses of Birth Outcomes for both Pre-pandemic and Pandemic Cohorts

Pre-Pandemic (n=1148)									
	Birth Weight (grams)			Gestational Age			Small for Gestational Age		
Characteristics	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***	***OR***	***(95%CI)***	***p-value***
Age (years)	-3.25	(-10.07, 3.56)	0.349	-0.06	(-0.08, -0.03)	<0.001	0.96	(0.90, 1.02)	0.168
BMI (kg/m2)	14.01	(5.32, 22.70)	0.002	-0.02	(-0.05, 0.01)	0.106	0.90	(0.83, 0.98)	0.019
Socioeconomic Status[1]	-7.34	(-26.58, 11.90)	0.454	-0.02	(-0.08, 0.05)	0.639	1.06	(0.90, 1.26)	0.477
Number of People in the Household	10.31	(-13.79, 34.40)	0.401	-0.02	(-0.10, 0.05)	0.539	0.97	(0.78, 1.21)	0.791
EPDS Scores	-3.40	(-11.93, 5.13)	0.435	-0.02	(-0.05, 0.004)	0.103	0.98	(0.91, 1.06)	0.612
PHQ-9 Scores	-2.89	(-9.90, 4.11)	0.418	-0.01	(-0.03, 0.01)	0.401	0.97	(0.91, 1.03)	0.312
GAD-7 Scores	-2.28	(-10.87, 6.32)	0.603	-0.01	(-0.04, 0.02)	0.435	0.96	(0.88, 1.04)	0.280
EPDS-3a Scores	-6.11	(-26.46, 14.23)	0.556	-0.03	(-0.10, 0.04)	0.406	0.93	(0.77, 1.12)	0.435
Ethnicity									
Han		Reference			Reference			Reference	
Other (Hui and other ethnicities)	12.63	(-244.68, 269.94)	0.923	-0.18	(-1.04, 0.68)	0.679	1.25	(0.16, 9.75)	0.832
Residential Area									
Urban		Reference			Reference			Reference	
Rural	-57.75	(-141.58, 26.09)	0.177	-0.26	(-0.54, 0.02)	0.073	1.37	(0.70, 2.68)	0.358
Marital Status									
Married		Reference			Reference			Reference	
Not Married (Divorced/separated/single/cohabit/widow)	117.92	(2.66, 233.18)	0.045	0.41	(0.03, 0.80)	0.036	0.45	(0.11, 1.89)	0.278
Household Income (Yuan)									
<50,000		Reference			Reference			Reference	
50,00-100,000	149.86	(55.03, 244.68)	0.002	0.14	(-0.18, 0.46)	0.380	0.77	(0.37, 1.59)	0.483
100,000-200,000	101.37	(6.53, 196.22)	0.036	-0.08	(-0.40, 0.24)	0.636	0.68	(0.33, 1.42)	0.310
200,000-300,000	157.47	(32.92, 282.01)	0.013	0.02	(-0.39, 0.44)	0.912	0.10	(0.01, 0.82)	0.032
>300,000	180.44	(32.80, 328.09)	0.017	-0.01	(-0.50, 0.48)	0.968	-	-	-
Education									
Middle school and lower		Reference			Reference			Reference	
High school or equivalent	44.33	(-47.58, 136.24)	0.344	0.03	(-0.27, 0.34)	0.829	0.73	(0.35, 1.53)	0.404
Undergraduate or equivalent and higher	24.48	(-51.53, 100.48)	0.528	0.21	(-0.04, 0.46)	0.101	0.61	(0.34, 1.13)	0.116
Employment									
Unemployed		Reference			Reference			Reference	
Employed (full-time/part-time/on paid leave)	14.81	(-41.39, 71.01)	0.605	0.13	(-0.06, 0.32)	0.176	0.65	(0.40, 1.06)	0.083
Smoking Status									

Never smoke		Reference			Reference			Reference	
Used to or still smoking	5.61	(-130.53, 141.75)	0.936	-0.41	(-0.86, 0.04)	0.071	1.00	(0.30, 3.31)	0.999
Passive Smoking									
Never		Reference			Reference			Reference	
Sometimes	28.21	(-34.19, 90.61)	0.375	0.18	(-0.03, 0.38)	0.098	0.53	(0.31, 0.92)	0.024
Almost everyday	22.13	(-60.85, 105.12)	0.601	0.24	(-0.03, 0.52)	0.083	0.89	(0.46, 1.72)	0.720
Alcohol consumption									
No[2]		Reference			Reference			Reference	
Yes	78.66	(-1.51, 158.83)	0.054	0.01	(-0.25, 0.28)	0.925	0.69	(0.31, 1.53)	0.361
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	
Unexpected	32.53	(-39.26, 104.33)	0.374	-0.10	(-0.34, 0.14)	0.396	0.47	(0.21, 1.02)	0.056
Well-prepared	-64.83	(-128.58, -1.08)	0.046	0.31	(0.52, -0.10)	0.004	0.96	(0.56, 1.64)	0.881
Types of conception									
Non-Assisted conception		Reference			Reference			Reference	
Assisted conception (IVF[3]*/ICSI*[4]*/other)*	-154.58	(-265.21, -43.95)	0.006	-0.94	(-1.31, -0.57)	<0.001	1.09	(0.43, 2.81)	0.850
History of adverse pregnancy outcomes[5]									
No		Reference			Reference			Reference	
Yes	16.61	(-51.78, 84.99)	0.634	0.05	(-0.17, 0.28)	0.636	1.01	(0.55, 1.85)	0.981
History of mental health issues									
No		Reference			Reference			Reference	
Yes	168.63	(-124.30, 461.55)	0.259	0.61	(-0.37, 1.58)	0.224	-	-	-
History of using drugs									
Never		Reference			Reference			Reference	
Used to or still use	28.97	(-196.53, 254.47)	0.801	0.42	(-0.33, 1.17)	0,271	-	-	-
Do you have kids before this pregnancy?									
No		Reference			Reference			Reference	
Yes	23.35	(-33.95, 80.66)	0.424	-0.41	(-0.60, -0.22)	<0.001	0.59	(0.34, 1.03)	0.063
Number of times being pregnant									
First time pregnant		Reference			Reference			Reference	
Second time	31.23	(-34.36, 96.81)	0.350	-0.16	(-0.38, 0.06)	0.145	0.60	(0.32, 1.11)	0.101
Third time	87.11	(7.48, 166.74)	0.032	-0.19	(-0.46, 0.07)	0.151	0.78	(0.39, 1.57)	0.492
Fourth time and above	8.71	(-87.55, 104.97)	0.859	-0.39	(-0.71, -0.07)	0.016	0.83	(0.36, 1.93)	0.671
Pandemic (n=2249)									
	Birth Weight (grams)			**Gestational Age**			**Small for Gestational Age**		
Characteristics	***Coeff.***	***(95%CI)***	***p-value***	***Coeff.***	***(95%CI)***	***p-value***	**OR**	***(95%CI)***	***p-value***
Age (years)	-0.30	(-4.82, 4.22)	0.896	-0.03	(-0.04, -0.02)	<0.001	1.01	(0.96, 1.05)	0.797

BMI (kg/m2)	12.92	(7.19, 18.66)	<0.001	-0.02	(-0.04, 0.002)	0.029	0.94	(0.88, 0.99)	0.031
Socioeconomic Status[1]	-16.14	(-29.93, -2.34)	0.022	-0.02	(-0.07, 0.02)	0.343	0.98	(0.85, 1.12)	0.73
Number of People in the Household	8.81	(-7.78, 25.39)	0.298	-0.01	(-0.06, 0.05)	0.796	1.04	(0.89, 1.21)	0.631
EPDS Scores	4.95	(-0.98, 10.88)	0.102	0.02	(-0.004, 0.03)	0.116	1.02	(0.97, 1.08)	0.443
PHQ-9 Scores	4.93	(-0.40, 10.26)	0.070	0.02	(0.01, 0.04)	0.012	1.00	(0.96, 1.06)	0.871
GAD-7 Scores	2.60	(-4.25, 9.45)	0.457	0,02	(-0.01, 0.04)	0.145	1.02	(0.96, 1.09)	0.491
EPDS-3a Scores	6.68	(-7.83, 21.19)	0.367	0.02	(-0.02, 0.07)	0.303	1.04	(0.91, 1.19)	0.598
Ethnicity									
Han		Reference			Reference			Reference	
Other (Hui and other ethnicities)	-117.47	(-281.21, 46.26)	0.160	-0.22	(-0.73, 0.29)	0.394	0.56	(0.08, 4.12)	0.566
Residential Area									
Urban		Reference			Reference			Reference	
Rural	20.11	(-36.33, 76.55)	0.485	-0.03	(-0.21, 0.15)	0.752	0.99	(0.56, 1.74)	0.960
Marital Status									
Married		Reference			Reference			Reference	
Not Married (Divorced/separated/single/cohabit/widow)	-51.82	(-291.72, 188.08)	0.672	-0.40	(-1.16, 0.37)	0.309	-	-	-
Household Income (Yuan)									
<50,000		Reference			Reference			Reference	
50,00-100,000	16.32	(-76.41, 109.05)	0.730	-0.06	(-0.35, 0.24)	0.701	0.79	(0.35, 1.82)	0.582
100,000-200,000	8.73	(-79.24, 96.70)	0.846	0.00	(-0.28, 0.28)	0.995	0.71	(0.32, 1.55)	0.390
200,000-300,000	12.07	(-88.13, 112.27)	0.813	0.03	(-0.29, -0.35)	0.856	0.52	(0.20, 1.39)	0.194
>300,000	-51.16	(-176.63, 74.30)	0.424	0.04	(-0.36, 0.44)	0.843	1.17	(0.41, 3.37)	0.770
Education									
Middle school and lower		Reference			Reference			Reference	
High school or equivalent	-1.48	(-66.05, 63.09)	0.964	0.13	(-0.08, 0.33)	0.226	1.05	(0.57, 1.91)	0.883
Undergraduate or equivalent and higher	-33.37	(-88.61, 21.86)	0.236	0.13	(-0.04, 0.31)	0.137	0.77	(0.45, 1.32)	0.339
Employment									
Unemployed		Reference			Reference			Reference	
Employed (full-time/part-time/on paid leave)	13.27	(-28.21, 54.74)	0.530	0.06	(-0.07, 0.19)	0.359	0.92	(0.61, 1.40)	0.705
Smoking Status									
Never smoke		Reference			Reference			Reference	
Used to or still smoking	60.98	(-120.04, 242.01)	0.509	-0.31	(-0.88, 0.27)	0.298	-	-	-
Passive Smoking									
Never		Reference			Reference			Reference	
Sometimes	3.20	(-44.83, 51.22)	0.896	-0.10	(-0.26, 0.05)	0.178	0.99	(0.62, 1.60)	0.983
Almost everyday	80.74	(3.92, 157.56)	0.039	0.14	(-0.11, 0.38)	0.273	0.75	(0.32, 1.77)	0.513

Alcohol consumption									
No[2]		Reference			Reference			Reference	
Yes	-22.56	(-151.49, 106.38)	0.732	-0.23	(-0.63, 0.18)	0.278	1.21	(0.37, 3.97)	0.754
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	
Unexpected	61.72	(9.78, 113.67)	0.020	0.07	(-0.09, 0.24)	0.389	1.45	(0.86, 2.44)	0.164
Well-prepared	-28.91	(-78.11, 20.28)	0.249	-0.02	(-0.18, 0.14)	0.801	1.56	(0.95, 2.54)	0.076
Types of conception									
Non-Assisted conception		Reference			Reference			Reference	
Assisted conception (IVF[3]*/ICSI*[4]*/other)*	87.39	(-28.83, 203.61)	0.140	-0.03	(-0.40, 0.34)	0.875	0.63	(0.15, 2.61)	0.521
History of adverse pregnancy outcomes[5]									
No		Reference			Reference			Reference	
Yes	3.76	(-53.81, 61.34)	0.898	-0.01	(-0.20, 0.17)	0.88	0.95	(0.53, 1.71)	0,868
History of mental health issues									
No		Reference			Reference			Reference	
Yes	-132.62	(-284.26, 19.02)	0.086	-0.36	(-0.85, 0.12)	0.143	1.13	(0.27, 4.78)	0.872
History of using drugs									
Never		Reference			Reference			Reference	
Used to or still use	-116.27	(-340.33, 107.80)	0.309	-0.43	(-1.14, 0.29)	0.240	2.71	(0.60, 12.18)	0.194
Do you have kids before this pregnancy?									
No		Reference			Reference			Reference	
Yes	74.17	(34.24, 114.10)	<0.001	-0.27	(-0.40, -0.14)	<0.001	0.62	(0.41, 0.93)	0.020
Number of times being pregnant									
First time pregnant		Reference			Reference			Reference	
Second time	41.98	(-4.08, 88.03)	0.074	-0.11	(-0.26, 0.04)	0.142	0.62	(0.39, 0.97)	0.039
Third time	55.51	(-3.30, 114.33)	0.064	-0.24	(-0.43, -0.06)	0.011	0.64	(0.35, 1.16)	0.145
Fourth time and above	80.37	(14.40, 146.34)	0.017	-0.40	(-0.61, -0.19)	<0.001	1.02	(0.57, 1.79)	0.959

[1]*Economic status compared to people around the participant, with 0 as the lowest and 10 the highest.*

[2]*No alcohol consumption is defined as not more than one drink of either 340ml of beer or 140ml of wine or 43ml of Chinese Baijiu.*

[3]*In vitro fertilization*

[4]*Intracytoplasmic sperm injection*

[5]*Adverse pregnancy outcomes include miscarriage, stillbirth, perinatal mortality, and birth defects.*

Table 3.7 Multivariable Analyses of Birth Outcomes for both Pre-pandemic and Pandemic Cohorts

Prenatal Depression Measured by EPDS and Birth Outcomes																		
Characteristics	Pre-Pandemic (N=1148)									During-Pandemic (N=2249)								
	Birth Weight (grams)			Gestation Week			Small for Gestational Age			Birth Weight (grams)			Gestation Week			Small for Gestational Age		
	Coeff.	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*
Age (years)				-0.03	(-0.05, -0.002)	0.030							-0.02	(-0.04, -0.002)	0.023			
BMI (kg/m2)	16.26	(7.45, 25.06)	<0.001				0.90	(0.82, 0.98)	0.020	11.97	(6.21, 17.73)	<0.001						
EPDS Scores	-3.69	(-12.24, 4.87)	0.389	-0.02	(-0.05, 0.003)	0.082	0.97	(0.90, 1.05)	0.435	4.68	(-1.21, 10.57)	0.120	0.01	(-0.01, 0.03)	0.190	1.02	(0.97, 1.08)	0.448
Marital Status																		
Married		Reference																
Not Married (Divorced/Seperated/single/cohabit/widow)	124.99	(9.42, 240.57)	0.034															
Household Income (Yuan)																		
<50,000		Reference																
50,00-100,000	146.34	(50.60, 242.08)	0.003															
100,000-200,000	102.36	(6.29, 198.44)	0.037															
200,000-300,000	166.30	(40.32, 292.29)	0.010															
>300,000	173.15	(22.67, 323.64)	0.024															
Education																		
Middle school and lower								Reference										
High school or equivalent							0.60	(0.28, 1.30)	0.196									
Undergraduate or equivalent and higher							0.42	(0.22, 0.81)	0.010									
Types of conception																		
Non-Assisted conception		Reference			Reference													
Assisted conception (IVF[1]/ICSI[2]/other)	-156.08	(-266.74, -45.42)	0.006	-1.06	(-1.45, -0.70)	<0.001												
Do you have kids before this pregnancy?																		
No					Reference			Reference			Reference			Reference			Reference	
Yes				-0.42	(-0.64, -0.20)	<0.001	0.53	(0.30, 0.96)	0.037	66.17	(26.21, 106.12)	0.001	-0.19	(-0.33, -0.04)	0.010	0.62	(0.41, 0.93)	0.020

Prenatal Depression Measured by PHQ-9 and Birth Outcomes																		
Characteristics	Pre-Pandemic (N=1148)									During-Pandemic (N=2249)								
	Birth Weight (grams)			Gestation Week			Small for Gestational Age			Birth Weight (grams)			Gestation Week			Small for Gestational Age		
	Coeff.	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*
Age (years)				-0.03	(-0.05, -0.001)	0.040							-0.02	(-0.03, -0.002)	0.025			
BMI (kg/m2)	16.33	(7.53, 25.13)	<0.001				0.90	(0.82, 0.98)	0.021	12.19	(6.44, 17.95)	<0.001						
PHQ-9 Scores	-3.45	(-10.40, 3.51)	0.332	-0.01	(-0.04, 0.01)	0.260	0.96	(0.90, 1.03)	0.260	5.51	(0.21, 10.81)	0.042	0.02	(0.001, 0.04)	0.030	1.00	(0.95, 1.05)	0.946
Marital Status																		
Married		Reference																
Not Married (Divorced/Seperated/single/cohabit/widow)	123.7	(8.61, 238.79)	0.035															
Household Income (Yuan)																		
<50,000		Reference																
50,00-100,000	147.31	(51.73, 242.89)	0.003															
100,000-200,000	104.11	(8.36, 199.86)	0.033															
200,000-300,000	168.58	(42.72, 294.43)	0.009															
>300,000	176.16	(26.29, 326.03)	0.021															
Education																		
Middle school and lower								Reference										
High school or equivalent							0.61	(0.28, 1.3)	0.199									
Undergraduate or equivalent and higher							0.43	(0.23, 0.83)	0.011									
Types of conception																		
Non-Assisted conception		Reference			Reference													
Assisted conception (IVF[1]/ICSI[2]/other)	-156.37	(-267.03, -45.72)	0.006	-1.08	(-1.45, -0.70)	<0.001												
Do you have kids before this pregnancy?																		
No					Reference			Reference			Reference			Reference			Reference	
Yes				-0.44	(-0.66, -0.22)	<0.001	0.53	(0.29, 0.96)	0.035	67.47	(27.51, 107.44)	0.001	-0.19	(-0.33, -0.04)	0.012	0.62	(0.41, 0.93)	0.020

Prenatal Anxiety Measured by GAD-7 and Birth Outcomes																		
Characteristics	Pre-Pandemic (N=1148)									During-Pandemic (N=2249)								
	Birth Weight (grams)			Gestation Week			Small for Gestational Age			Birth Weight			Gestation Week			Small for Gestational Age		
	Coeff.	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*Coeff.*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*
Age (years)				-0.03	(-0.05, -0.001)	0.035							-0.02	(-0.04, 0.0003)	0.018			
BMI (kg/m2)	16.25	(7.44, 25.06)	<0.001				0.90	(0.82, 0.98)	0.019	12.09	(6.33, 17.85)	<0.001						
GAD-7 Scores	-3.26	(-11.83, 5.30)	0.455	-0.02	(-0.05, 0.01)	0.207	0.95	(0.87, 1.03)	0.214	3.35	(-3.46, 10.17)	0.335	0.01	(-0.01, 0.03)	0.283	1.02	(0.96, 1.08)	0.582
Marital Status																		
Married		Reference																
Not Married (Divorced/Seperated/single/cohabit/widow)	123.91	(8.44, 239.38)	0.035															
Household Income (Yuan)																		
<50,000		Reference																
50,00-100,000	148.89	(53.35, 244.42)	0.002															
100,000-200,000	105.68	(10.00, 201.36)	0.030															
200,000-300,000	170.43	(44.46, 296.39)	0.008															
>300,000	178.44	(28.68, 328.21)	0.020															
Education																		
Middle school and lower								Reference										
High school or equivalent							0.60	(0.28, 1.30)	0.198									
Undergraduate or equivalent and higher							0.44	(0.23, 0.84)	0.013									
Types of conception																		
Non-Assisted conception		Reference			Reference													
Assisted conception (IVF[1]/ICSI[2]/other)	-155.48	(-266.12, -44.84)	0.006	-1.08	(-1.45, -0.70)	<0.001												
Do you have kids before this pregnancy?																		
No					Reference			Reference			Reference			Reference			Reference	
Yes				-0.44	(-0.66, -0.22)	<0.001	0.53	(0.29, 0.95)	0.033	67.07	(27.03, 107.11)	0.001	-0.18	(-0.33, -0.04)	0.013	0.62	(0.42, 0.93)	0.021

[1]*In vitro fertilization*

[2]*Intracytoplasmic sperm injection*

Discussion

Summary of Findings

This study assessed the prevalence of prenatal depression, anxiety, low birth weight, preterm birth and small for gestational age, as well as identified risk factors of these mental and birth outcomes before and during the COVID-19 pandemic in Ma'anshan, Anhui, China. Contrary to our expectations, we found that the prevalence of prenatal depression, anxiety, low birth weight and small for gestational age decreased during the pandemic compared to the pre-pandemic period. The prevalence of preterm birth was the same in both pre-pandemic and pandemic periods. Furthermore, our study also suggests that prenatal depression and anxiety were not strong risk factors of adverse birth outcomes, in both pre-pandemic and pandemic periods. The exception was PHQ-9 measured prenatal depression, which was significantly associated with preterm birth and small for gestational age during the pandemic. Furthermore, risk factors of prenatal depression and anxiety vary between pre-pandemic and pandemic periods.

Prevalence of Prenatal Depression and Anxiety

Pre-pandemic: This study assessed the prevalence of prenatal depression and anxiety before and during the pandemic using different tools, including EPDS, PHQ-9 and GAD-7. Compared to studies conducted before the COVID-19 pandemic using the same tools, our prenatal depression prevalence measured by EPDS (18.6%) was similar to those reported in another study also conducted in Anhui (19.1%) and another in Shenzhen (19.3%) (27,39). However, it was lower than those reported in Changsha (29.6%) and central China (39.9%) (40,41). As for depression measured by PHQ-9, our prevalence (48.0%) was much higher than those reported in southwestern China (16.3% to 18.1%) using the same tool (30). The differences in prevalence could be due to different cut-off points used in different measures (42). Other reasons for varied prevalence were likely due to diverse cultural, social, economic, and religious background in different provinces (42,43). Prenatal anxiety in our study was 36.3% before the pandemic, which was almost the same as it was in Shenyang, Zhengzhou and Chongqing (36.4%) (44).

Pandemic: During the pandemic, our EPDS assessed prenatal depression prevalence was 14.5%, which was much lower than it was in Wuhan (33.7%), the epicentre of the COVID-19 outbreaks

in China (45). The PHQ-9 assessed prenatal depression during the pandemic in this study (28.9%) was lower than that reported in Shenzhen (35.4%), Guangzhou (35.3%) and Changzhou (36.1%) (42,46,47). The prevalence of prenatal anxiety during the pandemic in our study was 26.7%, which was lower than in Changzhou (31.7%) and higher than in Guangzhou (19.0%) and Shenyang (11.8%) (47,46,48). The differences in the prevalence during the pandemic could also be due to the distinct severity of the local pandemic across multiple studies (49), as well as different cut-off points used in different measures (42).

An interesting finding was that the prevalence of prenatal depression and anxiety was lower in the pandemic cohort than it was in the pre-pandemic cohort. Many published studies reported higher rates of prenatal depression and anxiety during the pandemic compared to pre-pandemic periods. This is possibly due to the uncertainty regarding the effects of COVID-19 on fetal health, pandemic restrictions, and pandemic-related income loss (12,13,50,51). However, there were fewer studies that reported lower rates of prenatal mental health issues like this study (52,53). Another longitudinal study conducted in China reported non-significant differences in anxiety and depression during the pandemic (54). However, this study targeted the general Chinese population, rather than pregnant women. In our study, the reduction in the rates of prenatal depression and anxiety could be due to different factors. First, women may be more likely to receive more family support and care during their pregnancies, given household structures in China, which could be protective (7,55). A study reported that increased social support increases people's resilience to stress, further lead to less risk of developing prenatal anxiety and depression (56). Second, social activities during the pandemic were limited in China. For instance, pregnant women no longer needed to go to work, and this may translate into more time to focus more on their pregnancy. Findings could also be due to the severity of the COVID-19 pandemic in Ma'anshan, which was lower than those studies that reported increased prenatal depression and anxiety (12,13,50,51). A study reported that women from the pandemic's hardest-hit areas in China were more likely to experience anxiety (57). In addition, unlike other countries, China has adopted the dynamic zero-COVID policy nationally (58). This policy says "new outbreaks must be contained immediately, and there should be zero complacencies in fighting the epidemic" (59). The most important purpose of this strategy is to minimize the impact of the epidemic on the economy, society, production, and people's normal lives (58). The minimization of the pandemic impacts may have

also eased stress and panic brought by the disease among the general population. It is also important to note that the pre-pandemic and pandemic cohorts were not the same. Differences, other than those assessed in the study, might also impact these results. Therefore, we suggest that further research with longitudinal methods on the same population is needed to explore the changes in the prevalence of prenatal depression and anxiety.

Risk factors of Prenatal Depression and Anxiety

Pre-pandemic: Exploring potential risk factors is important to guide the development of prevention interventions when encountering public health emergencies. Overall, we found that before the pandemic, participants with higher self-reported socioeconomic status, a smaller number of people in the households, who were married, were not exposed to smoke, passive smoke, and alcohol, and who reported their pregnancy was acceptable or expected had less risk of experiencing prenatal depression. As for anxiety, participants of older age, who were married, were not exposed to passive smoke or alcohol, had no history of being diagnosed with mental health issues and reported their pregnancy was accepted or expected also had less risk of experiencing prenatal anxiety. These findings were consistent with previous literature (60–62).

Pandemic: As expected, during the pandemic, risk factors of prenatal depression and anxiety were different from those in the pre-pandemic period. Older age, a smaller number of people in the household, higher socioeconomic status and having children were protective against prenatal depression during the pandemic. Similarly, a study reported that older age was associated with less risk of prenatal anxiety (63). Older women might have experienced coping with previous pandemics (i.e., severe acute respiratory syndrome, H1N1 flu), thus they might be more likely to show higher resilience when facing the challenge during another pandemic (63). Furthermore, Wang et al. also reported that women who have children before this pregnancy had a lower risk of prenatal depression (63).Women who have children had experienced pregnancy and delivery, thus they might therefore be more prepared and less stressed when facing another pregnancy. Being exposed to passive smoking, having unexpected pregnancies, and being diagnosed with mental health issues before were risk factors for prenatal depression during the pandemic in this study. Furthermore, in this study, we found that higher education level was associated with lower risk of prenatal depression. However, Wang et al. reported a higher level of education was associated with

higher risks of developing prenatal depression (63). Pregnant women with a higher level of education might be more active in seeking information about COVID-19 and have better understanding of the COVID-19 situation. Drinking was also reported as a significant risk factor associated with prenatal depression in this study and it is consistent with other studies (64). In addition, we also found that participants without a history of adverse pregnancy outcomes, higher self-reported socioeconomic status and a smaller number of people in the household were less likely to experience prenatal anxiety. These were also reported in other similar studies (48,57,65).

Comparing the pre-pandemic and pandemic periods, the risk factors of prenatal depression and anxiety were different . For instance, passive smoking and the history of mental health issues were significant risk factors for prenatal depression during the pandemic but were not significant in the pre-pandemic analysis; socioeconomic status and smoking were associated with prenatal anxiety in the pandemic cohort but not in the pre-pandemic cohort. This could be due to the differences among these characteristics between the two cohorts' populations.

Prevalence of Adverse Birth Outcomes

Pre-pandemic: This study assessed the prevalence of low birth weight, preterm birth, and small gestational age before and during the pandemic. First, we found there was no significant change in mean birth weight or gestational age before and during the pandemic. In this study, the pre-pandemic prevalence of low birth weight, preterm birth and small for gestational age was 3.2%, 4.3% and 6.2%, respectively. Our result was lower than those in previous studies (5.2% to 6.1% for low birth weight, 5.2% to 7.3% for preterm birth, 11.3% to 13.2% (17,66–70).

Pandemic: During the pandemic, our study found that the prevalence of low birth weight and small for gestational age slightly lower than it was in the pre-pandemic periods, but that the prevalence of preterm birth remained the same at 4.3%. There were other studies that also reported a similar lower prevalence of low birth weight, preterm birth and small for gestational age during the COVID-19 pandemic compared to pre-pandemic levels (71–73). For instance, a study conducted in the U.S. reported a reduction in the overall rate of preterm birth from 9.3% to 10.2% to 7.1% (74). In Botswana there was also a 1.72% reduction in the risk of any adverse outcomes, including preterm birth and small for gestational age, and a 1.62% reduction in the risk of any

severe adverse birth outcomes (72). In Ireland, the reported rate of very-low-birth-weight infants also reduced from 8.2 to 2.2 per 1000 live births during the COVID-19 lockdown period, compared to periods prior to the pandemic (75). The reason may be explained by stress-related pathways (76). In this study, women who were in the pandemic cohort experienced less prenatal depression and anxiety. Thus, the rate of adverse birth outcomes was expected to reduce. Furthermore, Philip et al. suggested that "unparalleled and widespread socioenvironmental alterations to which pregnant women would have responded with appropriate behavioural and lifestyle modifications" might have led to a reduction in adverse birth outcomes (75). For instance, the lockdown restrictions likely resulted in mothers resting at home and not working. Women may also have received more partner and family support and focused more on their lifestyle and nutrition, impacting infant growth, further reducing the risk of adverse birth outcomes. Moreover, the substantial decreases in adverse birth outcomes rate could also be due to the implementation of the national COVID-19 mitigation measures in China (68). Bian et al., suggested that the COVID-19 mitigation measures, such as wearing masks, keeping physical distance, staying home, lack of population flow and increasing awareness of hygiene, could have reduced some known risk factors for adverse birth outcomes, including asymptomatic infection and inflammation, which could cause intrauterine infection and inflammation through vertical transmission, initiating a succession of mechanism resulting in adverse birth outcomes (68). Additionally, a study reported that increasing in preterm birth rates could have been due to increases in clinician-initiated deliveries at preterm gestation (77). Considering the severity of the COVID-19 pandemic, the health priorities have temporarily shifted to COVID-19-related tests, controls, and treatment, the utilization of obstetrics services in China have markedly decreased (78). This could have led to a reduction in clinician-initiated delivery at preterm gestation periods and further led to a lower rate in preterm birth in the pandemic cohort (77). However, there are studies argued that decreases in the utilization of obstetrics services could also lead to higher rates of adverse birth outcomes (78). Thus, the link between changes in obstetric services utilization during the pandemic and birth outcomes need further investigation.

However, there were also some contradictory findings. For instance, Preis et al. reported that the rate of preterm birth increased from 14.4% to 20.5% during the pandemic among African American women (74). In addition, many other studies reported increased rates of adverse birth

outcomes, especially among mothers infected with COVID-19. In one study in China, pregnant women with a confirmed COVID-19 diagnosis had 3.34 times higher risks of preterm birth compared to the ones without COVID-19 (79). In Bangladesh, pregnant women with COVID-19 were also 2.1 times more likely to give birth to a preterm baby (80). In America, women with COVID-19 were 1.4 times and 1.6 times more likely to experience moderate to late preterm birth and very to extreme preterm birth, respectively (81). However, our study did not assess the COVID-19 infection history among the participants, which might affect these findings. This would be an important direction in future research.

Impacts of Prenatal Depression and Anxiety on Birth Outcomes

To our knowledge, this is the first study aimed at exploring and comparing the impact of prenatal depression and anxiety on birth outcomes in China before and during the COVID-19 pandemic. Previous studies have largely been conducted before the pandemic, or during the pandemic but not both (24). Although study findings are inconsistent, it is worthwhile to investigate to better understand the pathways and impacts of prenatal depression and anxiety on birth outcomes.

We found that prenatal depression or anxiety was not significantly associated with lower birth weight, lower gestational age or small for gestational age in the pre-pandemic period after adjusting for other covariates. Similarly, many studies reported that prenatal depression or anxiety was not associated with increased risk for low birth weight or decreases in birth weight, higher risk of preterm birth and small for gestational age (39,82–84). During the pandemic, only PHQ-9 measured depression was significantly associated with low birth weight and preterm birth. Other tools measured depression or anxiety were not significantly associated with any of those birth outcomes. In this study, we found that a higher PHQ-9 score was associated with less risk of low birth weight and preterm birth. This finding, to our knowledge, was different from other similar studies. For instance, Preis et al. reported that prenatal stress and depression were significantly associated with higher risks of preterm birth (74). Smith et al. also reported that women with prenatal depression were 1.5 times more likely to give birth to preterm infants (84). Furthermore, many studies reported that prenatal depression and anxiety were significantly associated with low or lower birth weight, and associated with small for gestational age (39,74,85–92). In this study, better birth outcomes could be potentially explained by the Psychobiobehaviroral model. First,

stress reactivity is different from person to person, and this is why not all pregnant women who experienced prenatal stress, anxiety and depression will proceed to adverse birth outcomes such as preterm birth (23). Second, studies showed that social isolation has been associated with increased heart rate and blood pressure, and increased blood pressure is associated with adverse birth outcomes (23,56). During the pandemic, due to the implementation of the lockdown in China, women spent more time with families and obtained more family support (7,46). Especially among women who reported higher PHQ-9 scores, they were likely to show depressive symptoms and may have received more support and care from their families. Thus, during this period, they may have a lower risk of experiencing adverse conditions such as blood pressure, and further had a lower risk of adverse birth outcomes. Additionally, increased family support could have lad to better behaviours, such as increased nutrition intake and healthier lifestyle during the pregnancy, which could further strengthen infants' health (56). However, mental health status is not a stable factor and could be changing from time to time. In our study, we only analyzed one-time point, thus we might have missed the changes in their mental health. The mental health status at different stages and the changes in between could better explain why the birth outcomes had changed the way we explored. Therefore, it is important to carry out longitudinal studies in future to follow up the same persons' mental health status throughout their pregnancy and then investigate the association between the two, but also between the changes and the birth outcomes.

The inconsistent findings demonstrated that the impact of prenatal depression and anxiety on birth outcomes is complicated. It also indicated that more research needs to be done to explore the association between prenatal mental health issues and adverse birth outcomes. A better understanding of the methodological differences across studies including sample size, participant characteristics, the inclusion of confounding factors, and assessment of depression and anxiety vary across studies, is needed.

Limitations

This study had some limitations that are important to acknowledge. First, prenatal depression and anxiety were assessed using self-reported questionnaires. Although these tools demonstrated to have good reliability and validity in the Chinese population, clinician-administered diagnostic instruments are still considered the gold standard (39). In future research, it might be helpful to

integrate the result from clinical diagnoses with self-reported assessments. Second, in this study, demographic information was collected using self-reported surveys, so reporting bias cannot be avoided. Participants may have misreported information on some sensitive questions, such as income, socioeconomic status, history of being diagnosed with mental health issues and drug use. Third, in this study, the two populations from pre-pandemic and pandemic cohorts were not similar. It led to issues of not being able to compare the risk factors between the two cohorts effectively. Furthermore, in this study, we did not assess other information related to the COVID-19 pandemic. For instance, whether the participants were infected, their attitudes and perceptions towards the pandemic, and whether there were any major changes in life because of the pandemic could be key variables. Moreover, individuals' mental health status could be constantly changing during pregnancy. However, we have only used the baseline data and we might have missed the changes in their mental health status. Thus, we also suggest that longitudinal studies that focus on changes in prenatal depression and anxiety status or scores in the same cohort during the pandemic could help us better understand the trend of prenatal mental health issues and their impacts on birth outcomes. Another limitation is that our study was conducted in Ma'anshan, Anhui, China. The result might not be generalizable to larger scales such as among the Chinese population or to other countries or populations. In addition, the sample size used in this study was initially calculated for investigating the participants' perinatal mental health issues. Since one of our main outcomes of interest was birth outcomes in this study, we then calculated the power regarding the models that investigated birth outcomes. For instance, in the pandemic cohort, the result demonstrated that to achieve a minimum of 80% power, a sample size of 3570 would be more optimistic. However, we only had 2249 participants, and this could lead to the lack of power in the result.

Conclusion

In conclusion, the prevalence of prenatal depression, anxiety and adverse birth outcomes decreased after the onset of the COVID-19 pandemic. Prenatal depression and anxiety had no association with preterm birth, low birth weight or small for gestational age. Even though we found that higher PHQ-9 scores were associated with lower birth weight and a higher prevalence of small for gestational age, this was not consistent with the other mental health assessments. More research on the trend of prenatal depression and anxiety during the pandemic, as well as their impacts on birth outcomes, is needed. This will help to inform national planning, establish health priorities,

and guide clinical and public health responses to COVID-19 and other potential future pandemics and disasters.

Reference

1. World Health Orgnasiztion. Timeline: WHO's COVID-19 response [Internet]. [cited 2022 Feb 7]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

2. WHO Coronavirus (COVID-19) Dashboard [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

3. China: WHO Coronavirus Disease (COVID-19) Dashboard With Vaccination Data [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

4. Yang F, Yang BX, Stone TE, Wang XQ, Zhou Y, Zhang J, et al. Stigma towards depression in a community-based sample in China. Comprehensive Psychiatry. 2020 Feb 1;97:152152.

5. Huang Y, Wang Y, Wang H, Liu Z, Yu X, Yan J, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. The Lancet Psychiatry. 2019 Mar 1;6(3):211–24.

6. Lu J, Xu X, Huang Y, Li T, Ma C, Xu G, et al. Prevalence of depressive disorders and treatment in China: a cross-sectional epidemiological study. The Lancet Psychiatry. 2021 Nov;8(11):981–90.

7. Tang X, Lu Z, Hu D, Zhong X. Influencing factors for prenatal Stress, anxiety and depression in early pregnancy among women in Chongqing, China. Journal of Affective Disorders. 2019 Jun 15;253:292–302.

8. Nisar A, Yin J, Waqas A, Bai X, Wang D, Rahman A, et al. Prevalence of perinatal depression and its determinants in Mainland China: A systematic review and meta-analysis. Journal of Affective Disorders. 2020 Dec 1;277:1022–37.

9. Dennis CL, Falah-Hassani K, Shiri R. Prevalence of antenatal and postnatal anxiety: Systematic review and meta-analysis. The British Journal of Psychiatry. 2017 May;210(5):315–23.

10. Premji SS, Dobson KS, Prashad A, Yamamoto S, Tao F, Zhu B, et al. What stakeholders think: perceptions of perinatal depression and screening in China's primary care system. BMC Pregnancy and Childbirth. 2021 Jan 6;21(1):15.

11. CGHE. Perinatal Depression Screening in China [Internet]. GACD. [cited 2022 Aug 15]. Available from: https://www.gacd.org/community/research-network/projects/mh09

12. Dong H, Hu R, Huang G, Zhang M, Lu C, Huang D, et al. Investigation on the mental health status of pregnant women in China during the Pandemic of COVID-19. Arch Gynecol Obstet. 2021;303(2):463–9.

13. Yan H, Ding Y, Guo W. Mental Health of Pregnant and Postpartum Women During the Coronavirus Disease 2019 Pandemic: A Systematic Review and Meta-Analysis. Frontiers in Psychology [Internet]. 2020 [cited 2022 Aug 2];11. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.617001

14. Katz J, Lee AC, Kozuki N, Lawn JE, Cousens S, Blencowe H, et al. Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: a pooled country analysis. The Lancet. 2013 Aug 3;382(9890):417–25.

15. Hug L, Alexander M, You D, Alkema L. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. The Lancet Global Health. 2019 Jun 1;7(6):e710–20.

16. Lin L, Lu C, Chen W, Li C, Guo VY. Parity and the risks of adverse birth outcomes: a retrospective study among Chinese. BMC Pregnancy and Childbirth. 2021 Mar 26;21(1):257.

17. Shen L, Wang J, Duan Y, Yang Z. Prevalence of low birth weight and macrosomia estimates based on heaping adjustment method in China. Sci Rep. 2021 Jul 22;11(1):15016.

18. Chawanpaiboon S, Vogel JP, Moller AB, Lumbiganon P, Petzold M, Hogan D, et al. Global, regional, and national estimates of levels of preterm birth in 2014: a systematic review and modelling analysis. Lancet Glob Health. 2018 Oct 30;7(1):e37–46.

19. Miao H, Li B, Li W, Yao F, Chen Y, Chen R, et al. Adverse birth outcomes in Guangdong province, China, 2014–2017: a spatiotemporal analysis of 2.9 million births. BMJ Open. 2019 Nov;9(11):e030629.

20. Ding W, Lu J, Zhou Y, Wei W, Zhou Z, Chen M. Knowledge, attitudes, practices, and influencing factors of anxiety among pregnant women in Wuhan during the outbreak of COVID-19: a cross-sectional study. BMC Pregnancy Childbirth. 2021;21(1):80.

21. Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, et al. The Effects of the World Trade Center Event on Birth Outcomes among Term Deliveries at Three Lower Manhattan Hospitals. Environ Health Perspect. 2004 Dec;112(17):1772–8.

22. Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

23. Premji SS, Yim IS, Dosani (Mawji) A, Kanji Z, Sulaiman S, Musana JW, et al. Psychobiobehavioral Model for Preterm Birth in Pregnant Women in Low- and Middle-Income Countries. BioMed Research International. 2015 Aug 27;2015:e450309.

24. Zhao T, Zuo H, Campbell SM, Jhangri GS, Dobson KS, Li JY, et al. The Impacts of Prenatal Mental Health Issues on Birth Outcomes during the COVID-19 Pandemic: A Scoping Review. International Journal of Environmental Research and Public Health. 2022 Jan;19(13):7670.

25. Coronavirus COVID-19 (2019-nCoV) [Internet]. [cited 2022 Aug 9]. Available from: https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6

26. Wang Y, Guo X, Lau Y, Chan KS, Yin L, Chen J. Psychometric evaluation of the Mainland Chinese version of the Edinburgh Postnatal Depression Scale. Int J Nurs Stud. 2009 Jun;46(6):813–23.

27. Zhang L, Wang L, Cui S, Yuan Q, Huang C, Zhou X. Prenatal Depression in Women in the Third Trimester: Prevalence, Predictive Factors, and Relationship With Maternal-Fetal

Attachment. Frontiers in Public Health [Internet]. 2021 [cited 2022 Jul 25];8. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2020.602005

28. Gao M, Hu J, Yang L, Ding N, Wei X, Li L, et al. Association of sleep quality during pregnancy with stress and depression: a prospective birth cohort study in China. BMC Pregnancy Childbirth. 2019 Dec;19(1):1–8.

29. Lu S, Reavley N, Zhou J, Su J, Pan X, Xiang Q, et al. Depression among the general adult population in Jiangsu Province of China: prevalence, associated factors and impacts. Soc Psychiatry Psychiatr Epidemiol. 2018 Oct;53(10):1051–61.

30. Guo J, Zheng A, He J, Ai M, Gan Y, Zhang Q, et al. The prevalence of and factors associated with antenatal depression among all pregnant women first attending antenatal care: a cross-sectional study in a comprehensive teaching hospital. BMC Pregnancy Childbirth. 2021 Oct 26;21(1):713.

31. Williams N. The GAD-7 questionnaire. Occupational Medicine. 2014 Apr 1;64(3):224.

32. Tong X, An D, McGonigal A, Park SP, Zhou D. Validation of the Generalized Anxiety Disorder-7 (GAD-7) among Chinese people with epilepsy. Epilepsy Res. 2016 Feb;120:31–6.

33. Sinesi A, Maxwell M, O'Carroll R, Cheyne H. Anxiety scales used in pregnancy: systematic review. BJPsych Open. 2019 Jan;5(1):e5.

34. Austin MPV, Mule V, Hadzi-Pavlovic D, Reilly N. Screening for anxiety disorders in third trimester pregnancy: a comparison of four brief measures. Arch Womens Ment Health. 2022 Apr;25(2):389–97.

35. Low birthweight [Internet]. UNICEF DATA. [cited 2021 Nov 24]. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/

36. Ngo TV, Gammeltoft T, Nguyen HTT, Meyrowitsch DW, Rasch V. Antenatal depressive symptoms and adverse birth outcomes in Hanoi, Vietnam. PLOS ONE. 2018 Nov 2;13(11):e0206650.

37. Capital Institute of Pediatrics, Coordinating Study Group of Nine Cities on the Physical Growth and Development of Children. [Growth standard curves of birth weight, length and head circumference of Chinese newborns of different gestation]. Zhonghua Er Ke Za Zhi. 2020 Sep 2;58(9):738–46.

38. Preterm birth [Internet]. [cited 2022 Aug 9]. Available from: https://www.who.int/news-room/fact-sheets/detail/preterm-birth

39. Li X, Gao R, Dai X, Liu H, Zhang J, Liu X, et al. The association between symptoms of depression during pregnancy and low birth weight: a prospective study. BMC Pregnancy Childbirth. 2020 Mar 6;20:147.

40. Chen J, Cross WM, Plummer V, Lam L, Sun M, Qin C, et al. The risk factors of antenatal depression: A cross-sectional survey. Journal of Clinical Nursing. 2019;28(19–20):3599–609.

41. Yang Y, Mao J, Ye Z, Zeng X, Zhao H, Liu Y, et al. Determinants of sleep quality among pregnant women in China: a cross-sectional survey. The Journal of Maternal-Fetal & Neonatal Medicine. 2018 Nov 17;31(22):2980–5.

42. Lin W, Wu B, Chen B, Lai G, Huang S, Li S, et al. Sleep Conditions Associate with Anxiety and Depression Symptoms among Pregnant Women during the Epidemic of COVID-19 in Shenzhen. J Affect Disord. 2021 Feb 15;281:567–73.

43. Zhang Y, Muyiduli X, Wang S, Jiang W, Wu J, Li M, et al. Prevalence and relevant factors of anxiety and depression among pregnant women in a cohort study from south-east China. Journal of Reproductive and Infant Psychology. 2018 Oct 20;36(5):519–29.

44. Ma R, Yang F, Zhang L, Sznajder KK, Zou C, Jia Y, et al. Resilience mediates the effect of self-efficacy on symptoms of prenatal anxiety among pregnant women: a nationwide smartphone cross-sectional study in China. BMC Pregnancy Childbirth. 2021 Dec;21(1):1–9.

45. Sun G, Wang Q, Lin Y, Li R, Yang L, Liu X, et al. Perinatal Depression of Exposed Maternal Women in the COVID-19 Pandemic in Wuhan, China. Front Psychiatry. 2020;11:551812.

46. Zheng Z, Zhang R, Liu T, Cheng P, Zhou Y, Lu W, et al. The Psychological Impact of the Coronavirus Disease 2019 Pandemic on Pregnant Women in China. Frontiers in Psychiatry [Internet]. 2021 [cited 2022 Jul 25];12. Available from: https://www.frontiersin.org/articles/10.3389/fpsyt.2021.628835

47. Wang L, Yang N, Zhou H, Mao X, Zhou Y. Pregnant Women's Anxiety and Depression Symptoms and Influence Factors in the COVID-19 Pandemic in Changzhou, China. Frontiers in Psychology [Internet]. 2022 [cited 2022 Jul 18];13. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.855545

48. Cui C, Zhai L, Sznajder KK, Wang J, Sun X, Wang X, et al. Prenatal anxiety and the associated factors among Chinese pregnant women during the COVID-19 pandemic—a smartphone questionnaire survey study. BMC Psychiatry. 2021 Dec 10;21:619.

49. Maffly-Kipp J, Eisenbeck N, Carreno DF, Hicks J. Mental health inequalities increase as a function of COVID-19 pandemic severity levels. Soc Sci Med. 2021 Sep;285:114275.

50. Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. Journal of Affective Disorders. 2020 Aug;273:5–13.

51. Lopez-Morales H, Del Valle MV, Canet-Juric L, Andres ML, Galli JI, Poo F, et al. Mental health of pregnant women during the COVID-19 pandemic: A longitudinal study. Psychiatry Res. 2021;295(qc4, 7911385):113567.

52. Ayaz R, Hocaoğlu M, Günay T, Yardımcı O devrim, Turgut A, Karateke A. Anxiety and depression symptoms in the same pregnant women before and during the COVID-19 pandemic. Journal of Perinatal Medicine. 2020 Nov;48(9):965–70.

53. Overbeck G, Rasmussen IS, Siersma V, Andersen JH, Kragstrup J, Wilson P, et al. Depression and anxiety symptoms in pregnant women in Denmark during COVID-19. Scand J Public Health. 2021 Nov;49(7):721–9.

54. Wang C, Pan R, Wan X, Tan Y, Xu L, McIntyre RS, et al. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. Brain Behav Immun. 2020 Jul;87:40–8.

55. Zheng QX, Jiang XM, Lin Y, Liu GH, Lin YP, Kang YL, et al. The influence of psychological response and security sense on pregnancy stress during the outbreak of coronavirus disease 2019: A mediating model. Journal of Clinical Nursing. 2020;29(21–22):4248–57.

56. Ozbay F, Johnson DC, Dimoulas E, Morgan CA, Charney D, Southwick S. Social Support and Resilience to Stress. Psychiatry (Edgmont). 2007 May;4(5):35–40.

57. Liu X, Chen M, Wang Y, Sun L, Zhang J, Shi Y, et al. Prenatal anxiety and obstetric decisions among pregnant women in Wuhan and Chongqing during the COVID-19 outbreak: a cross-sectional study. BJOG: An International Journal of Obstetrics & Gynaecology. 2020 Sep 15;127(10):1229–40.

58. Liu J, Liu M, Liang W. The Dynamic COVID-Zero Strategy in China. CCDCW. 2022 Jan 28;4(4):74–5.

59. Policies energize hard-hit economy [Internet]. [cited 2022 Aug 3]. Available from: http://english.www.gov.cn/policies/policywatch/202208/03/content_WS62e9ca3fc6d02e533532ed0b.html

60. Fall A, Goulet L, Vézina M. Comparative study of major depressive symptoms among pregnant women by employment status. Springerplus. 2013 Apr 30;2(1):201.

61. Howard LM, Oram S, Galley H, Trevillion K, Feder G. Domestic Violence and Perinatal Mental Disorders: A Systematic Review and Meta-Analysis. PLoS Med. 2013 May 28;10(5):e1001452.

62. Field T. Prenatal Depression Risk Factors, Developmental Effects and Interventions: A Review. J Pregnancy Child Health. 2017 Feb;4(1):301.

63. Wang Q, Song B, Di JL, Mo PKH, Zhou FR, Zhao J, et al. Mental health and preventive behaviour of pregnant women in China during the early phase of the COVID-19 period. Infect Dis Pover. 2021;10(1):37.

64. Li C, Huo L, Wang R, Qi L, Wang W, Zhou X, et al. The prevalence and risk factors of depression in prenatal and postnatal women in China with the outbreak of Corona Virus Disease 2019. J Affect Disord. 2021 Mar 1;282:1203–9.

65. Cao Y, Liu J, Zhang Y, Li Y, Chen Z, Lu J. Pregnant women's psychological state and influence factors: anxiety, and depression during COVID-19 outbreak. J Perinat Med. 2021;49(6):664–73.

66. Chen Y, Li G, Ruan Y, Zou L, Wang X, Zhang W. An epidemiological survey on low birth weight infants in China and analysis of outcomes of full-term low birth weight infants. BMC Pregnancy Childbirth. 2013 Dec;13(1):1–9.

67. Chen C, Zhang JW, Xia HW, Zhang HX, Betran AP, Zhang L, et al. Preterm Birth in China Between 2015 and 2016. Am J Public Health. 2019 Nov;109(11):1597–604.

68. Bian Z, Qu X, Ying H, Liu X. Are COVID-19 mitigation measures reducing preterm birth rate in China? BMJ Global Health. 2021 Aug 1;6(8):e006359.

69. Deng K, Liang J, Mu Y, Liu Z, Wang Y, Li M, et al. Preterm births in China between 2012 and 2018: an observational study of more than 9 million women. Lancet Glob Health. 2021 Sep;9(9):e1226–41.

70. He H, Miao H, Liang Z, Zhang Y, Jiang W, Deng Z, et al. Prevalence of small for gestational age infants in 21 cities in China, 2014-2019. Sci Rep. 2021 Apr 5;11(1):7500.

71. Been JV, Burgos Ochoa L, Bertens LCM, Schoenmakers S, Steegers EAP, Reiss IKM. Impact of COVID-19 mitigation measures on the incidence of preterm birth: a national quasi-experimental study. Lancet Public Health. 2020 Nov;5(11):e604–11.

72. Caniglia EC, Magosi LE, Zash R, Diseko M, Mayondi G, Mabuta J, et al. Modest reduction in adverse birth outcomes following the COVID-19 lockdown. Am J Obstet Gynecol. 2021 Jun;224(6):615.e1-615.e12.

73. Khalil A, von Dadelszen P, Draycott T, Ugwumadu A, O'Brien P, Magee L. Change in the Incidence of Stillbirth and Preterm Delivery During the COVID-19 Pandemic. JAMA. 2020 Aug 18;324(7):705–6.

74. Preis H, Mahaffey B, Pati S, Heiselman C, Lobel M. Adverse Perinatal Outcomes Predicted by Prenatal Maternal Stress Among U.S. Women at the COVID-19 Pandemic Onset. Annals of Behavioral Medicine. 2021 Mar;55(3):179–91.

75. Philip RK, Purtill H, Reidy E, Daly M, Imcha M, McGrath D, et al. Unprecedented reduction in births of very low birthweight (VLBW) and extremely low birthweight (ELBW) infants during the COVID-19 lockdown in Ireland: a 'natural experiment' allowing analysis of data from the prior two decades. BMJ Glob Health. 2020 Sep 30;5(9):e003075.

76. Shapiro GD, Fraser WD, Frasch MG, Séguin JR. Psychosocial stress in pregnancy and preterm birth: associations and mechanisms. J Perinat Med. 2013 Nov;41(6):631–45.

77. Richter LL, Ting J, Muraca GM, Boutin A, Wen Q, Lyons J, et al. Temporal Trends in Preterm Birth, Neonatal Mortality, and Neonatal Morbidity Following Spontaneous and Clinician-Initiated Delivery in Canada, 2009-2016. Journal of Obstetrics and Gynaecology Canada. 2019 Dec;41(12):1742-1751.e6.

78. Li L, Cao Y, Fan J, Li T, Lang J, Zhang H, et al. Impact of COVID-19 Pandemic on the Clinical Activities in Obstetrics and Gynecology: A National Survey in China. Frontiers in Medicine [Internet]. 2021 [cited 2022 Sep 20];8. Available from: https://www.frontiersin.org/articles/10.3389/fmed.2021.633477

79. Yang R, Mei H, Zheng T, Fu Q, Zhang Y, Buka S, et al. Pregnant women with COVID-19 and risk of adverse birth outcomes and maternal-fetal vertical transmission: a population-based cohort study in Wuhan, China. BMC Med. 2020 Oct 19;18(1):330.

80. Binte Masud S, Zebeen F, Alam DW, Hossian M, Zaman S, Begum RA, et al. Adverse Birth Outcomes Among Pregnant Women With and Without COVID-19: A Comparative Study From Bangladesh. J Prev Med Public Health. 2021 Nov;54(6):422–30.

81. Karasek D, Baer RJ, McLemore MR, Bell AJ, Blebu BE, Casey JA, et al. The association of COVID-19 infection in pregnancy with preterm birth: A retrospective cohort study in California. The Lancet Regional Health – Americas [Internet]. 2021 Oct 1 [cited 2022 Aug 9];2. Available from: https://www.thelancet.com/journals/lanam/article/PIIS2667-193X(21)00019-3/fulltext

82. Van Dijk AE, Van Eijsden M, Stronks K, Gemke RJBJ, Vrijkotte TGM. Maternal depressive symptoms, serum folate status, and pregnancy outcome: results of the Amsterdam Born Children and their Development study. Am J Obstet Gynecol. 2010 Dec;203(6):563.e1-7.

83. Wang SY, Chen CH. The association between prenatal depression and obstetric outcome in Taiwan: a prospective study. J Womens Health (Larchmt). 2010 Dec;19(12):2247–51.

84. Smith MV, Shao L, Howell H, Lin H, Yonkers KA. Perinatal Depression and Birth Outcomes in a Healthy Start Project. Matern Child Health J. 2011 Apr;15(3):401–9.

85. Nasreen HE, Kabir ZN, Forsell Y, Edhborg M. Low birth weight in offspring of women with depressive and anxiety symptoms during pregnancy: results from a population based study in Bangladesh. BMC Public Health. 2010 Aug 26;10:515.

86. Goedhart G, Snijders AC, Hesselink AE, van Poppel MN, Bonsel GJ, Vrijkotte TGM. Maternal depressive symptoms in relation to perinatal mortality and morbidity: results from a large multiethnic cohort study. Psychosom Med. 2010 Oct;72(8):769–76.

87. Hodgkinson SC, Colantuoni E, Roberts D, Berg-Cross L, Belcher HME. Depressive Symptoms and Birth Outcomes among Pregnant Teenagers. J Pediatr Adolesc Gynecol. 2010 Feb;23(1):16–22.

88. Uguz F, Gezginc K, Yazici F. Are major depression and generalized anxiety disorder associated with intrauterine growth restriction in pregnant women? A case-control study. Gen Hosp Psychiatry. 2011 Dec;33(6):640.e7-9.

89. Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

90. El-Mohandes AAE, Kiely M, Gantz MG, El-Khorazaty MN. Very preterm birth is reduced in women receiving an integrated behavioral intervention: a randomized controlled trial. Matern Child Health J. 2011 Jan;15(1):19–28.

91. Kiely M, El-Mohandes AAE, Gantz MG, Chowdhury D, Thornberry JS, El-Khorazaty MN. Understanding the Association of Biomedical, Psychosocial and Behavioral Risks with Adverse Pregnancy Outcomes. Matern Child Health J. 2011 Dec;15(Suppl 1):85–95.

92. Wdowiak A, Makara-Studzinska M, Raczkiewicz D, Janczyk P, Slabuszewska-Jozwiak A, Wdowiak-Filip A, et al. Effect of excessive body weight and emotional disorders on the course of pregnancy and well-being of a newborn before and during covid-19 pandemic. J Clin Med. 2021;10(4):1–16.

Chapter 4 Discussion and Conclusion

Adverse birth outcomes, including low birth weight, preterm birth, and small for gestational age are associated with increased neonatal morbidity and mortality (1). They also increase the risk of long-term impacts in childhood and adulthood, including impaired neurodevelopment, non-communicable diseases, and psychological and emotional distress (1,2). Although many interventions have been implemented to enhance the level of medical care and improve the health condition of infants and young children, adverse birth outcomes have not been effectively reduced (3). Adverse birth outcomes are still challenging public health problems in China (3).

Prenatal depression and anxiety have been found to be associated with adverse birth outcomes, including preterm birth, low birth weight, and small for gestational age (4). For instance, Ding et al. reported that women who have prenatal anxiety experience 1.5 times higher risks of preterm birth and 1.8 times higher risk of delivering low-birth-weight infants (5). In China, there is increasing literature reporting the importance and severity of prenatal depression and anxiety.

Previous studies have reported that infectious disease outbreaks and disasters could increase the risk of developing depression and anxiety and could possibly be due to stress-related pathways (6). Coronavirus disease 2019 (COVID-19), which has strong infectivity and severe pathogenicity, first broke out in Wuhan, China in December 2019 (7). On March 11, 2020, the World Health Organization (WHO) declared COVID-19 as a pandemic. COVID-19 has heavily impacted more than 222 countries, areas, or territories. As of July 27, 2022, the cumulative infection cases were over 5.8 million in China with more than 24,000 deaths (8). The sensitivity of the pandemic could indicate that pregnant women are at higher risk of developing prenatal depression and anxiety during this critical time. Studies suggested that the level of depression among pregnant women has significantly increased from 3.5% to 8.2% pre-pandemic to 50.6% during-pandemic, with nearly 27% of the pregnant women experienced moderate to severe depression (7). The estimated prevalence of prenatal anxiety has also increased from 15.2% pre-pandemic to 37% during-pandemic (9).

Considering the severity of the COVID-19 pandemic, the rate of prenatal mental health disorders, and the association between prenatal mental health disorders and adverse birth outcomes, related

adverse birth outcomes are likely to be impacted, possibly adding further burdens to the current healthcare system in China. To our knowledge, the impact of prenatal mental health issues on adverse birth outcomes during the COVID-19 pandemic in China has not been well explored (10). Therefore, this thesis aimed to explore the differences in prenatal mental disorders and adverse birth outcomes between pre-pandemic and during-pandemic periods, and to study the impacts of those mental disorders on birth outcomes in China.

Summary of Thesis Findings

In Chapter 2, a scoping review synthesized evidence from literature published between late 2019 to July 2021 on the impacts of prenatal mental health issues on birth outcomes during the COVID-19 pandemic. First, this review highlighted that pregnant women were likely to experience heightened mental health issues during the pandemic. Such increases were likely to be due to uncertainty regarding the effects of COVID-19 on maternal-fetal health, pandemic restrictions, and pandemic-related financial strain. Second, the results suggested that prenatal depression and anxiety increased the risk of developing adverse birth outcomes, including preterm birth, low birth weight and small for gestational age, during the COVID-19 pandemic.

However, only two studies were eligible to be included in the review. This demonstrated that the existing knowledge on the impact of prenatal mental health issues on birth outcomes during the COVID-19 pandemic is not yet well established. We also found that in some cases, the rates of adverse birth outcomes decreased during the pandemic even with increased mental health issues, which emphasized that the relationship between prenatal mental health and birth outcomes is nuanced and complex. Furthermore, neither of the two studies were conducted in China. Therefore, the impacts of prenatal mental health issues on birth outcomes during the pandemic remained unstudied in China.

Chapter 3 aimed to address knowledge gaps identified in Chapter 2 by exploring the impacts of prenatal mental health issues on birth outcomes before and during the COVID-19 pandemic in Ma'anshan, Anhui, China. This chapter found that during the pandemic, the prevalence of prenatal depression and anxiety decreased compared to levels before the pandemic. We suggest that the reduction could be due to increased family support among the participants as they were required to stay home with families as a result of the strict lockdown restrictions. Furthermore, the COVD-

19 pandemic was less severe in Anhui so participants might not have felt as stressed. Additionally, China has adopted the dynamic zero-COVID policy nationally to minimize the impact of the epidemic on the economy, society, production and people's normal lives.

We also found that the prevalence of preterm birth, low birth weight and small for gestational age decreased compared to periods prior to the pandemic. This could be due to additional partner and family support and having more time to focus on their lifestyle and nutrition, which supports infant growth. Most importantly, we also found that in most cases, there was no association between prenatal depression and anxiety, and birth outcomes. Interestingly, we did find that higher PHQ-9 measured depression scores were significantly associated with higher infant birth weights and longer gestation age. This finding, to our knowledge, was the opposite of other similar studies (5,11–21). During the pandemic, with increased family and social support during their pregnancy, pregnant women who showed depressive symptoms might have been detected earlier (4,22). As a result, mothers might have received care earlier, decreasing risks to infant health. In addition, findings also provided insights into prenatal mental health disorders and adverse birth outcomes by exploring the sociodemographic risk factors for prenatal depression and anxiety, preterm birth, low birth weight and small for gestational age before and during the pandemic in Anhui.

However, this study had some potential limitations. First, demographic information and prenatal depression and anxiety were assessed using self-reported questionnaires. This could cause potential recall and social desirability biases. Second, the population in the two cohorts were not similar. Thus, potential risk factors of prenatal depression and anxiety might not be comparable between the two cohorts. Third, our study was conducted in Ma'anshan, Anhui, China. The result might not be generalizable to a larger scale such as among the Chinese population or to other countries or populations.

Contributions, Gaps and Future Directions

This study aimed to address the gap of unstudied impacts of prenatal depression and anxiety of birth outcomes identified in Chapter 2 within the Chinese context. Results provided insight into how prenatal depression and anxiety, as well as birth outcomes might have changed between pre-

and during-pandemic periods. Findings are intended to provide stakeholders with better understanding of how the pandemic could have impacted perinatal health.

There are several gaps that emerged in this study. First, factors related to changes in the prevalence of prenatal depression, anxiety and adverse birth outcomes during the pandemic are still understudied. Furthermore, risk factors that change over time, such as stress and perceptions towards the pandemic, were not assessed in this study. Longitudinal studies could be a future direction to investigate changes in prenatal mental health disorders and birth outcomes. For instance, following up with the same population and repeated mental health assessments at different time points could be informative. This would provide information on if and how outcomes change over time, as well as identify potential factors that are associated with these changes. In addition, this could also address the issues of not being able to compare the risk factors among the two different populations as presented in this study. Second, this study included only selected sociodemographic factors. It would be important to also look at more factors that are specifically related to the COVID-19 pandemic. For instance, these could include the infection history of the participants, participants' perceptions and attitudes towards the pandemic, the changes in participants' pregnancy experiences during the pandemic, and pandemic-related depressive, anxiety, and stress symptoms. These might also give us insights into how prenatal mental disorders and birth outcomes might be different from the pre-pandemic period.

Conclusion

In conclusion, findings highlighted the impacts of prenatal depression and anxiety on birth outcomes before and during the pandemic in Anhui, China. Current literature indicates there are gaps and inconsistencies regarding the changes in prenatal mental health disorders and adverse birth outcomes during the pandemic, suggesting the relationship between prenatal mental health and birth outcomes could be more nuanced. In this study, it remains unclear why the prevalence of prenatal depression, anxiety and adverse birth outcomes has reduced since the pandemic occurred. Evidence is lacking when it comes to understand why the association between prenatal mental health disorders and birth outcomes were not significant in some studies but were in others. This thesis has also highlighted outstanding gaps and potential future research directions. The

results from this thesis will help to improve our understanding of prenatal depression, anxiety, and adverse birth outcomes under the COVID-19 pandemic, particularly in the Chinese context.

Reference

1. Muhihi A, Sudfeld CR, Smith ER, Noor RA, Mshamu S, Briegleb C, et al. Risk factors for small-for-gestational-age and preterm births among 19,269 Tanzanian newborns. BMC Pregnancy Childbirth. 2016 Dec;16(1):1–12.

2. Li J, Qiu J, Lv L, Mao B, Huang L, Yang T, et al. Paternal factors and adverse birth outcomes in Lanzhou, China. BMC Pregnancy Childbirth. 2021 Dec;21(1):1–12.

3. Miao H, Li B, Li W, Yao F, Chen Y, Chen R, et al. Adverse birth outcomes in Guangdong province, China, 2014–2017: a spatiotemporal analysis of 2.9 million births. BMJ Open. 2019 Nov;9(11):e030629.

4. Tang X, Lu Z, Hu D, Zhong X. Influencing factors for prenatal Stress, anxiety and depression in early pregnancy among women in Chongqing, China. Journal of Affective Disorders. 2019 Jun 15;253:292–302.

5. Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

6. Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

7. Dong H, Hu R, Huang G, Zhang M, Lu C, Huang D, et al. Investigation on the mental health status of pregnant women in China during the Pandemic of COVID-19. Arch Gynecol Obstet. 2021;303(2):463–9.

8. China: WHO Coronavirus Disease (COVID-19) Dashboard With Vaccination Data [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

9. Yan H, Ding Y, Guo W. Mental Health of Pregnant and Postpartum Women During the Coronavirus Disease 2019 Pandemic: A Systematic Review and Meta-Analysis. Frontiers in

Psychology [Internet]. 2020 [cited 2022 Aug 2];11. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.617001

10. Zhao T, Zuo H, Campbell SM, Jhangri GS, Dobson KS, Li JY, et al. The Impacts of Prenatal Mental Health Issues on Birth Outcomes during the COVID-19 Pandemic: A Scoping Review. International Journal of Environmental Research and Public Health. 2022 Jan;19(13):7670.

11. Preis H, Mahaffey B, Pati S, Heiselman C, Lobel M. Adverse Perinatal Outcomes Predicted by Prenatal Maternal Stress Among U.S. Women at the COVID-19 Pandemic Onset. Ann Behav Med. 2021;55(3):179–91.

12. Smith RD, Peahl AF, Moniz MH. Prenatal care redesign: creating flexible maternity care models through virtual care. Am J Obstet Gynecol. 2020;223(3):389.

13. Field T, Diego M, Hernandez-Reif M, Schanberg S, Kuhn C, Yando R, et al. Pregnancy anxiety and comorbid depression and anger: effects on the fetus and neonate. Depress Anxiety. 2003;17(3):140–51.

14. Nasreen HE, Kabir ZN, Forsell Y, Edhborg M. Low birth weight in offspring of women with depressive and anxiety symptoms during pregnancy: results from a population based study in Bangladesh. BMC Public Health. 2010 Aug 26;10:515.

15. El-Mohandes AAE, Kiely M, Gantz MG, El-Khorazaty MN. Very preterm birth is reduced in women receiving an integrated behavioral intervention: a randomized controlled trial. Matern Child Health J. 2011 Jan;15(1):19–28.

16. Kiely M, El-Mohandes AAE, Gantz MG, Chowdhury D, Thornberry JS, El-Khorazaty MN. Understanding the Association of Biomedical, Psychosocial and Behavioral Risks with Adverse Pregnancy Outcomes. Matern Child Health J. 2011 Dec;15(Suppl 1):85–95.

17. Wdowiak A, Makara-Studzinska M, Raczkiewicz D, Janczyk P, Slabuszewska-Jozwiak A, Wdowiak-Filip A, et al. Effect of excessive body weight and emotional disorders on the course of pregnancy and well-being of a newborn before and during covid-19 pandemic. J Clin Med. 2021;10(4):1–16.

18. Li X, Gao R, Dai X, Liu H, Zhang J, Liu X, et al. The association between symptoms of depression during pregnancy and low birth weight: a prospective study. BMC Pregnancy Childbirth. 2020 Mar 6;20:147.

19. Goedhart G, Snijders AC, Hesselink AE, van Poppel MN, Bonsel GJ, Vrijkotte TGM. Maternal depressive symptoms in relation to perinatal mortality and morbidity: results from a large multiethnic cohort study. Psychosom Med. 2010 Oct;72(8):769–76.

20. Hodgkinson SC, Colantuoni E, Roberts D, Berg-Cross L, Belcher HME. Depressive Symptoms and Birth Outcomes among Pregnant Teenagers. J Pediatr Adolesc Gynecol. 2010 Feb;23(1):16–22.

21. Uguz F, Gezginc K, Yazici F. Are major depression and generalized anxiety disorder associated with intrauterine growth restriction in pregnant women? A case-control study. Gen Hosp Psychiatry. 2011 Dec;33(6):640.e7-9.

22. Zheng Z, Zhang R, Liu T, Cheng P, Zhou Y, Lu W, et al. The Psychological Impact of the Coronavirus Disease 2019 Pandemic on Pregnant Women in China. Frontiers in Psychiatry [Internet]. 2021 [cited 2022 Jul 25];12. Available from: https://www.frontiersin.org/articles/10.3389/fpsyt.2021.628835

Bibliography

Austin MPV, Mule V, Hadzi-Pavlovic D, Reilly N. Screening for anxiety disorders in third trimester pregnancy: a comparison of four brief measures. Arch Womens Ment Health. 2022 Apr;25(2):389–97.

Ayaz R, Hocaoğlu M, Günay T, Yardımcı O devrim, Turgut A, Karateke A. Anxiety and depression symptoms in the same pregnant women before and during the COVID-19 pandemic. Journal of Perinatal Medicine. 2020 Nov;48(9):965–70.

Ayaz R, Hocaoğlu M, Günay T, Yardımcı O devrim, Turgut A, Karateke A. Anxiety and depression symptoms in the same pregnant women before and during the COVID-19 pandemic. Journal of Perinatal Medicine. 2020 Nov;48(9):965–70.

Been JV, Burgos Ochoa L, Bertens LCM, Schoenmakers S, Steegers EAP, Reiss IKM. Impact of COVID-19 mitigation measures on the incidence of preterm birth: a national quasi-experimental study. Lancet Public Health. 2020 Nov;5(11):e604–11.

Bian Z, Qu X, Ying H, Liu X. Are COVID-19 mitigation measures reducing preterm birth rate in China? BMJ Global Health. 2021 Aug 1;6(8):e006359.

Binte Masud S, Zebeen F, Alam DW, Hossian M, Zaman S, Begum RA, et al. Adverse Birth Outcomes Among Pregnant Women With and Without COVID-19: A Comparative Study From Bangladesh. J Prev Med Public Health. 2021 Nov;54(6):422–30.

Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal R, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012 Jun 9;379(9832):2162–72.

Campbell S. earch Hedge to Retrieve Studies related to COVID-19 from the SCOPUS Database [Internet]. John W. Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/16r1ChRPvy2spv6yZYbJVzQut0r5wr0AolZuFXgw3HIw/edit?usp=embed_facebook

Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID EMBASE Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1TEJrJsh1HUKszA5BoGvr8YoeCHlNCA8sw3ekw--ylLQ/edit

Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID PsycInfo Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1u2tWwOAlfNjun1bXsc4TUe6A9MMt8Y2Fmj0R49qDXKs/edit

Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID MEDLINE Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1VQnOBmBAwAT5fkqQfxtQgvmCbXqC3ZpDtxo-v24yvIQ/edit?usp=embed_facebook

Campbell S. Search Hedge to Retrieve Studies related to COVID-19 from the EBSCO CINAHL Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/17w4RulQkUjJnAeIVyvLalCHPudBqobIlE8Qhtll5qTA/edit?usp=embed_facebook

Caniglia EC, Magosi LE, Zash R, Diseko M, Mayondi G, Mabuta J, et al. Modest reduction in adverse birth outcomes following the COVID-19 lockdown. Am J Obstet Gynecol. 2021 Jun;224(6):615.e1-615.e12.

Caniglia EC, Magosi LE, Zash R, Diseko M, Mayondi G, Mabuta J, et al. Modest reduction in adverse birth outcomes following the COVID-19 lockdown. Am J Obstet Gynecol. 2021 Jun;224(6):615.e1-615.e12.

Cao Y, Liu J, Zhang Y, Li Y, Chen Z, Lu J. Pregnant women's psychological state and influence factors: anxiety, and depression during COVID-19 outbreak. J Perinat Med. 2021;49(6):664–73.

Capital Institute of Pediatrics, Coordinating Study Group of Nine Cities on the Physical Growth and Development of Children. [Growth standard curves of birth weight, length and head circumference of Chinese newborns of different gestation]. Zhonghua Er Ke Za Zhi. 2020 Sep 2;58(9):738–46.

Ceulemans M, Foulon V, Ngo E, Panchaud A, Winterfeld U, Pomar L, et al. Mental health status of pregnant and breastfeeding women during the COVID-19 pandemic-A multinational cross-sectional study. Acta Obstet Gynecol Scand. 2021;100(7):1219–29.

Ceulemans M, Hompes T, Foulon V. Mental health status of pregnant and breastfeeding women during the COVID-19 pandemic: A call for action. International Journal of Gynecology & Obstetrics. 2020;151(1):146–7.

CGHE. Perinatal Depression Screening in China [Internet]. GACD. [cited 2022 Aug 15]. Available from: https://www.gacd.org/community/research-network/projects/mh09

CGHE. Perinatal Depression Screening in China [Internet]. GACD. [cited 2022 Aug 15]. Available from: https://www.gacd.org/community/research-network/projects/mh09

Chawanpaiboon S, Vogel JP, Moller AB, Lumbiganon P, Petzold M, Hogan D, et al. Global, regional, and national estimates of levels of preterm birth in 2014: a systematic review and modelling analysis. Lancet Glob Health. 2018 Oct 30;7(1):e37–46.

Chen C, Zhang JW, Xia HW, Zhang HX, Betran AP, Zhang L, et al. Preterm Birth in China Between 2015 and 2016. Am J Public Health. 2019 Nov;109(11):1597–604.

Chen J, Cross WM, Plummer V, Lam L, Sun M, Qin C, et al. The risk factors of antenatal depression: A cross-sectional survey. Journal of Clinical Nursing. 2019;28(19–20):3599–609.

Chen Y, Li G, Ruan Y, Zou L, Wang X, Zhang W. An epidemiological survey on low birth weight infants in China and analysis of outcomes of full-term low birth weight infants. BMC Pregnancy Childbirth. 2013 Dec;13(1):1–9.

China: WHO Coronavirus Disease (COVID-19) Dashboard With Vaccination Data [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

China: WHO Coronavirus Disease (COVID-19) Dashboard With Vaccination Data [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

China: WHO Coronavirus Disease (COVID-19) Dashboard With Vaccination Data [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

Coronavirus COVID-19 (2019-nCoV) [Internet]. [cited 2022 Aug 9]. Available from: https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6

Coronavirus COVID-19 (2019-nCoV) [Internet]. [cited 2022 Aug 9]. Available from: https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6

Cui C, Zhai L, Sznajder KK, Wang J, Sun X, Wang X, et al. Prenatal anxiety and the associated factors among Chinese pregnant women during the COVID-19 pandemic——a smartphone questionnaire survey study. BMC Psychiatry. 2021 Dec 10;21:619.

Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. Early Human Development. 2011 Dec 1;87(12):813–20.

Deng K, Liang J, Mu Y, Liu Z, Wang Y, Li M, et al. Preterm births in China between 2012 and 2018: an observational study of more than 9 million women. Lancet Glob Health. 2021 Sep;9(9):e1226–41.

Dennis CL, Falah-Hassani K, Shiri R. Prevalence of antenatal and postnatal anxiety: Systematic review and meta-analysis. The British Journal of Psychiatry. 2017 May;210(5):315–23.

Dennis CL, Falah-Hassani K, Shiri R. Prevalence of antenatal and postnatal anxiety: Systematic review and meta-analysis. The British Journal of Psychiatry. 2017 May;210(5):315–23.

Ding W, Lu J, Zhou Y, Wei W, Zhou Z, Chen M. Knowledge, attitudes, practices, and influencing factors of anxiety among pregnant women in Wuhan during the outbreak of COVID-19: a cross-sectional study. BMC Pregnancy Childbirth. 2021;21(1):80.

Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

Ding XX, Wu YL, Xu SJ, Zhu RP, Jia XM, Zhang SF, et al. Maternal anxiety during pregnancy and adverse birth outcomes: A systematic review and meta-analysis of prospective cohort studies. Journal of Affective Disorders. 2014 Apr 20;159:103–10.

Dong H, Hu R, Huang G, Zhang M, Lu C, Huang D, et al. Investigation on the mental health status of pregnant women in China during the Pandemic of COVID-19. Arch Gynecol Obstet. 2021;303(2):463–9.

Dong H, Hu R, Huang G, Zhang M, Lu C, Huang D, et al. Investigation on the mental health status of pregnant women in China during the Pandemic of COVID-19. Arch Gynecol Obstet. 2021;303(2):463–9.

Dong H, Hu R, Huang G, Zhang M, Lu C, Huang D, et al. Investigation on the mental health status of pregnant women in China during the Pandemic of COVID-19. Arch Gynecol Obstet. 2021;303(2):463–9.

Eaton NR, Keyes KM, Krueger RF, Balsis S, Skodol AE, Markon KE, et al. An invariant dimensional liability model of gender differences in mental disorder prevalence: Evidence from a national sample. Journal of Abnormal Psychology. 2012;121(1):282–8.

El-Mohandes AAE, Kiely M, Gantz MG, El-Khorazaty MN. Very preterm birth is reduced in women receiving an integrated behavioral intervention: a randomized controlled trial. Matern Child Health J. 2011 Jan;15(1):19–28.

El-Mohandes AAE, Kiely M, Gantz MG, El-Khorazaty MN. Very preterm birth is reduced in women receiving an integrated behavioral intervention: a randomized controlled trial. Matern Child Health J. 2011 Jan;15(1):19–28.

Fall A, Goulet L, Vézina M. Comparative study of major depressive symptoms among pregnant women by employment status. Springerplus. 2013 Apr 30;2(1):201.

Field T, Diego M, Hernandez-Reif M, Schanberg S, Kuhn C, Yando R, et al. Pregnancy anxiety and comorbid depression and anger: effects on the fetus and neonate. Depress Anxiety. 2003;17(3):140–51.

Field T. Prenatal Depression Risk Factors, Developmental Effects and Interventions: A Review. J Pregnancy Child Health. 2017 Feb;4(1):301.

Gao J, Zheng P, Jia Y, Chen H, Mao Y, Chen S, et al. Mental health problems and social media exposure during COVID-19 outbreak. PLOS ONE. 2020 Apr 16;15(4):e0231924.

Gao M, Hu J, Yang L, Ding N, Wei X, Li L, et al. Association of sleep quality during pregnancy with stress and depression: a prospective birth cohort study in China. BMC Pregnancy Childbirth. 2019 Dec;19(1):1–8.

Goedhart G, Snijders AC, Hesselink AE, van Poppel MN, Bonsel GJ, Vrijkotte TGM. Maternal depressive symptoms in relation to perinatal mortality and morbidity: results from a large multiethnic cohort study. Psychosom Med. 2010 Oct;72(8):769–76.

Goedhart G, Snijders AC, Hesselink AE, van Poppel MN, Bonsel GJ, Vrijkotte TGM. Maternal depressive symptoms in relation to perinatal mortality and morbidity: results from a large multiethnic cohort study. Psychosom Med. 2010 Oct;72(8):769–76.

Guo J, Zheng A, He J, Ai M, Gan Y, Zhang Q, et al. The prevalence of and factors associated with antenatal depression among all pregnant women first attending antenatal care: a cross-sectional study in a comprehensive teaching hospital. BMC Pregnancy Childbirth. 2021 Oct 26;21(1):713.

Hannah Ritchie, Max Roser. Mental Health - Our World in Data [Internet]. [cited 2021 Jul 25]. Available from: https://ourworldindata.org/mental-health

Harville E, Xiong X, Buekens P. Disasters and Perinatal Health: A Systematic Review. Obstet Gynecol Surv. 2010 Nov;65(11):713–28.

He H, Miao H, Liang Z, Zhang Y, Jiang W, Deng Z, et al. Prevalence of small for gestational age infants in 21 cities in China, 2014-2019. Sci Rep. 2021 Apr 5;11(1):7500.

Hodgkinson SC, Colantuoni E, Roberts D, Berg-Cross L, Belcher HME. Depressive Symptoms and Birth Outcomes among Pregnant Teenagers. J Pediatr Adolesc Gynecol. 2010 Feb;23(1):16–22.

Hodgkinson SC, Colantuoni E, Roberts D, Berg-Cross L, Belcher HME. Depressive Symptoms and Birth Outcomes among Pregnant Teenagers. J Pediatr Adolesc Gynecol. 2010 Feb;23(1):16–22.

Hompes T, Izzi B, Gellens E, Morreels M, Fieuws S, Pexsters A, et al. Investigating the influence of maternal cortisol and emotional state during pregnancy on the DNA methylation status of the glucocorticoid receptor gene (NR3C1) promoter region in cord blood. Journal of Psychiatric Research. 2013 Jul 1;47(7):880–91.

Hompes T, Izzi B, Gellens E, Morreels M, Fieuws S, Pexsters A, et al. Investigating the influence of maternal cortisol and emotional state during pregnancy on the DNA methylation status of the glucocorticoid receptor gene (NR3C1) promoter region in cord blood. Journal of Psychiatric Research. 2013 Jul 1;47(7):880–91.

Howard LM, Molyneaux E, Dennis CL, Rochat T, Stein A, Milgrom J. Non-psychotic mental disorders in the perinatal period. The Lancet. 2014 Nov 15;384(9956):1775–88.

Howard LM, Oram S, Galley H, Trevillion K, Feder G. Domestic Violence and Perinatal Mental Disorders: A Systematic Review and Meta-Analysis. PLoS Med. 2013 May 28;10(5):e1001452.

Huang Y, Wang Y, Wang H, Liu Z, Yu X, Yan J, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. The Lancet Psychiatry. 2019 Mar 1;6(3):211–24.

Huang Y, Wang Y, Wang H, Liu Z, Yu X, Yan J, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. The Lancet Psychiatry. 2019 Mar 1;6(3):211–24.

Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. Psychiatry Research. 2020 Jun 1;288:112954.

Hug L, Alexander M, You D, Alkema L. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. The Lancet Global Health. 2019 Jun 1;7(6):e710–20.

James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018 Nov 10;392(10159):1789–858.

Karasek D, Baer RJ, McLemore MR, Bell AJ, Blebu BE, Casey JA, et al. The association of COVID-19 infection in pregnancy with preterm birth: A retrospective cohort study in California. The Lancet Regional Health – Americas [Internet]. 2021 Oct 1 [cited 2022 Aug 9];2. Available from: https://www.thelancet.com/journals/lanam/article/PIIS2667-193X(21)00019-3/fulltext

Katz J, Lee AC, Kozuki N, Lawn JE, Cousens S, Blencowe H, et al. Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: a pooled country analysis. The Lancet. 2013 Aug 3;382(9890):417–25.

Khalil A, von Dadelszen P, Draycott T, Ugwumadu A, O'Brien P, Magee L. Change in the Incidence of Stillbirth and Preterm Delivery During the COVID-19 Pandemic. JAMA. 2020 Aug 18;324(7):705–6.

Kiely M, El-Mohandes AAE, Gantz MG, Chowdhury D, Thornberry JS, El-Khorazaty MN. Understanding the Association of Biomedical, Psychosocial and Behavioral Risks with Adverse Pregnancy Outcomes. Matern Child Health J. 2011 Dec;15(Suppl 1):85–95.

Kiely M, El-Mohandes AAE, Gantz MG, Chowdhury D, Thornberry JS, El-Khorazaty MN. Understanding the Association of Biomedical, Psychosocial and Behavioral Risks with Adverse Pregnancy Outcomes. Matern Child Health J. 2011 Dec;15(Suppl 1):85–95.

Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. Journal of Affective Disorders. 2020 Aug;273:5–13.

Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. Journal of Affective Disorders. 2020 Aug;273:5–13.

Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. Journal of Affective Disorders. 2020 Aug;273:5–13.

Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, et al. The Effects of the World Trade Center Event on Birth Outcomes among Term Deliveries at Three Lower Manhattan Hospitals. Environ Health Perspect. 2004 Dec;112(17):1772–8.

Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, et al. The Effects of the World Trade Center Event on Birth Outcomes among Term Deliveries at Three Lower Manhattan Hospitals. Environ Health Perspect. 2004 Dec;112(17):1772–8.

Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, et al. The Effects of the World Trade Center Event on Birth Outcomes among Term Deliveries at Three Lower Manhattan Hospitals. Environ Health Perspect. 2004 Dec;112(17):1772–8.

Lee ACC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, et al. National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. Lancet Glob Health. 2013 Jul;1(1):e26-36.

Li C, Huo L, Wang R, Qi L, Wang W, Zhou X, et al. The prevalence and risk factors of depression in prenatal and postnatal women in China with the outbreak of Corona Virus Disease 2019. J Affect Disord. 2021 Mar 1;282:1203–9.

Li J, Qiu J, Lv L, Mao B, Huang L, Yang T, et al. Paternal factors and adverse birth outcomes in Lanzhou, China. BMC Pregnancy Childbirth. 2021 Dec;21(1):1–12.

Li L, Cao Y, Fan J, Li T, Lang J, Zhang H, et al. Impact of COVID-19 Pandemic on the Clinical Activities in Obstetrics and Gynecology: A National Survey in China. Frontiers in Medicine [Internet]. 2021 [cited 2022 Sep 20];8. Available from: https://www.frontiersin.org/articles/10.3389/fmed.2021.633477

Li X, Gao R, Dai X, Liu H, Zhang J, Liu X, et al. The association between symptoms of depression during pregnancy and low birth weight: a prospective study. BMC Pregnancy Childbirth. 2020 Mar 6;20:147.

Li X, Gao R, Dai X, Liu H, Zhang J, Liu X, et al. The association between symptoms of depression during pregnancy and low birth weight: a prospective study. BMC Pregnancy Childbirth. 2020 Mar 6;20:147.

Lin L, Lu C, Chen W, Li C, Guo VY. Parity and the risks of adverse birth outcomes: a retrospective study among Chinese. BMC Pregnancy and Childbirth. 2021 Mar 26;21(1):257.

Lin L, Lu C, Chen W, Li C, Guo VY. Parity and the risks of adverse birth outcomes: a retrospective study among Chinese. BMC Pregnancy and Childbirth. 2021 Mar 26;21(1):257.

Lin W, Wu B, Chen B, Lai G, Huang S, Li S, et al. Sleep Conditions Associate with Anxiety and Depression Symptoms among Pregnant Women during the Epidemic of COVID-19 in Shenzhen. J Affect Disord. 2021 Feb 15;281:567–73.

Liu J, Liu M, Liang W. The Dynamic COVID-Zero Strategy in China. CCDCW. 2022 Jan 28;4(4):74–5.

Liu X, Chen M, Wang Y, Sun L, Zhang J, Shi Y, et al. Prenatal anxiety and obstetric decisions among pregnant women in Wuhan and Chongqing during the COVID-19 outbreak: a cross-sectional study. BJOG: An International Journal of Obstetrics & Gynaecology. 2020 Sep 15;127(10):1229–40.

Lopez-Morales H, Del Valle MV, Canet-Juric L, Andres ML, Galli JI, Poo F, et al. Mental health of pregnant women during the COVID-19 pandemic: A longitudinal study. Psychiatry Res. 2021;295(qc4, 7911385):113567.

Low birthweight [Internet]. UNICEF DATA. [cited 2021 Nov 24]. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/

Low birthweight [Internet]. UNICEF DATA. [cited 2021 Nov 24]. Available from: https://data.unicef.org/topic/nutrition/low-birthweight/

Lu J, Xu X, Huang Y, Li T, Ma C, Xu G, et al. Prevalence of depressive disorders and treatment in China: a cross-sectional epidemiological study. The Lancet Psychiatry. 2021 Nov;8(11):981–90.

Lu S, Reavley N, Zhou J, Su J, Pan X, Xiang Q, et al. Depression among the general adult population in Jiangsu Province of China: prevalence, associated factors and impacts. Soc Psychiatry Psychiatr Epidemiol. 2018 Oct;53(10):1051–61.

Ma R, Yang F, Zhang L, Sznajder KK, Zou C, Jia Y, et al. Resilience mediates the effect of self-efficacy on symptoms of prenatal anxiety among pregnant women: a nationwide smartphone cross-sectional study in China. BMC Pregnancy Childbirth. 2021 Dec;21(1):1–9.

Maffly-Kipp J, Eisenbeck N, Carreno DF, Hicks J. Mental health inequalities increase as a function of COVID-19 pandemic severity levels. Soc Sci Med. 2021 Sep;285:114275.

Mental Health - PAHO/WHO | Pan American Health Organization [Internet]. [cited 2022 Aug 9]. Available from: https://www.paho.org/en/topics/mental-health

Mental health [Internet]. [cited 2022 Aug 9]. Available from: https://www.who.int/health-topics/mental-health

Miao H, Li B, Li W, Yao F, Chen Y, Chen R, et al. Adverse birth outcomes in Guangdong province, China, 2014–2017: a spatiotemporal analysis of 2.9 million births. BMJ Open. 2019 Nov;9(11):e030629.

Miao H, Li B, Li W, Yao F, Chen Y, Chen R, et al. Adverse birth outcomes in Guangdong province, China, 2014–2017: a spatiotemporal analysis of 2.9 million births. BMJ Open. 2019 Nov;9(11):e030629.

Miao H, Li B, Li W, Yao F, Chen Y, Chen R, et al. Adverse birth outcomes in Guangdong province, China, 2014–2017: a spatiotemporal analysis of 2.9 million births. BMJ Open. 2019 Nov;9(11):e030629.

Moreno C, Wykes T, Galderisi S, Nordentoft M, Crossley N, Jones N, et al. How mental health care should change as a consequence of the COVID-19 pandemic. Lancet Psychiatry. 2020 Sep;7(9):813–24.

Muhihi A, Sudfeld CR, Smith ER, Noor RA, Mshamu S, Briegleb C, et al. Risk factors for small-for-gestational-age and preterm births among 19,269 Tanzanian newborns. BMC Pregnancy Childbirth. 2016 Dec;16(1):1–12.

Nasreen HE, Kabir ZN, Forsell Y, Edhborg M. Low birth weight in offspring of women with depressive and anxiety symptoms during pregnancy: results from a population based study in Bangladesh. BMC Public Health. 2010 Aug 26;10:515.

Nasreen HE, Kabir ZN, Forsell Y, Edhborg M. Low birth weight in offspring of women with depressive and anxiety symptoms during pregnancy: results from a population based study in Bangladesh. BMC Public Health. 2010 Aug 26;10:515.

Ngo TV, Gammeltoft T, Nguyen HTT, Meyrowitsch DW, Rasch V. Antenatal depressive symptoms and adverse birth outcomes in Hanoi, Vietnam. PLOS ONE. 2018 Nov 2;13(11):e0206650.

Ngo TV, Gammeltoft T, Nguyen HTT, Meyrowitsch DW, Rasch V. Antenatal depressive symptoms and adverse birth outcomes in Hanoi, Vietnam. PLOS ONE. 2018 Nov 2;13(11):e0206650.

Ngo TV, Gammeltoft T, Nguyen HTT, Meyrowitsch DW, Rasch V. Antenatal depressive symptoms and adverse birth outcomes in Hanoi, Vietnam. PLOS ONE. 2018 Nov 2;13(11):e0206650.

Nisar A, Yin J, Waqas A, Bai X, Wang D, Rahman A, et al. Prevalence of perinatal depression and its determinants in Mainland China: A systematic review and meta-analysis. Journal of Affective Disorders. 2020 Dec 1;277:1022–37.

Nisar A, Yin J, Waqas A, Bai X, Wang D, Rahman A, et al. Prevalence of perinatal depression and its determinants in Mainland China: A systematic review and meta-analysis. Journal of Affective Disorders. 2020 Dec 1;277:1022–37.

Nowacka U, Kozlowski S, Issat T, Januszewski M, Jakimiuk A, Sierdzinski J. Covid-19 pandemic-related anxiety in pregnant women. Int J Environ Res Public Health. 2021;18(14):7221.

Overbeck G, Rasmussen IS, Siersma V, Andersen JH, Kragstrup J, Wilson P, et al. Depression and anxiety symptoms in pregnant women in Denmark during COVID-19. Scand J Public Health. 2021 Nov;49(7):721–9.

Overbeck G, Rasmussen IS, Siersma V, Andersen JH, Kragstrup J, Wilson P, et al. Depression and anxiety symptoms in pregnant women in Denmark during COVID-19. Scand J Public Health. 2021 Nov;49(7):721–9.

Ozbay F, Johnson DC, Dimoulas E, Morgan CA, Charney D, Southwick S. Social Support and Resilience to Stress. Psychiatry (Edgmont). 2007 May;4(5):35–40.

Philip RK, Purtill H, Reidy E, Daly M, Imcha M, McGrath D, et al. Unprecedented reduction in births of very low birthweight (VLBW) and extremely low birthweight (ELBW) infants during the COVID-19 lockdown in Ireland: a 'natural experiment' allowing analysis of data from the prior two decades. BMJ Glob Health. 2020 Sep 30;5(9):e003075.

Philip RK, Purtill H, Reidy E, Daly M, Imcha M, McGrath D, et al. Unprecedented reduction in births of very low birthweight (VLBW) and extremely low birthweight (ELBW) infants during the COVID-19 lockdown in Ireland: a 'natural experiment' allowing analysis of data from the prior two decades. BMJ Glob Health. 2020 Sep 30;5(9):e003075.

Policies energize hard-hit economy [Internet]. [cited 2022 Aug 3]. Available from: http://english.www.gov.cn/policies/policywatch/202208/03/content_WS62e9ca3fc6d02e533532ed0b.html

Preis H, Mahaffey B, Pati S, Heiselman C, Lobel M. Adverse Perinatal Outcomes Predicted by Prenatal Maternal Stress Among U.S. Women at the COVID-19 Pandemic Onset. Ann Behav Med. 2021;55(3):179–91.

Preis H, Mahaffey B, Pati S, Heiselman C, Lobel M. Adverse Perinatal Outcomes Predicted by Prenatal Maternal Stress Among U.S. Women at the COVID-19 Pandemic Onset. Ann Behav Med. 2021;55(3):179–91.

Preis H, Mahaffey B, Pati S, Heiselman C, Lobel M. Adverse Perinatal Outcomes Predicted by Prenatal Maternal Stress Among U.S. Women at the COVID-19 Pandemic Onset. Ann Behav Med. 2021;55(3):179–91.

Premji SS, Dobson KS, Prashad A, Yamamoto S, Tao F, Zhu B, et al. What stakeholders think: perceptions of perinatal depression and screening in China's primary care system. BMC Pregnancy and Childbirth. 2021 Jan 6;21(1):15.

Premji SS, Dobson KS, Prashad A, Yamamoto S, Tao F, Zhu B, et al. What stakeholders think: perceptions of perinatal depression and screening in China's primary care system. BMC Pregnancy and Childbirth. 2021 Jan 6;21(1):15.

Premji SS, Yim IS, Dosani (Mawji) A, Kanji Z, Sulaiman S, Musana JW, et al. Psychobiobehavioral Model for Preterm Birth in Pregnant Women in Low- and Middle-Income Countries. BioMed Research International. 2015 Aug 27;2015:e450309.

Preterm birth [Internet]. [cited 2022 Feb 15]. Available from: https://www.who.int/news-room/fact-sheets/detail/preterm-birth

Preterm birth [Internet]. [cited 2022 Feb 15]. Available from: https://www.who.int/news-room/fact-sheets/detail/preterm-birth

Richter LL, Ting J, Muraca GM, Boutin A, Wen Q, Lyons J, et al. Temporal Trends in Preterm Birth, Neonatal Mortality, and Neonatal Morbidity Following Spontaneous and Clinician-Initiated Delivery in Canada, 2009-2016. Journal of Obstetrics and Gynaecology Canada. 2019 Dec;41(12):1742-1751.e6.

Shapiro GD, Fraser WD, Frasch MG, Séguin JR. Psychosocial stress in pregnancy and preterm birth: associations and mechanisms. J Perinat Med. 2013 Nov;41(6):631–45.

Shen L, Wang J, Duan Y, Yang Z. Prevalence of low birth weight and macrosomia estimates based on heaping adjustment method in China. Sci Rep. 2021 Jul 22;11(1):15016.

Sidebottom AC, Hellerstedt WL, Harrison PA, Hennrikus D. An examination of prenatal and postpartum depressive symptoms among women served by urban community health centers. Arch Womens Ment Health. 2014 Feb 1;17(1):27–40.

Sinesi A, Maxwell M, O'Carroll R, Cheyne H. Anxiety scales used in pregnancy: systematic review. BJPsych Open. 2019 Jan;5(1):e5.

Smith MV, Shao L, Howell H, Lin H, Yonkers KA. Perinatal Depression and Birth Outcomes in a Healthy Start Project. Matern Child Health J. 2011 Apr;15(3):401–9.

Smith RD, Peahl AF, Moniz MH. Prenatal care redesign: creating flexible maternity care models through virtual care. Am J Obstet Gynecol. 2020;223(3):389.

Smits L, Krabbendam L, de Bie R, Essed G, van Os J. Lower birth weight of Dutch neonates who were in utero at the time of the 9/11 attacks. Journal of Psychosomatic Research. 2006 Nov 1;61(5):715–7.

Sun G, Wang Q, Lin Y, Li R, Yang L, Liu X, et al. Perinatal Depression of Exposed Maternal Women in the COVID-19 Pandemic in Wuhan, China. Front Psychiatry. 2020;11:551812.

Tamirat KS, Sisay MM, Tesema GA, Tessema ZT. Determinants of adverse birth outcome in Sub-Saharan Africa: analysis of recent demographic and health surveys. BMC Public Health. 2021 Jun 7;21(1):1092.

Tang X, Lu Z, Hu D, Zhong X. Influencing factors for prenatal Stress, anxiety and depression in early pregnancy among women in Chongqing, China. Journal of Affective Disorders. 2019 Jun 15;253:292–302.

Tang X, Lu Z, Hu D, Zhong X. Influencing factors for prenatal Stress, anxiety and depression in early pregnancy among women in Chongqing, China. Journal of Affective Disorders. 2019 Jun 15;253:292–302.

Tang X, Lu Z, Hu D, Zhong X. Influencing factors for prenatal Stress, anxiety and depression in early pregnancy among women in Chongqing, China. Journal of Affective Disorders. 2019 Jun 15;253:292–302.

Thayer ZM, Gildner TE. COVID-19-related financial stress associated with higher likelihood of depression among pregnant women living in the United States. American Journal of Human Biology. 2021;33(3):e23508.

Tong X, An D, McGonigal A, Park SP, Zhou D. Validation of the Generalized Anxiety Disorder-7 (GAD-7) among Chinese people with epilepsy. Epilepsy Res. 2016 Feb;120:31–6.

Uguz F, Gezginc K, Yazici F. Are major depression and generalized anxiety disorder associated with intrauterine growth restriction in pregnant women? A case-control study. Gen Hosp Psychiatry. 2011 Dec;33(6):640.e7-9.

Uguz F, Gezginc K, Yazici F. Are major depression and generalized anxiety disorder associated with intrauterine growth restriction in pregnant women? A case-control study. Gen Hosp Psychiatry. 2011 Dec;33(6):640.e7-9.

Van Dijk AE, Van Eijsden M, Stronks K, Gemke RJBJ, Vrijkotte TGM. Maternal depressive symptoms, serum folate status, and pregnancy outcome: results of the Amsterdam Born Children and their Development study. Am J Obstet Gynecol. 2010 Dec;203(6):563.e1-7.

Vigo D, Thornicroft G, Atun R. Estimating the true global burden of mental illness. The Lancet Psychiatry. 2016 Feb;3(2):171–8.

Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. Int J Environ Res Public Health. 2020 Mar 6;17(5):E1729.

Wang C, Pan R, Wan X, Tan Y, Xu L, McIntyre RS, et al. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. Brain Behav Immun. 2020 Jul;87:40–8.

Wang L, Yang N, Zhou H, Mao X, Zhou Y. Pregnant Women's Anxiety and Depression Symptoms and Influence Factors in the COVID-19 Pandemic in Changzhou, China. Frontiers in Psychology [Internet]. 2022 [cited 2022 Jul 18];13. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.855545

Wang Q, Song B, Di JL, Mo PKH, Zhou FR, Zhao J, et al. Mental health and preventive behaviour of pregnant women in China during the early phase of the COVID-19 period. Infect Dis Pover. 2021;10(1):37.

Wang SY, Chen CH. The association between prenatal depression and obstetric outcome in Taiwan: a prospective study. J Womens Health (Larchmt). 2010 Dec;19(12):2247–51.

Wang Y, Guo X, Lau Y, Chan KS, Yin L, Chen J. Psychometric evaluation of the Mainland Chinese version of the Edinburgh Postnatal Depression Scale. Int J Nurs Stud. 2009 Jun;46(6):813–23.

Wdowiak A, Makara-Studzinska M, Raczkiewicz D, Janczyk P, Slabuszewska-Jozwiak A, Wdowiak-Filip A, et al. Effect of excessive body weight and emotional disorders on the course of pregnancy and well-being of a newborn before and during covid-19 pandemic. J Clin Med. 2021;10(4):1–16.

Wdowiak A, Makara-Studzinska M, Raczkiewicz D, Janczyk P, Slabuszewska-Jozwiak A, Wdowiak-Filip A, et al. Effect of excessive body weight and emotional disorders on the course of pregnancy and well-being of a newborn before and during covid-19 pandemic. J Clin Med. 2021;10(4):1–16.

Wdowiak A, Makara-Studzińska M, Raczkiewicz D, Janczyk P, Słabuszewska-Jóźwiak A, Wdowiak-Filip A, et al. Effect of Excessive Body Weight and Emotional Disorders on the Course of Pregnancy and Well-Being of a Newborn before and during COVID-19 Pandemic. Journal of Clinical Medicine. 2021 Jan;10(4):656.

WHO Coronavirus (COVID-19) Dashboard [Internet]. [cited 2022 Aug 9]. Available from: https://covid19-who-int.login.ezproxy.library.ualberta.ca

Williams N. The GAD-7 questionnaire. Occupational Medicine. 2014 Apr 1;64(3):224.

Woody CA, Ferrari AJ, Siskind DJ, Whiteford HA, Harris MG. A systematic review and meta-regression of the prevalence and incidence of perinatal depression. J Affect Disord. 2017 Sep;219:86–92.

World Health Orgnasiztion. Mental disorders [Internet]. [cited 2021 Jul 25]. Available from: https://www.who.int/news-room/fact-sheets/detail/mental-disorders

World Health Orgnasiztion. Timeline: WHO's COVID-19 response [Internet]. [cited 2022 Feb 7]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

World Health Orgnasiztion. Timeline: WHO's COVID-19 response [Internet]. [cited 2022 Feb 7]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

World Health Orgnasiztion. Timeline: WHO's COVID-19 response [Internet]. [cited 2022 Feb 7]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

World Health Orgnasiztion. WHO Coronavirus (COVID-19) Dashboard [Internet]. [cited 2022 Feb 7]. Available from: https://covid19.who.int

World Health Orgnasiztion. WHO Coronavirus (COVID-19) Dashboard [Internet]. [cited 2022 Feb 7]. Available from: https://covid19.who.int

Xu J, Wang J, Wimo A, Qiu C. The economic burden of mental disorders in China, 2005–2013: implications for health policy. BMC Psychiatry. 2016 May 11;16(1):137.

Yan H, Ding Y, Guo W. Mental Health of Pregnant and Postpartum Women During the Coronavirus Disease 2019 Pandemic: A Systematic Review and Meta-Analysis. Frontiers in Psychology [Internet]. 2020 [cited 2022 Aug 2];11. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.617001

Yan H, Ding Y, Guo W. Mental Health of Pregnant and Postpartum Women During the Coronavirus Disease 2019 Pandemic: A Systematic Review and Meta-Analysis. Frontiers in Psychology [Internet]. 2020 [cited 2022 Aug 2];11. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.617001

Yang F, Yang BX, Stone TE, Wang XQ, Zhou Y, Zhang J, et al. Stigma towards depression in a community-based sample in China. Comprehensive Psychiatry. 2020 Feb 1;97:152152.

Yang F, Yang BX, Stone TE, Wang XQ, Zhou Y, Zhang J, et al. Stigma towards depression in a community-based sample in China. Comprehensive Psychiatry. 2020 Feb 1;97:152152.

Yang R, Mei H, Zheng T, Fu Q, Zhang Y, Buka S, et al. Pregnant women with COVID-19 and risk of adverse birth outcomes and maternal-fetal vertical transmission: a population-based cohort study in Wuhan, China. BMC Med. 2020 Oct 19;18(1):330.

Yang Y, Mao J, Ye Z, Zeng X, Zhao H, Liu Y, et al. Determinants of sleep quality among pregnant women in China: a cross-sectional survey. The Journal of Maternal-Fetal & Neonatal Medicine. 2018 Nov 17;31(22):2980–5.

Zhang L, Wang L, Cui S, Yuan Q, Huang C, Zhou X. Prenatal Depression in Women in the Third Trimester: Prevalence, Predictive Factors, and Relationship With Maternal-Fetal Attachment. Frontiers in Public Health [Internet]. 2021 [cited 2022 Jul 25];8. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2020.602005

Zhang Y, Muyiduli X, Wang S, Jiang W, Wu J, Li M, et al. Prevalence and relevant factors of anxiety and depression among pregnant women in a cohort study from south-east China. Journal of Reproductive and Infant Psychology. 2018 Oct 20;36(5):519–29.

Zhao T, Zuo H, Campbell SM, Jhangri GS, Dobson KS, Li JY, et al. The Impacts of Prenatal Mental Health Issues on Birth Outcomes during the COVID-19 Pandemic: A Scoping Review. International Journal of Environmental Research and Public Health. 2022 Jan;19(13):7670.

Zhao T, Zuo H, Campbell SM, Jhangri GS, Dobson KS, Li JY, et al. The Impacts of Prenatal Mental Health Issues on Birth Outcomes during the COVID-19 Pandemic: A Scoping Review. International Journal of Environmental Research and Public Health. 2022 Jan;19(13):7670.

Zheng QX, Jiang XM, Lin Y, Liu GH, Lin YP, Kang YL, et al. The influence of psychological response and security sense on pregnancy stress during the outbreak of coronavirus disease 2019: A mediating model. Journal of Clinical Nursing. 2020;29(21–22):4248–57.

Zheng Z, Zhang R, Liu T, Cheng P, Zhou Y, Lu W, et al. The Psychological Impact of the Coronavirus Disease 2019 Pandemic on Pregnant Women in China. Frontiers in Psychiatry [Internet]. 2021 [cited 2022 Jul 25];12. Available from: https://www.frontiersin.org/articles/10.3389/fpsyt.2021.628835

Zheng Z, Zhang R, Liu T, Cheng P, Zhou Y, Lu W, et al. The Psychological Impact of the Coronavirus Disease 2019 Pandemic on Pregnant Women in China. Frontiers in Psychiatry [Internet]. 2021 [cited 2022 Jul 25];12. Available from: https://www.frontiersin.org/articles/10.3389/fpsyt.2021.628835

Appendices

Appendix 1 PRISMA-S Checklist

Table A1. PRISMA-S checklist.

Section/Topic	#	Checklist Item	Location(s) Reported
INFORMATION SOURCES AND METHODS			
Database name	1	Name each individual database searched, stating the platform for each.	Methods
Multi-database searching	2	If databases were searched simultaneously on a single platform, state the name of the platform, listing all of the databases searched.	Methods
Study registries	3	List any study registries searched.	Methods
Online resources and browsing	4	Describe any online or print source purposefully searched or browsed (e.g., tables of contents, print conference proceedings, web sites), and how this was done.	N/A
Citation searching	5	Indicate whether cited references or citing references were examined, and describe any methods used for locating cited/citing references (e.g., browsing reference lists, using a citation index, setting up email alerts for references citing included studies).	N/A
Contacts	6	Indicate whether additional studies or data were sought by contacting authors, experts, manufacturers, or others.	N/A
Other methods	7	Describe any additional information sources or search methods used.	Methods
SEARCH STRATEGIES			
Full search strategies	8	Include the search strategies for each database and information source, copied and pasted exactly as run.	Appendix
Limits and restrictions	9	Specify that no limits were used, or describe any limits or restrictions applied to a search (e.g., date or time period, language, study design) and provide justification for their use.	Methods
Search filters	10	Indicate whether published search filters were used (as originally designed or modified), and if so, cite the filter(s) used.	Methods
Prior work	11	Indicate when search strategies from other literature reviews were adapted or reused for a substantive part or all of the search, citing the previous review(s).	N/A

Updates	12	Report the methods used to update the search(es) (e.g., rerunning searches, email alerts).	N/A
Dates of searches	13	For each search strategy, provide the date when the last search occurred.	Methods
PEER REVIEW			
Peer review	14	Describe any search peer review process.	N/A
MANAGING RECORDS			
Total Records	15	Document the total number of records identified from each database and other information sources.	Appendix
Deduplication	16	Describe the processes and any software used to deduplicate records from multiple database searches and other information sources.	Methods

Appendix 2 Scoping Review Protocol

The Impacts of Mental Health Factors on Birth Outcomes During Covid-19 Pandemic - A Scoping Review Protocol

Introduction

In order to address both mental health issues among pregnant women, as well as the potential adverse birth outcomes during COVID-19 pandemic, there is a need to understand potential mental health factors on birth outcomes during COVID-19 pandemic. It is important to assess and map the current literature and apply the result of this scoping review to inform future research and policy development that is related to mental health factors on birth outcomes during the COVID-19 pandemic.

Objectives of the Scoping Review: To assess the state of the literature related to the impacts of prenatal stress, anxiety and depressive symptoms during pregnancy on adverse birth outcomes, including preterm birth, low birth weight, small for gestational age, macrosomia, neonatal death and congenital anomaly among pregnant women during the COVID-19 pandemic.

Review Question

The guiding question for the scoping review is: **What are the impacts of mental health factors on birth outcomes during the COVID-19 Pandemic?**

Methods

This scoping review will be conducted using the methodologies proposed by Arksey and O'Malley's and Joanna Briggs Institute (JBI) (1,2). The scoping review methodologies recommendations by Levac, Colquhoun and O'Brien will also be reviewed to guide the process (3).

Furthermore, PRISMA-ScR (an extension of the PRISMA) will be used to guide the writing of the scoping review (Appendix 1). This scoping review protocol will also be published on the Open Science Framework site.

Inclusion Criteria and Restrictions

Types of Participants: This review will consider studies that discuss the prenatal stress, anxiety and depressive symptoms, on adverse birth outcomes, including preterm birth, low birth weight, small for gestational age, macrosomia, neonatal death and congenital anomaly among mothers who have given birth during the COVID-19 pandemic.

Concept: This scoping review will include studies assessing prenatal mental health issues and factors that had impacts on the birth outcomes among mothers who have given birth during the COVID-19 pandemic.

Types of Evidence Sources: This scoping review will include systematic reviews, analytical studies and descriptive studies. As for analytical observational studies, the review will include the following study designs: cohort studies (prospective, retrospective and mixed cohort studies), case-control studies and cross-sectional studies. As for descriptive studies, this review will include ecological studies. Additionally, qualitative studies and mixed methods studies which meet the inclusion criteria will also be included. Case studies or case reports will not be included as those are less likely to be generalizable. Additionally, evidence sources such as comments, editorials, letters, books, articles without peer-reviews, and other grey literature will not be included.

Language and Time Frame Restrictions: This review will be restricted to 2019 (initial identification of Covid 19 virus) to current. No language restrictions will be applied.

Searching Strategy

This scoping review will implement a 3-step searching strategy that was recommended by JBI (2):

Step 1: An initial limited search relevant to the topic was conducted in two online databases, which were Ovid Medline and EBSCOhost CINAHL. This step aims to identify and analyze the text words from titles, abstracts and keywords used to describe the articles from the initial limited search results. These text words were used to develop full searching strategies for this

scoping review. In this step, the searching terms for the initial search were 'COVID-19', 'mental health' and 'adverse birth outcomes'.

Step 2: The search will be executed by an expert searcher/librarian (SC) on the following databases: PROSPERO, Cochrane Library (CDSR and Central Register of Controlled Trials), OVID Medline, Ovid EMBASE, OVID PsycInfo, EBSCO CINAHL, and SCOPUS, using controlled vocabulary (eg: MeSH, Emtree, etc) and keywords representing the concepts "COVID19" and "mental health" and "birth outcomes". All searches will be adjusted appropriately for different databases. Searches will be limited to late 2019 to present. The search includes variants of search filters from the John W. Scott Health Sciences Search Filters (4,5). No other limits will be applied. Results will be exported to the COVIDENCE systematic review program. Duplicates will be removed. Example search strategies are available in Appendix 2.

Step 3: A snowball search on the reference lists of the identified articles will be conducted to capture the missing articles from the previous steps.

Screening

Following the search, all identified articles will be exported to COVIDENCE review management software. Titles and abstracts will be screened by two independent reviewers by using the inclusion criteria and the following screening questions:

1. Does the research focus on pregnant women and/or mothers who gave birth during COVID-19 pandemic?
   Yes/No/Maybe
2. Does the research focus on prenatal stress, anxiety and depressive symptoms during COVID-19 pandemic?
   Yes/No/Maybe
3. Does the research focus on adverse birth outcomes?
   Yes/No/Maybe

If the articles meet the inclusion criteria and 'Yes' or 'Maybe' are selected from the screening questions, these articles shall be kept for further full-text analysis.

Following the screening on titles and abstracts, the remaining articles will be taken for full-text analysis. The following questions will be used as a guide:

1. Does the research focus on prenatal stress, anxiety and depressive symptoms during COVID-19 pandemic?
   Yes/No
2. Does the research focus on pregnant women and/or mothers who gave birth during COVID-19 pandemic?
   Yes/No
3. Does the research focus on adverse birth outcomes?
   Yes/No
4. Does the research focus on the impacts of stress, anxiety and depressive symptoms on adverse birth outcomes during COVID-19 pandemic?
   Yes/No

Only the articles that provide a 'Yes' answer for all four questions will be included in the review.

The results of the search will be presented in a PRISMA diagram and will also be reported in full in the final report. Any disagreements between the two reviewers will be discussed and resolved. A third reviewer will be involved if there is a lack of consensus.

Data Extraction

For data extraction process, the following information need to be captured according to the JBI recommendation (2):

1. Author(s)
2. Year of publication
3. Origin/country of origin (where the source was published or conducted)
4. Aims/purpose
5. Population and sample size within the source of evidence (if applicable)
6. Methodology / methods
7. Outcomes and details of these (e.g., how measured) (if applicable)
8. Key findings that relate to the scoping review question/s.

All the data will be extracted using the template data extraction instrument recommended by JBI (Appendix 3) (2). However, this instrument will be modified and revised as necessary.

Data Presentation

The extracted data will be presented in a table that aligns with the scoping review objectives. A narrative summary will also be provided to describe the result and to address the scoping review questions.

Conclusion

In conclusion, this scoping review will be used to inform a broad view of mental health factors on adverse birth outcomes during the COVID-19 Pandemic. This information will also be used to inform future research and policy development that is related to the impacts of mental health factors on adverse birth outcomes during the COVID-19 Pandemic.

Reference

1. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. International Journal of Social Research Methodology. 2005 Feb 1;8(1):19–32.

2. Chapter 11: Scoping reviews - JBI Manual for Evidence Synthesis - JBI Global Wiki [Internet]. [cited 2022 Aug 10]. Available from: https://jbi-global-wiki.refined.site/space/MANUAL/4687342/Chapter+11%3A+Scoping+reviews

3. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implementation Science. 2010 Sep 20;5(1):69.

4. Campbell S. Filter to Retrieve Studies Related to COVID19 and Variants from the OVID MEDLINE Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/1VQnOBmBAwAT5fkqQfxtQgvmCbXqC3ZpDtxo-v24yvIQ/edit?usp=embed_facebook

5. Campbell S. Search Hedge to Retrieve Studies related to COVID-19 from the EBSCO CINAHL Database [Internet]. John Scott Health Sciences Library. 2021 [cited 2022 Feb 7]. Available from: https://docs.google.com/document/d/17w4RulQkUjJnAeIVyvLalCHPudBqobIlE8Qhtll5qTA/edit?usp=embed_facebook

Appendix 1 PRISMA-S Checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	
Limitations	20	Discuss the limitations of the scoping review process.	
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. ;169:467–473. doi: 10.7326/M18-0850

Appendix 2 Example Searching Strings

Ovid MEDLINE(R) ALL <1946 to July 26, 2021>

#	Search Statement	Results
1	exp Coronavirus/	85818
2	exp Coronavirus Infections/	104836
3	(coronavirus* or corona virus* or OC43 or NL63 or 229E or HKU1 or HCoV* or ncov* or covid* or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus*).mp.	176694
4	(or/1-3) and 20200601:20301231.(ep).	115200
5	4 not (SARS or SARS-CoV or MERS or MERS-CoV or Middle East respiratory syndrome or camel* or dromedar* or equine or coronary or coronal or covidence* or covidien or influenza virus or HIV or bovine or calves or TGEV or feline or porcine or BCoV or PED or PEDV or PDCoV or FIPV or FCoV or SADS-CoV or canine or CCov or zoonotic or avian influenza or H1N1 or H5N1 or H5N6 or IBV or murine corona*).mp.	46230
6	((pneumonia or covid* or coronavirus* or corona virus* or ncov* or 2019-ncov or sars*).mp. or exp pneumonia/) and Wuhan.mp.	5588
7	(2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19 or covid 2019 or ((novel or new or nouveau) adj2 (CoV on nCoV or covid or coronavirus* or corona virus or Pandemi*2)) or ((covid or covid19 or covid-19) and pandemic*2) or (coronavirus* and pneumonia)).mp.	161412
8	COVID-19.rx,px,ox. or severe acute respiratory syndrome coronavirus 2.os.	4645
9	Covid-19/	94250
10	(variant* adj2 (India* or "South Africa*" or UK or English or Brazil* or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37")).mp.	4449
11	("B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2").mp.	530
12	or/5-11	167457
13	12 and 20191101:20301231.(dt).	161454
14	exp Pregnancy Complications/	442678
15	exp Pregnancy Outcome/	77812
16	exp Obstetric Labor Complications/	72047

17	exp Obstetric Labor, Premature/	28601
18	exp Fetal Death/	29935
19	"congenital, hereditary, and neonatal diseases and abnormalities"/	890
20	("adverse birth outcome*" or stillbirth* or "low birthweight*" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomal*").mp.	66064
21	("spontaneous abortion*" or "postpartum hemorhage" or "post partum hemorhage").mp.	10894
22	((labor or labour or deliver* or childbirth* or birth*) adj3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)).mp.	70898
23	or/14-22	527852
24	exp Mental Health/	45210
25	exp Psychology/	68604
26	exp Psychiatry/	106292
27	Anxiety/	89498
28	Depression/	130306
29	(mental* adj3 (ill* or well* or disorder* or disease* or health* or unwell*)).mp.	403543
30	anxiety disorders/ or agoraphobia/ or anxiety, separation/ or neurocirculatory asthenia/ or neurotic disorders/ or obsessive-compulsive disorder/ or hoarding disorder/ or panic disorder/ or phobic disorders/ or phobia, social/	82771
31	(((anxiety or depression or depressive or hypervigilance or agoraphobia or neuroses or neurosis or neurotic or paranoi* or catastrophiz* or catastorphis*or) and obsessive-compulsive) or panic or phobia or stress or ptsd or psycho* or "internalising symptom*" or "internalizing symptom*" or wellness or "seasonal affective disorder*" or psychiatr*).mp.	2890504
32	(dysthymic disorder* or "use disorder" or "psychotropic drug*" or "brain disease*" or "neurotransmitter agent*" or cognitive or "social problems" or "alcohol abuse*" or "drug abuse*").mp.	594133
33	("seasonal affective disorder*" or "internali?ing symptoms" or "common mental disorders" or cmd or cmds).ti,ab.	8063
34	or/24-33	3387821
35	13 and 23 and 34	231

CINAHL Plus with Full Text

Limiters/Expanders

Search Modes - Find all my search terms

#	Query	Results
S1	(((MH "Coronavirus+") OR (MH "Coronavirus Infections+") or (coronavirus* or corona virus* or OC43 or NL63 or 229E or HKU1 or HCoV* or ncov* or covid* or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus*)) NOT ((SARS or SARS-CoV or MERS or MERS-CoV or Middle East respiratory syndrome or camel* or dromedar* or equine or coronary or coronal or covidence* or covidien or influenza virus or HIV or bovine or calves or TGEV or feline or porcine or BCoV or PED or PEDV or PDCoV or FIPV or FCoV or SADS-CoV or canine or CCov or zoonotic or avian influenza or H1N1 or H5N1 or H5N6 or IBV or murine corona*)) or (MH "COVID-19") OR (MH "COVID-19 Pandemic") OR (MH "SARS-CoV-2") or(covid or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or ((novel or new or nouveau) N2 (CoV or nCoV or coronavirus* or "corona virus" or Pandemi*)) or (variant* N2 (India* or "South Africa*" or UK or English or Brazil* or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37")) or ("B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2")) and EM 20190601-20301231	61,878
S2	(MH "Pregnancy Outcomes")	25,494
S3	(MH "Pregnancy Complications+")	100,854
S4	(MH "Perinatal Death")	8,709
S5	(MH "Infant, Low Birth Weight+")	15,192
S6	(MH "Infant, Large for Gestational Age") OR (MH "Infant, Postmature") OR (MH "Infant, Premature")	24,902
S7	"adverse birth outcome*" or stillbirth* or "low birthweight*" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomal*	25,026
S8	(((labor or labour or deliver* or childbirth* or birth*) N3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)) or "spontaneous abortion*")	31,274
S9	stillbirth* or "still birth*" or stillborn or "still born" or "intrauterine death" or "perinatal death" or "fetus death" or "fetal demise" or "fetal death"	12,791
S10	S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9	163,731
S11	(MH "Mental Health") OR (MH "Behavioral and Mental Disorders+")	897,469
S12	(MH "Psychology, Clinical+")	1,037

S13	((mental* or psychiatric*) N3 (ill* or well* or disorder* or disease* or health* or unwell*))	229,030
S14	(anxiety or depression or depressive or hypervigilance or agoraphobia or neuroses or neurosis or neurotic or paranoi* or catastrophiz* or catastorphis*or and obsessive-compulsive or panic or phobia or stress or ptsd or psycho* or "internalising symptom*" or "internalizing symptom*" or wellness or "seasonal affective disorder*" or psychiatr*)	1,135,565
S15	("dysthymic disorder*" or "use disorder" or "psychotropic drug*" or "brain disease*" or "neurotransmitter agent*" or cognitive or "social problems" or "alcohol abuse*" or "drug abuse*")	200,728
S16	(S11 OR S12 OR S13 OR S14 OR S15)	1,615,363
S17	S1 AND S10 AND S16	105

Appendix 3 JBI template source of evidence details, characteristics and results extraction instrument

Scoping Review Details	
Scoping Review title:	
Review objective/s:	
Review question/s:	
Inclusion/Exclusion Criteria	
Population	
Concept	
Context	
Types of evidence source	
Evidence source Details and Characteristics	
Citation details (e.g. author/s, date, title, journal, volume, issue, pages)	
Country	
Context	
Participants (details e.g. age/sex and number)	
Details/Results extracted from source of evidence (in relation to the concept of the scoping review)	
E.g. Quality of Life Domains assessed	
E.g. Number of items in tool	
E.g. details of psychometric validation of tool	

Appendix 3 Detailed Searching Strings

Table A2. Detailed Searching Strings

Ovid MEDLINE(R) ALL <1946 to July 26, 2021>

#	Search Statement	Results
1	exp Coronavirus/	85818
2	exp Coronavirus Infections/	104836
3	(coronavirus* or corona virus* or OC43 or NL63 or 229E or HKU1 or HCoV* or ncov* or covid* or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus*).mp.	176694
4	(or/1-3) and 20200601:20301231.(ep).	115200
5	4 not (SARS or SARS-CoV or MERS or MERS-CoV or Middle East respiratory syndrome or camel* or dromedar* or equine or coronary or coronal or covidence* or covidien or influenza virus or HIV or bovine or calves or TGEV or feline or porcine or BCoV or PED or PEDV or PDCoV or FIPV or FCoV or SADS-CoV or canine or CCov or zoonotic or avian influenza or H1N1 or H5N1 or H5N6 or IBV or murine corona*).mp.	46230
6	((pneumonia or covid* or coronavirus* or corona virus* or ncov* or 2019-ncov or sars*).mp. or exp pneumonia/) and Wuhan.mp.	5588
7	(2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19 or covid 2019 or ((novel or new or nouveau) adj2 (CoV on nCoV or covid or coronavirus* or corona virus or Pandemi*2)) or ((covid or covid19 or covid-19) and pandemic*2) or (coronavirus* and pneumonia)).mp.	161412
8	COVID-19.rx,px,ox. or severe acute respiratory syndrome coronavirus 2.os.	4645
9	Covid-19/	94250
10	(variant* adj2 (India* or "South Africa*" or UK or English or Brazil* or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37")).mp.	4449
11	("B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2").mp.	530
12	or/5-11	167457
13	12 and 20191101:20301231.(dt).	161454
14	exp Pregnancy Complications/	442678
15	exp Pregnancy Outcome/	77812
16	exp Obstetric Labor Complications/	72047
17	exp Obstetric Labor, Premature/	28601
18	exp Fetal Death/	29935
19	"congenital, hereditary, and neonatal diseases and abnormalities"/	890
20	("adverse birth outcome*" or stillbirth* or "low birthweight*" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomal*").mp.	66064
21	("spontaneous abortion*" or "postpartum hemorhage" or "post partum hemorhage").mp.	10894
22	((labor or labour or deliver* or childbirth* or birth*) adj3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)).mp.	70898
23	or/14-22	527852
24	exp Mental Health/	45210
25	exp Psychology/	68604
26	exp Psychiatry/	106292
27	Anxiety/	89498

28	Depression/	130306
29	(mental* adj3 (ill* or well* or disorder* or disease* or health* or unwell*)).mp.	403543
30	anxiety disorders/ or agoraphobia/ or anxiety, separation/ or neurocirculatory asthenia/ or neurotic disorders/ or obsessive-compulsive disorder/ or hoarding disorder/ or panic disorder/ or phobic disorders/ or phobia, social/	82771
31	(((anxiety or depression or depressive or hypervigilance or agoraphobia or neuroses or neurosis or neurotic or paranoi* or catastrophiz* or catastorphis*or) and obsessive-compulsive) or panic or phobia or stress or ptsd or psycho* or "internalising symptom*" or "internalizing symptom*" or wellness or "seasonal affective disorder*" or psychiatr*).mp.	2890504
32	(dysthymic disorder* or "use disorder" or "psychotropic drug*" or "brain disease*" or "neurotransmitter agent*" or cognitive or "social problems" or "alcohol abuse*" or "drug abuse*").mp.	594133
33	("seasonal affective disorder*" or "internali?ing symptoms" or "common mental disorders" or cmd or cmds).ti,ab.	8063
34	or/24-33	3387821
35	13 and 23 and 34	231

Embase <1974 to 2021 July 26>

#	Search Statement	Results
1	((exp Coronavirus/ or exp Coronavirus Infections/ or (coronavirus* or corona virus* or OC43 or NL63 or 229E or HKU1 or HCoV* or ncov* or covid* or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus* or D614G).mp.) not (SARS or SARS-CoV or MERS or MERS-CoV or Middle East respiratory syndrome or camel* or dromedar* or equine or coronary or coronal or covidence* or covidien or influenza virus or HIV or bovine or calves or TGEV or feline or porcine or BCoV or PED or PEDV or PDCoV or FIPV or FCoV or SADS-CoV or canine or CCov or zoonotic or avian influenza or H1N1 or H5N1 or H5N6 or IBV or murine corona*).mp.) or coronavirus disease 2019/ or (((pneumonia or covid* or coronavirus* or corona virus* or ncov* or 2019-ncov or sars*).mp. or exp pneumonia/) and Wuhan.mp.) or ("coronavirus disease 2019" or "2019 ncov" or ncov19 or ncov-19 or "2019 novel CoV" or severe acute respiratory syndrome coronavirus 2 or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19 or "covid 2019" or "B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2" or ((cov* or corona* or SARS) and (variant* adj2 (India* or "South Africa*" or UK or English or Brazil* or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37"))) or ((novel or new or nouveau) adj2 (CoV or nCoV or coronavirus* or corona virus))).mp.	175153
2	"parameters concerning the fetus, newborn and pregnancy"/ or apgar score/ or birth weight/ or fetus mortality/ or fetus outcome/ or fetus risk/ or fetus weight/ or gestational age/ or live birth/ or exp perinatal morbidity/ or perinatal mortality/ or pregnancy outcome/ or prenatal mortality/ or exp fetus death/	316934
3	exp labor complication/ or exp pregnancy complication/	308606
4	birth/ or birth weight/ or caesarean birth/ or "labor (childbirth)"/ or natural childbirth/ or premature birth/ or birth injuries/ or birth trauma/	244903
5	(exp congenital disorder/ and (neonat* or newborn*).mp.) or newborn disease/ or dysmaturity/ or immaturity/ or large for gestational age/ or low birth weight/ or neonatal alloimmune thrombocytopenia/ or neonatal hemorrhage/ or neonatal hyperbilirubinemia/ or neonatal pneumonia/ or neonatal respiratory distress syndrome/ or neonatal stress/ or neonatal thrombocytopenia/ or newborn anemia/ or newborn apnea/ or newborn diabetes mellitus/ or newborn hemolytic disease/ or newborn hepatitis/ or newborn hypoxia/ or newborn infection/ or newborn jaundice/ or newborn ophthalmia/ or newborn sepsis/ or newborn tetanus/ or perinatal asphyxia/ or perinatal stress/ or prematurity/ or retrolental fibroplasia/ or "transient tachypnea of the newborn"/ [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	332734

6	("adverse birth outcome*" or stillbirth* or "low birthweight*" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomal*").mp.	93650
7	(((labor or labour or deliver* or childbirth* or birth*) adj3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)) or "spontaneous abortion*").mp.	142238
8	or/2-7	806020
9	exp mental health/	178312
10	exp psychology/	367416
11	exp mental disease/	2317236
12	((mental* or psychiatric*) adj3 (ill* or well* or disorder* or disease* or health* or unwell*)).mp.	609171
13	(((anxiety or depression or depressive or hypervigilance or agoraphobia or neuroses or neurosis or neurotic or paranoi* or catastrophiz* or catastorphis*or and obsessive-compulsive or panic or phobia or stress or ptsd or psycho* or "internalising symptom*" or "internalizing symptom*" or wellness or "seasonal affective disorder*" or psychiatr*).mp.	3137713
14	(dysthymic disorder* or "use disorder" or "psychotropic drug*" or "brain disease*" or "neurotransmitter agent*" or cognitive or "social problems" or "alcohol abuse*" or "drug abuse*").mp.	846971
15	neurocirculatory asthenia.mp.	160
16	major depression/ or dysthymic disorder/ or atypical depression/ or internalizing symptoms/ or seasonal affective disorder/ or mental health/ or primary mental health prevention/	227428
17	(depression or ("common mental disorders" or cmd or cmds)).mp.	731977
18	or/9-17	4933377
19	1 and 8 and 18	425
20	limit 19 to dc=20190601-20210726	421

APA PsycInfo <1806 to July Week 3 2021>

#	Search Statement	Results
1	((exp Coronavirus/ or (coronavirus* or corona virus* or OC43 or NL63 or 229E or HKU1 or HCoV* or ncov* or covid* or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus* or D614G).mp.) not (SARS or SARS-CoV or MERS or MERS-CoV or Middle East respiratory syndrome or camel* or dromedar* or equine or coronary or coronal or covidence* or covidien or influenza virus or HIV or bovine or calves or TGEV or feline or porcine or BCoV or PED or PEDV or PDCoV or FIPV or FCoV or SADS-CoV or canine or CCov or zoonotic or avian influenza or H1N1 or H5N1 or H5N6 or IBV or murine corona*).mp.) or Covid-19/ or (((pneumonia or covid* or coronavirus* or corona virus* or ncov* or 2019-ncov or sars*).mp. or exp pneumonia/) and Wuhan.mp.) or ("coronavirus disease 2019" or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or severe acute respiratory syndrome coronavirus 2 or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or covid19 or covid-19 or covid 2019 or "B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2" or (variant* adj2 ("South Africa*" or UK or English or Brazil* or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37")) or ("B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2") or ((novel or new or nouveau) adj2 (CoV or nCoV or coronavirus* or corona virus))).mp.	7625
2	obstetrical complications/ or exp birth/ or birth injuries/ or caesarean birth/ or premature birth/	17831
3	pregnancy outcomes/ or exp birth/ or induced abortion/ or exp obstetrical complications/ or spontaneous abortion/ or	22232

	birth injuries/ or birth weight/	
4	Stillbirths/	0
5	exp Congenital Disorders/	8202
6	("adverse birth outcome*" or stillbirth* or "low birthweight*" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomal*").mp.	4037
7	(((labor or labour or deliver* or childbirth* or birth*) adj3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)) or "spontaneous abortion*").mp.	11298
8	or/2-7	35212
9	1 and 8	25
10	limit 9 to up=20190601-20211231	24

CINAHL Plus with Full Text

Limiters/Expanders

Search Modes - Find all my search terms

#	Query	Results
S1	(((MH "Coronavirus+") OR (MH "Coronavirus Infections+") or (coronavirus* or corona virus* or OC43 or NL63 or 229E or HKU1 or HCoV* or ncov* or covid* or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus*)) NOT ((SARS or SARS-CoV or MERS or MERS-CoV or Middle East respiratory syndrome or camel* or dromedar* or equine or coronary or coronal or covidence* or covidien or influenza virus or HIV or bovine or calves or TGEV or feline or porcine or BCoV or PED or PEDV or PDCoV or FIPV or FCoV or SADS-CoV or canine or CCov or zoonotic or avian influenza or H1N1 or H5N1 or H5N6 or IBV or murine corona*)) or (MH "COVID-19") OR (MH "COVID-19 Pandemic") OR (MH "SARS-CoV-2") or(covid or 2019-ncov or ncov19 or ncov-19 or 2019-novel CoV or sars-cov2 or sars-cov-2 or sarscov2 or sarscov-2 or Sars-coronavirus2 or Sars-coronavirus-2 or SARS-like coronavirus* or coronavirus-19 or ((novel or new or nouveau) N2 (CoV or nCoV or coronavirus* or "corona virus" or Pandemi*)) or (variant* N2 (India* or "South Africa*" or UK or English or Brazil* or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37")) or ("B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2")) and EM 20190601-20301231	61,878
S2	(MH "Pregnancy Outcomes")	25,494
S3	(MH "Pregnancy Complications+")	100,854
S4	(MH "Perinatal Death")	8,709
S5	(MH "Infant, Low Birth Weight+")	15,192
S6	(MH "Infant, Large for Gestational Age") OR (MH "Infant, Postmature") OR (MH "Infant, Premature")	24,902
S7	"adverse birth outcome*" or stillbirth* or "low birthweight*" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomal*	25,026

S8	(((labor or labour or deliver* or childbirth* or birth*) N3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)) or "spontaneous abortion*")	31,274
S9	stillbirth* or "still birth*" or stillborn or "still born" or "intrauterine death" or "perinatal death" or "fetus death" or "fetal demise" or "fetal death"	12,791
S10	S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9	163,731
S11	(MH "Mental Health") OR (MH "Behavioral and Mental Disorders+")	897,469
S12	(MH "Psychology, Clinical+")	1,037
S13	((mental* or psychiatric*) N3 (ill* or well* or disorder* or disease* or health* or unwell*))	229,030
S14	(anxiety or depression or depressive or hypervigilance or agoraphobia or neuroses or neurosis or neurotic or paranoi* or catastrophiz* or catastorphis*or and obsessive-compulsive or panic or phobia or stress or ptsd or psycho* or "internalising symptom*" or "internalizing symptom*" or wellness or "seasonal affective disorder*" or psychiatr*)	1,135,565
S15	("dysthymic disorder*" or "use disorder" or "psychotropic drug*" or "brain disease*" or "neurotransmitter agent*" or cognitive or "social problems" or "alcohol abuse*" or "drug abuse*")	200,728
S16	(S11 OR S12 OR S13 OR S14 OR S15)	1,615,363
S17	S1 AND S10 AND S16	105

SCOPUS Searched July 27, 2021 Results n=95

(((TITLE-ABS-KEY ((coronavirus* OR "corona virus*" OR oc43 OR nl63 OR 229e OR hku1 OR hcov* OR ncov* OR covid* OR "sars-cov*" OR sarscov* OR "Sars-coronavirus*" OR "Severe Acute Respiratory Syndrome Coronavirus*" OR d614g))) AND NOT ((TITLE-ABS-KEY ((sars OR sars-cov OR mers OR mers-cov OR "Middle East respiratory syndrome or camel*" OR dromedar* OR equine OR coronary OR coronal OR covidence* OR covidien OR influenza AND virus OR hiv OR bovine OR calves OR tgev OR feline OR porcine OR bcov))) OR (TITLE-ABS-KEY ((ped OR pedv OR pdcov OR fipv OR fcov OR sads-cov OR canine OR ccov OR zoonotic OR "avian influenza" OR h1n1 OR h5n1 OR h5n6 OR ibv OR murine AND corona*))))) OR (TITLE-ABS-KEY ((pneumonia OR covid* OR coronavirus* OR corona AND virus* OR ncov* OR 2019-ncov OR sars*) AND wuhan) OR ((2019-ncov OR ncov19 OR ncov-19 OR 2019-novel AND cov OR sars-cov2 OR sars-cov-2 OR sarscov2 OR sarscov-2 OR sars-coronavirus2 OR sars-coronavirus-2 OR "SARS-like coronavirus*" OR coronavirus-19 OR covid19 OR covid-19 OR "covid 2019" OR "B.1.1.7" OR "B.1.351" OR "B.1.617.1" OR "B.1.617.2" OR (variant* W/2 (india* OR "South Africa*" OR uk OR english OR brazil* OR alpha OR beta OR delta OR gamma OR kappa OR lambda OR "P.1" OR "C.37")) OR ((covid OR covid19 OR covid-19) AND pandemic*) OR (coronavirus* AND pneumonia)))) OR (TITLE ((novel OR new OR nouveau) AND (cov OR ncov OR covid OR coronavirus* OR corona AND virus OR pandemi*))) OR (ABS ((novel OR new OR nouveau) AND (cov OR ncov OR covid OR coronavirus* OR corona AND virus OR pandemi*))) OR (KEY ((novel OR new OR nouveau) AND (cov OR ncov OR covid OR coronavirus* OR corona AND virus OR pandemi*))) AND ORIG-LOAD-DATE > 20190630) AND (TITLE-ABS-KEY ("birth outcome*" OR "birth complication*" OR stillbirth* OR "fetal death*" OR "low birthweight*" OR "low birth weigh" OR "small for gestational age" OR sga OR macrosomia OR "neonatal death" OR "congenital anomal*" OR "pregnancy outcome*" OR "obstetrical outcome*" OR "obstetrical complication*" OR "labor complication*" OR "spontaneous abortion*") OR TITLE-ABS-KEY ((labor OR labour OR deliver* OR childbirth* OR birth*) W/3 (prematur* OR pre-mature* OR preterm OR pre-term OR early OR difficult*))) AND (TITLE-ABS-KEY ((mental* W/3 (ill* OR well* OR disorder* OR disease* OR health* OR unwell*))) OR

TITLE-ABS-KEY ((anxiety OR depression OR depressive OR hypervigilance OR agoraphobia OR neuroses OR neurosis OR neurotic OR paranoi* OR catastrophiz* OR catastorphis*or AND obsessive-compulsive OR panic OR phobia OR stress OR ptsd OR psycho* OR "internalising symptom*" OR "internalizing symptom*" OR wellness OR "seasonal affective disorder*" OR psychiatr*)) OR TITLE-ABS-KEY ("use disorder" OR "psychotropic drug*" OR "brain disease*" OR "neurotransmitter agent*" OR cognitive OR "social problems" OR "alcohol abuse*" OR "drug abuse*"))

Cochrane Library (CDSR and Central Register of Controlled Trials)
Searched July 27, 2021

ID	Search	Hits
#1	MeSH descriptor: [COVID-19] explode all trees	467
#2	(covid19 or "covid 19" or "coronavirus 2019" or "corona virus 2019" or "sars cov2"):ti,ab,kw	5991
#3	variant* near (india* or "south african" or England or UK or Brazil or alpha or beta or delta or gamma or kappa or lambda or "P.1" or "C.37")	121
#4	"B.1.1.7" or "B.1.351" or "B.1.617.1" or "B.1.617.2"	8
#5	wuhan and (pandemic or corona* or pneumonia)	284
#6	#1 or #2 or #3 or #4 or #5	6175
#7	MeSH descriptor: [Pregnancy Complications] explode all trees	12263
#8	MeSH descriptor: [Pregnancy Outcome] explode all trees	3750
#9	MeSH descriptor: [Obstetric Labor Complications] explode all trees	4070
#10	MeSH descriptor: [Obstetric Labor, Premature] explode all trees	2259
#11	MeSH descriptor: [Fetal Death] explode all trees	367
#12	("adverse birth outcome" or stillbirth* or "low birthweight" or "low birth weigh" or "small for gestational age" or SGA or macrosomia or "neonatal death" or "congenital anomalities"):ti	771
#13	("spontaneous abortion"):ti	139
#14	((labor or labour or deliver* or childbirth* or birth*) Near 3 (prematur* or pre-mature* or preterm or pre-term or early or difficult*)):ti,ab	1773
#15	#7 or #8 or #9 or #10 or #11 #12 or #13 or #14	15308
#16	#6 and #15	16
#17	MeSH descriptor: [Mental Health] explode all trees	1654
#18	MeSH descriptor: [Mental Disorders] explode all trees	75966
#19	MeSH descriptor: [Psychology] explode all trees	1090
#20	MeSH descriptor: [Anxiety] explode all trees	8306
#21	MeSH descriptor: [Depression] explode all trees	12932
#22	((mental* near 3 (ill* or well* or disorder* or disease* or health* or unwell*))):ti	31
#23	((psychiatric* near 3 (ill* or well* or disorder* or disease* or health* or unwell*))):ti	4
#24	(("dysthymic disorder" or "use disorder" or "psychotropic drug" or "brain disease" or "neurotransmitter agent" or cognitive or "social problems" or "alcohol abuse" or "drug abuse")):ti	29197
#25	("seasonal affective disorder" or "internalising symptoms" or "internalizing symptoms" or "common mental disorders"):ti	354
#26	#17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25	108957

#27	#16 and #26	5

PROSPERO Searched July 27, 2021

Line	Search for	Hits
#1	(((coronavirus or corona-virus) AND (wuhan or beijing or shanghai or Italy or South-Korea or korea or China or Chinese or 2019-nCoV or nCoV or COVID-19 or Covid19 or SARS-CoV* or SARSCov2 or ncov)) OR (pneumonia AND Wuhan) or "COVID-19" or "2019-nCoV" or "SARS-CoV" or SARSCOV2 or 2019-nCov or "2019 coronavirus" or "2019 corona virus" or covid19 or ncov OR "novel corona virus" or "new corona virus" or "nouveau corona virus" or "2019 corona virus" OR "novel coronavirus" or "new coronavirus" or "nouveau coronavirus" or "2019 coronavirus") NOT Animal:DB	4745
#2	"birth outcome*" OR "birth complication*" OR stillbirth* OR "fetal death* OR "low birthweight*" OR "low birth weigh" OR "small for gestational age" OR sga OR macrosomia OR "neonatal death" OR "congenital anomal*" OR "pregnancy outcome*" OR "obstetrical outcome*" OR "obstetrical complication*" OR "labor complication*" OR "spontaneous abortion*" NOT Animal:DB	3042
#3	"difficult labo*" or "premature labo*" or "preterm labo*" or "early labo*" NOT Animal:DB	247
#4	"difficult birth*" or "premature birth*" or "preterm birth*" or "early birth*" or "immature birth*" NOT Animal:DB	1286
#5	"difficult childbirth*" or "premature childbirth*" or "preterm childbirth*" NOT Animal:DB	0
#6	"obstetrical complication*" or "fetus death*" or stillbirth* NOT Animal:DB	876
#7	"mental ill*" or "mental* well*" or "mental disease*" or "mental* disorder*" or "mental* unwell*" NOT Animal:DB	5075
#8	"psychiatric* disease*" or "psychiatric* ill*" or "psychiatric* disorder*" or "psychiartric* health*" NOT Animal:DB	1658
#9	anxiety OR depression OR depressive OR hypervigilance OR agoraphobia OR neuroses OR neurosis OR neurotic OR paranoi* OR catastrophiz* OR catastorphis*or AND obsessive-compulsive OR panic OR phobia OR stress OR wellness OR "seasonal affective disorder*" NOT Animal:DB	9190
#10	"use disorder" OR "psychotropic drug*" OR "brain disease*" OR "neurotransmitter agent*" OR cognitive OR "social problems" OR "alcohol abuse*" OR "drug abuse*" NOT Animal:DB	11626

#11	#3 OR #4 OR #5 OR #6 OR #2	3557	
#12	#7 OR #8 OR #9 OR #10		20246
#13	#1 AND #11 AND #12		13

Appendix 4 References for Calculating Small for Gestational Age

Table A3. The 10th percentile reference values of birth weight among male and female newborns from 24 to 42 gestation weeks[1].

Gestation Week[2]	*Male Infants (P_{10}(g))*[3]	*Female Infants (P_{10}(g))*[4]
24	570	498
25	640	572
26	719	654
27	809	745
28	910	844
29	1023	951
30	1150	1068
31	1292	1198
32	1451	1344
33	1628	1509
34	1823	1695
35	2033	1902
36	2258	2125
37	2487	2357
38	2701	2579
39	2874	2762
40	3002	2896
41	3100	3005
42	3188	3101

[1] Capital Institute of Pediatrics, Coordinating Study Group of Nine Cities on the Physical Growth and Development of Children. [Growth standard curves of birth weight, length, and head circumference of Chinese newborns of different gestation]. Zhonghua Er Ke Za Zhi. 2020 Sep 2;58(9):738–46.

[2] Gestation weeks refer to the whole number of the gestational age, for instance, 24 weeks refers to the gestational age of 24+0 weeks.

[3, 4] P refers to percentile, P_{10} refers to the 10th percentil

Appendix 5 Sub-analyses for Prenatal Depression and Anxiety using Multiple Logistic Regression

Table A4 Univariate Analyses of Prenatal Depression and Anxiety for both Pre-pandemic and During-pandemic Cohorts using Multiple Logistic Regression

Characteristics	Pre-Pandemic (n=1148)											
	Depression Measured by EPDS				Depression Measured by PHQ-9				Anxiety Measured by GAD-7			
	n (%) had depression	*OR*	*(95%CI)*	*p-value*	n (%) had depression	*OR*	*(95%CI)*	*p-value*	n (%) had anxiety	*OR*	*(95%CI)*	*p-value*
Age (years)		0.97	(0.94, 1.01)	0.127		0.99	(0.96, 1.02)	0.358		0.98	(0.95, 1.01)	0.168
BMI (kg/m2)		0.98	(0.93, 1.03)	0.413		0.98	(0.95, 1.02)	0.364		0.97	(0.94, 1.01)	0.194
Socioeconomic Status[1]		0.83	(0.75, 0.92)	0.001		0.94	(0.87, 1.02)	0.155		0.86	(0.79, 0.93)	<0.001
Number of People in the Household		1.27	(1.13, 1.44)	<0.001		1.09	(0.98, 1.20)	0.107		1.01	(0.38, 0.77)	0.001
Ethnicity												
Han	211 (18.5)		Reference		542 (47.4)		Reference		413 (36.1)		Reference	
Other (Hui and other ethnicities)	2 (0.2)	0.73	(0.16, 3.26)	0.675	8 (0.7)	1.44	(0.50, 4.19)	0.499	4 (0.4)	0.69	(0.22, 2.23)	0.538
Residential Area												
Urban	181 (15.8)		Reference		478 (41.6)		Reference		360 (31.4)		Reference	
Rural	33 (2.9)	1.39	(0.91, 2.13)	0.122	73 (6.4)	1.19	(0.83, 1.69)	0.338	57 (5.0)	1.22	(0.85, 1.75)	0.28
Marital Status												
Married	189 (16.5)		Reference		506 (44.1)		Reference		382 (33.3)		Reference	
Not Married (Divorced/Seperated/single/cohabit/widow)	25 (2.2)	2.44	(1.47, 4.06)	0.001	45 (3.9)	1.81	(1.11, 2.94)	0.017	35 (3.1)	1.67	(1.04, 2.69)	0.034
Household Income (Yuan)												
<50,000	32 (2.8)		Reference		64 (5.6)		Reference		48 (4.2)		Reference	
50,00-100,000	78 (6.8)	0.65	(0.40, 1.03)	0.069	206 (17.9)	0.88	(0.59, 1.31)	0.532	164 (14.3)	0.99	(0.66, 1.49)	0.971
100,000-200,000	75 (6.5)	0.64	(0.40, 1.03)	0.064	198 (17.3)	0.87	(0.58, 1.29)	0.478	147 (12.8)	0.88	(0.58, 1.32)	0.53
200,000-300,000	21 (1.8)	0.75	(0.40, 1.40)	0.369	55 (4.8)	1.1	(0.66, 1.86)	0.706	41 (3.6)	1.07	(0.63, 1.82)	0.8
>300,000	8 (0.7)	0.48	(0.20, 1.11)	0.085	28 (2.4)	0.92	(0.49, 1.71)	0.789	17 (1.5)	0.68	(0.35, 1.33)	0.263

Education												
Middle school and lower	51 (4.4)		Reference		91 (7.9)		Reference		68 (5.9)		Reference	
High school or equivalent	43 (3.8)	0.67	(0.42, 1.06)	0.088	112 (9.8)	1.14	(0.78, 1.66)	0.514	82 (7.1)	1.07	(0.72, 1.60)	0.727
Undergraduate or equivalent and higher	129 (10.5)	0.57	(0.40, 0.84)	0.004	348 (30.3)	1.09	(0.80, 1.50)	0.576	267 (23.3)	1.12	(0.81, 1.56)	0.495
Employment												
Unemployed	114 (9.9)		Reference		236 (20.6)		Reference		176 (15.3)		Reference	
Employed (full-time/part-time/on paid leave)	100 (8.7)	0.56	(0.42, 0.76)	<0.001	315 (27.4)	0.92	(0.72, 1.16)	0.465	241 (21.0)	0.97	(0.76, 1.24)	0.803
Smoking Status												
Never smoke	201 (17.5)		Reference		518 (45.1)		Reference		394 (34.3)		Reference	
Used to or still smoking	13 (1.1)	1.53	(0.80, 2.92)	0.202	33 (2.9)	2.05	(1.14, 3.68)	0.016	23 (2.0)	1.47	(0.83, 2.58)	0.185
Passive Smoking												
Never	68 (5.9)		Reference		148 (12.9)		Reference		108 (9.4)		Reference	
Sometimes	106 (9.2)	0.93	(0.66, 1.31)	0.68	294 (25.6)	1.4	(1.08, 1.83)	0.012	228 (19.9)	1.45	(1.10, 1.92)	0.009
Almost everyday	40 (3.5)	1.1	(0.71, 1.70)	0.677	109 (9.5)	1.79	(1.26, 2.54)	0.001	81 (7.1)	1.64	(1.14, 2.35)	0.008
Alcohol consumption												
No[2]	172 (15.0)		Reference		450 (39.2)		Reference		350 (30.5)		Reference	
Yes	42 (3.7)	1.77	(1.20, 2.62)	0.004	101 (8.8)	2.26	(1.59, 3.21)	<0.001	67 (5.8)	1.4	(0.99, 1.97)	0.055
Attitude toward this pregnancy												
Acceptable	87 (7.6)		Reference		263 (22.9)		Reference		187 (16.3)		Reference	
Unexpected	69 (6.0)	1.97	(1.38, 2.82)	<0.001	137 (11.9)	1.26	(0.94, 1.70)	0.125	109 (9.5)	1.45	(1.07, 1.96)	0.018
Well-prepared	58 (5.1)	1.08	(0.75, 1.55)	0.689	151 (13.2)	0.85	(0.65, 1.12)	0.242	121 (10.5)	1.05	(0.79, 1.39)	0.734
Types of conception												
Non-Assisted conception	202 (17.6)		Reference		518 (45.1)		Reference		393 (34.2)		Reference	
Assisted conception (IVF[3]/ICSI[4]/other)	12 (1.1)	0.79	(0.42, 1.50)	0.477	33 (2.9)	0.8	(0.50, 1.28)	0.351	24 (2.1)	0.78	(0.47, 1.29)	0.331
History of adverse pregnancy outcomes[5]												
No	163 (14.2)		Reference		427 (37.2)		Reference		314 (27.4)		Reference	
Yes	51 (4.4)	1.23	(0.87, 1.75)	0.244	124 (10.8)	1.2	(0.91, 1.60)	0.201	103 (9.0)	1.42	(1.06, 1.90)	0.017
History of mental health issues												
No	207 (18.0)		Reference		544 (47.4)		Reference		410 (35.7)		Reference	

Yes	7 (0.6)	10.5	(2.69, 40.92)	<0.001	7 (0.6)	2.55	(0.66, 9.90)	0.177	7 (0.6)	4.14	(1.07, 16.11)	0.04
History of using drugs												
Never	203 (17.7)		Reference		541 (47.1)		Reference		407 (35.5)		Reference	
Used to or still use	11 (1.0)	8.38	(3.06, 22.92)	<0.001	10 (0.9)	1.56	(0.59, 4.12)	0.372	10 (0.9)	2.54	(0.96, 6.73)	0.06
Do you have kids before this pregnancy?												
No	124 (10.8)		Reference		360 (31.4)		Reference		273 (23.8)		Reference	
Yes	90 (7.8)	1.33	(0.98, 1.80)	0.066	191 (16.6)	0.85	(0.67, 1.08)	0.194	144 (12.5)	0.87	(0.68, 1.12)	0.276
Number of times being pregnant												
First time pregnant	84 (7.3)		Reference		246 (21.4)		Reference		182 (15.9)		Reference	
Second time	60 (5.2)	1.07	(0.74, 1.54)	0.73	156 (13.6)	0.88	(0.67, 1.16)	0.372	127 (11.1)	1.05	(0.79, 1.40)	0.746
Third time	43 (3.8)	1.47	(0.97, 2.21)	0.07	86 (7.5)	0.87	(0.62, 1.21)	0.406	72 (6.3)	1.08	(0.76, 1.53)	0.659
Fourth time and above	27 (2.4)	1.39	(0.85, 2.26)	0.186	63 (5.5)	1.08	(0.73, 1.60)	0.703	36 (3.1)	0.72	(0.47, 1.11)	0.135
Characteristics	**During-Pandemic (n=2249)**											
	Depression Measured by EPDS				**Depression Measured by PHQ-9**				**Anxiety Measured by GAD-7**			
	n (%) had depression	***OR***	***(95%CI)***	***p-value***	**n (%) had depression**	***OR***	***(95%CI)***	***p-value***	**n (%) had anxiety**	***OR***	***(95%CI)***	***p-value***
Age (years)		0.98	(0.95, 1.00)	0.078		0.96	(0.93, 0.98)	<0.001		0.98	(0.96, 1.0)	0.034
BMI (kg/m2)		1.02	(0.99, 1.06)	0.22		1.01	(0.98, 1.03)	0.711		1.01	(0.98, 1.03)	0.626
Socioeconomic Status[1]		0.85	(0.78, 0.93)	<0.001		0.91	(0.85, 0.98)	0.008		0.94	(0.88, 1.01)	0.084
Number of People in the Household		1.13	(1.03, 1.25)	0.01		1.05	(0.98, 1.14)	0.175		1.03	(0.95, 1.11)	0.495
Ethnicity												
Han	320 (14.3)		Reference		644 (28.7)		Reference		593 (26.4)		Reference	
Other (Hui and other ethnicities)	6 (0.3)	1.18	(0.49, 2.86)	0.712	6 (0.3)	0.49	(0.20, 1.17)	0.109	7 (0.3)	0.66	(0.29, 1.51)	0.324
Residential Area												
Urban	211 (11.3)		Reference		440 (23.6)		Reference		408 (21.9)		Reference	
Rural	53 (2.9)	1.39	(0.93, 1.80)	0.121	98 (5.3)	1.15	(0.89, 1.50)	0.286	97 (5.2)	1.26	(0.97, 1.64)	0.086
Marital Status												
Married	261 (14.1)		Reference		528 (28.4)		Reference		499 (26.9)		Reference	

Not Married												
(Divorced/Separated/single/cohabit/widow)	4 (0.2)	1.86	(0.60, 5.74)	0.282	9 (0.5)	2.79	(1.07, 7.27)	0.036	6 (0.3)	1.46	(0.54, 3.98)	0.456
Household Income (Yuan)												
<50,000	16 (0.9)		Reference		36 (2.1)		Reference		31 (1.8)		Reference	
50,00-100,000	67 (3.9)	1.21	(0.67, 2.18)	0.519	137 (7.9)	1.11	(0.72, 1.71)	0.654	123 (7.1)	1.16	(0.74, 1.84)	0.514
100,000-200,000	118 (6.8)	1.11	(0.63, 1.94)	0.724	232 (13.4)	0.94	(0.62, 1.42)	0.755	221 (12.7)	1.07	(0.70, 1.66)	0.746
200,000-300,000	32 (1.8)	1.03	(0.54, 1.97)	0.92	65 (3.74)	0.9	(0.56, 1.46)	0.677	64 (3.7)	1.08	(0.66, 1.78)	0.748
>300,000	12 (0.7)	0.99	(0.44, 2.20)	0.976	31 (1.8)	1.2	(0.67, 2.15)	0.532	33 (1.9)	1.62	(0.90, 2.92)	0.106
Education												
Middle school and lower	73 (3.9)		Reference		124 (6.7)		Reference		108 (5.8)		Reference	
High school or equivalent	61 (3.3)	0.64	(0.44, 0.93)	0.02	124 (6.7)	0.76	(0.56, 1.03)	0.076	111 (6.0)	0.8	(0.59, 1.10)	0.165
Undergraduate or equivalent and higher	130 (7.0)	0.54	(0.39, 0.74)	<0.001	289 (15.6)	0.69	(0.54, 0.89)	0.005	286 (15.4)	0.84	(0.64, 1.09)	0.188
Employment												
Unemployed	157 (8.5)		Reference		294 (15.9)		Reference		263 (14.2)		Reference	
Employed (full-time/part-time/on paid leave)	108 (5.8)	0.62	(0.48, 0.81)	<0.001	242 (13.1)	0.73	(0.59, 0.89)	0.002	241 (13.0)	0.85	(0.69, 1.04)	0.112
Smoking Status												
Never smoke	258 (14.0)		Reference		523 (28.3)		Reference		492 (26.6)		Reference	
Used to or still smoking	6 (0.3)	2.14	(0.84, 5.48)	0.11	12 (0.7)	2.71	(1.19, 6.19)	0.018	11 (0.6)	2.48	(1.09, 5.66)	0.031
Passive Smoking												
Never	152 (8.3)		Reference		315 (17.2)		Reference		310 (16.9)		Reference	
Sometimes	77 (4.2)	1.28	(0.95, 1.73)	0.1	153. (8.4)	1.27	(1.01, 1.60)	0.04	136 (7.4)	1.1	(0.87, 1.39)	0.427
Almost everyday	34 (1.89)	1.97	(1.30, 3.00)	0.001	61 (3.33)	1,87	(1.32, 2.65)	<0.001	54 (3.0)	1.57	(1.10, 2.24)	0.013
Alcohol consumption												
No[2]	250 (13.6)		Reference		508 (27.7)		Reference		480 (26.2)		Reference	
Yes	13 (0.7)	2.04	(1.08, 3.88)	0.029	22 (1.2)	1.84	(1.05, 3.22)	0.033	19 (1.0)	1.56	(0.88, 2.77)	0.128
Attitude toward this pregnancy												
Acceptable	112 (6.1)		Reference		254 (13.8)		Reference		236 (12.8)		Reference	
Unexpected	86 (4.7)	1.57	(1.16, 2.14)	0.004	153 (8.3)	1.22	(0.96, 1.56)	0.103	140 (7.6)	1.19	(0.93, 1.53)	0.171
Well-prepared	67 (3.6)	0.98	(0.71, 1.36)	0.914	128 (7.0)	0.77	(0.60, 0.99)	0.043	129 (7.0)	0.87	(0.68, 1.11)	0.25

Types of conception												
Non-Assisted conception	255 (13.9)		Reference		518 (28.1)		Reference		488 (26.5)		Reference	
Assisted conception (IVF[3]/ICSI[4]/other)	10 (0.5)	1.17	(0.59, 2.34)	0.651	17 (0.9)	0.94	(0.53, 1.66)	0.835	17 (0.9)	1.02	(0.58, 1.81)	0.938
History of adverse pregnancy outcomes[5]												
No	208 (11.6)		Reference		432 (24.2)		Reference		400 (22.4)		Reference	
Yes	48 (2.7)	1.21	(0.86, 1.70)	0.281	87 (4.9)	1.03	(0.79, 1.36)	0.81	92 (5.1)	1.25	(0.95, 1.64)	0.112
History of mental health issues												
No	253 (13.8)		Reference		513 (27.9)		Reference		483 (26.3)		Reference	
Yes	12 (0.7)	3.2	(1.57, 6.50)	0.001	20 (1.1)	3.35	(1.70, 6.60)	<0.001	21 (1.1)	4.1	(2.07, 8.13)	<0.001
History of using drugs												
Never	260 (14.2)		Reference		528 (28.8)		Reference		497 (27.1)		Reference	
Used to or still use	3 (0.2)	1.38	(0.39, 4.88)	0.615	4 (0.2)	0.81	(0.26, 2.53)	0.722	5 (0.3)	1.21	(0.42, 3.49)	0.728
Do you have kids before this pregnancy?												
No	195 (8.7)		Reference		411 (18.3)		Reference		379 (16.9)		Reference	
Yes	131 (5.8)	1.04	(0.82, 1.32)	0.744	239 (10.6)	0.85	(0.71, 1.03)	0.108	221 (9.8)	0.86	(0.71, 1.05)	0.138
Number of times being pregnant												
First time pregnant	129 (5.7)		Reference		284 (12.6)		Reference		258 (11.5)		Reference	
Second time	99 (4.4)	1.09	(0.82, 1.44)	0.554	192 (8.5)	0.93	(0.75, 1.15)	0.499	184 (8.2)	1	(0.80, 1.25)	0.999
Third time	47 (2.1)	1.04	(0.73, 1.50)	0.812	85 (3.8)	0.8	(0.61, 1.07)	0.129	76 (3.4)	0.79	(0.59, 1.06)	0.12
Fourth time and above	51 (2.3)	1.69	(1.18, 2.43)	0.004	88 (3.9)	1.33	(0.99, 1.79)	0.055	81 (3.6)	1.34	(0.99, 1.82)	0.054

[1]Economic status compared to people around the participant, with 0 as the lowest and 10 the highest.

[2]No alcohol consumption is defined as not more than one drink of either 340ml of beer or 140ml of wine or 43ml of Chinese Baijiu.

[3]In vitro fertilization

[4]Intracytoplasmic sperm injection

[5]Adverse pregnancy outcomes include miscarriage, stillbirth, perinatal mortality, and birth defects.

Table A5 Multivariable Analyses of Prenatal Depression and Anxiety for both Pre-pandemic and During-pandemic Cohorts using Multiple Logistic Regression

Characteristics	Pre-pandemic (n-1148)								
	Depression Measured by EPDS			Depression Measured by PHQ-9			Anxiety Measured by GAD-7		
	OR	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*	*OR*	*(95%CI)*	*p-value*
Socioeconomic Status[1]	0.83	(0.75, 0.93)	0.001				0.86	(0.78, 0.94)	0.001
Number of People in the Household	1.23	(1.08, 1.40)	0.002						
Marital Status									
Married		Reference			Reference			Reference	
Not Married (Divorced/Separated/single/cohabit/widow)	1.9	(1.10, 3.28)	0.021						
Employment									
Unemployed		Reference			Reference			Reference	
Employed (full-time/part-time/on paid leave)	0.68	(0.49, 0.93)	0.018						
Passive Smoking									
Never		Reference			Reference			Reference	
Sometimes				1.41	(1.08, 1.84)	0.012	1.39	(1.04, 1.85)	0.024
Almost everyday				1.73	(1.21, 2.46)	0.003	1.5	(1.03, 2.18)	0.033
Alcohol consumption									
No[2]		Reference			Reference			Reference	
Yes				2.22	(1.56, 3.17)	<0.001	1.35	(0.94, 1.93)	0.102
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	
Unexpected	1.75	(1.20, 2.56)	0.004				1.47	(1.07, 2.03)	0.017
Well-prepared	1.37	(0.93, 2.01)	0.108				1.02	(0.76, 1.37)	0.897
History of adverse pregnancy outcomes[3]									
No		Reference			Reference			Reference	
Yes							1.82	(1.29, 2.58)	0.001
History of mental health issues									
No		Reference			Reference			Reference	
Yes	12.2	(2.94, 50.63)	0.001				1.62	(0.78, 14.39)	0.106
History of using drugs									
Never		Reference			Reference			Reference	

Used to or still use							1.83	(0.61, 5.47)	0.278
Number of times being pregnant									
First time pregnant	Reference			Reference			Reference		
Second time							0.82	(0.60, 1.12)	0.219
Third time							0.77	(0.52, 1.13)	0.18
Fourth time and above							0.47	(0.29, 0.76)	0.002

Characteristics	**During-pandemic (n=2249)**								
	Depression Measured by EPDS			**Depression Measured by PHQ-9**			**Anxiety Measured by GAD-7**		
	OR	***(95%CI)***	***p-value***	***OR***	***(95%CI)***	***p-value***	***OR***	***(95%CI)***	***p-value***
Age (years)				0.95	(0.92, 0.97)	<0.001			
Socioeconomic Status[1]	0.88	(0.80, 0.97)	0.003	0.93	(0.87, 0.99)	0.039	0.92	(0..85, 0.99)	0.021
Number of People in the Household									
Household Income (Yuan)									
<50,000		Reference			Reference			Reference	
50,00-100,000							1.26	(0.79, 2.01)	0.329
100,000-200,000							1.19	(0.76, 1.86)	0.437
200,000-300,000							1.29	(0.76, 2.27)	0.344
>300,000							2.04	(1.10, 3.80)	0.024
Education									
Middle school and lower		Reference			Reference			Reference	
High school or equivalent	0.66	(0.45, 0.96)	0.032						
Undergraduate or equivalent and higher	0.61	(0.44, 0.85)	0.003						
Passive Smoking									
Never		Reference			Reference			Reference	
Sometimes				1.22	(0.97, 1.54)	0.096			
Almost everyday				1.57	(1.08, 2.27)	0.017			
Alcohol consumption									
No[2]		Reference			Reference			Reference	
Yes									
Attitude toward this pregnancy									
Acceptable		Reference			Reference			Reference	

	Unexpected	1.46	(1.06. 2.00)	0.02						
	Well-prepared	0.96	(0.69, 1.34)	0.807						
History of mental health issues										
	No		Reference			Reference			Reference	
	Yes	3.19	(1.54, 6.63)	0.002				4.67	(2.26, 9.66)	<0.001
Number of times being pregnant										
	First time pregnant		Reference			Reference			Reference	
	Second time				1.03	(0.80, 1.32)	0.838			
	Third time				1.02	(0.72, 1.43)	0.93			
	Fourth time and above				1.84	(1.27, 2.66)	0.001			

[1]Economic status compared to people around the participant, with 0 as the lowest and 10 the highest.

[2]No alcohol consumption is defined as not more than one drink of either 340ml of beer or 140ml of wine or 43ml of Chinese Baijiu.

[3]Adverse pregnancy outcomes include miscarriage, stillbirth, perinatal mortality, and birth defect.