

RESEARCH

Open Access



Effect of pandemic-induced PTSD in pregnant women on infant physical growth: a prospective cohort study

Fang Ye¹, Jie Chen¹, Xinying Gao¹, Hong Lin², Yuanmei Chen¹, Jing Liu¹, Qi Sun¹ and Qi Zhang^{1*} 

Abstract

Background The COVID-19 pandemic has had a profound impact on global mental health, particularly affecting vulnerable groups such as pregnant women. Post-traumatic stress disorder (PTSD) in this population may potentially hinder infant physical development, underscoring the necessity for specific interventions. This study seeks to explore the prevalence of PTSD among pregnant women during the pandemic and its implications for infant physical development, thereby providing evidence to mitigate the adverse effects of the pandemic on maternal and child health.

Methods A prospective cohort study was carried out involving 450 pregnant women from December 2022 to February 2023. Data included demographic details, PTSD evaluation using the PTSD Checklist-Civilian version (PCL-C) scale, coping mechanisms, and infant growth indicators at three months postpartum. Statistical methods included descriptive statistics, univariate analysis, and multivariate analysis of covariance (ANCOVA) to control for confounding factors.

Results The study enrolled a total of 450 pregnant women. Following exclusions and follow-up attrition, 422 pregnant women were analyzed. There were 72 pregnant women with PTSD and 350 without PTSD. There was no statistically significant difference in birth weight between the two groups of participants. Three months after birth, infants of PTSD-positive mothers exhibited significantly lower weight percentiles at three months ($P < 0.001$), adjusted for birth weight, feeding method, and coping strategies. Multivariate analysis affirmed a 9.44-point reduction in weight percentile among infants in the PTSD-positive group (95% CI: 4.01–14.87, $P = 0.001$). Conclusion: Pregnant women suffering from PTSD during the pandemic are at risk of giving birth to infants with impaired physical growth. These findings highlight the critical need for mental health support for pregnant women to foster optimal infant development and to guide public health policies and clinical practices.

Keywords COVID-19, PTSD, Pregnant women, Infant growth, Mental health, Cohort

*Correspondence:

Qi Zhang

zhangqikeyan@163.com

¹Department of Pediatrics, China-Japan Friendship Hospital, Beijing 100029, China

²Department of Obstetrics, China-Japan Friendship Hospital, Beijing 100029, China



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

Introduction

Between December 2022 and January 2023, China witnessed a surge in Omicron variant infections after three years of stringent pandemic prevention and control measures initiated since December 2019. These measures exerted significant nationwide and global repercussions, resulting in substantial alterations in people's daily routines. Numerous studies conducted during the COVID-19 pandemic have documented a high prevalence of anxiety, depression, and psychological stress among the general populace, signifying a marked decline in mental health [1, 2]. Pregnant women, constituting a unique cohort, encounter multifarious pressures during the pandemic, encompassing isolation, scarce medical resources, and apprehensions regarding their own and their newborn's well-being, all of which may elevate their susceptibility to post-traumatic stress disorder (PTSD) [3].

PTSD is a psychological affliction that ensues subsequent to experiencing or witnessing a life-threatening incident, marked by recurrent distressing recollections, avoidance of trauma-associated stimuli, persistent hypervigilance, and negative emotional dispositions [4]. Prevalent studies have demonstrated that the mental health condition of pregnant women is intimately linked to the physical growth and development of their offspring [5]. The stress levels of pregnant women can impinge on the growth of fetuses and infants via diverse conduits, including modifying the endocrine milieu of the mother, influencing the constitution of breast milk, and through the tenor of mother-infant interactions [6–8]. Consequently, examining the repercussions of PTSD in pregnant women during the COVID-19 pandemic on the physical growth of infants holds great import for comprehending the protracted ramifications of the pandemic on early childhood development [9–12].

In the light of the above-presented background, the aim of this paper is to investigate the prevalence of post-traumatic stress disorder (PTSD) among pregnant women during the COVID-19 pandemic and to examine its potential impact on infant physical development. By providing empirical evidence, we intend to assess the association between PTSD in pregnant women and the physical growth of their infants at three months postpartum, thereby informing public health policies and clinical practices aimed at supporting the mental well-being of pregnant women and promoting optimal infant development. By instituting a prospective cohort study, we will amass data on the mental health status of pregnant women, the growth and development of infants, and other pertinent factors, with the aim of unveiling potential correlations between maternal PTSD and infant physical growth, and to furnish references for subsequent public health policies and clinical practices.

Methods

Study design and participants

This research constituted a prospective cohort study. All pregnant women who delivered at the obstetrics department of our hospital between December 1, 2022, and February 28, 2023, were invited to complete a structured questionnaire. The supplementary inclusion criterion entailed voluntary participation in the study and the ability to read accurately or communicate verbally. Exclusion criteria included pregnant women with a history of mental illness, psychological disorders (such as anxiety, depression, phobias, obsessive-compulsive disorder, schizophrenia, etc.), as well as those with severe medical conditions that may affect lactation (such as organ failure), and those whose newborns were twins, premature infants, low birth weight infants, or had been transferred to pediatrics for treatment due to asphyxia, infection, etc. Upon enrollment in the study, pregnant women were furnished with informed consent that encompassed information pertaining to the study's objectives, procedures, benefits of participation, and voluntary nature of participation.

The diagnosis of each participant was performed according to the Diagnostic and Statistical Manual of Mental Disorders - the 5th edition (DSM-V) [13]. Then data were collected at two time points: (a) at the baseline when the pregnant woman was between 2 and 4 days postpartum, we measured the mother's PTSD symptoms, and collected data from medical records regarding the diagnosis, treatment, outcomes of COVID-19, demographic information, and coping strategies; (b) at 3 months (90+0~20 days) after delivery, the infant were invited returning to the pediatric department for physical growth measurements. The measurements included standardized anthropometric measures (weight, length, head circumference), and percentiles were recorded.

Study tool

The study tool consists of three parts: basic information, PTSD, and coping strategies. The basic information section includes diagnosis, treatment, outcomes of COVID-19, demographic information, and coping strategies.

For PTSD assessment, the PTSD Checklist-Civilian version (PCL-C) scale was selected, which is a civilian version of the scale for evaluating PTSD, suitable for assessing the experiences of ordinary people (as opposed to war) after encountering trauma in everyday life. The scale requires the respondent to independently evaluate their actual situation over the past month, using a 5-point scoring standard, with scores ranging from "completely disagree" to "fully agree" in ascending order. The scale consists of 17 items across 3 dimensions, with a total score ranging from 17 to 85. A total score of 17 to 37 scores is indicative of "without PTSD symptoms," 38 to

49 scores indicating “potential risk of PTSD,” and 50–85 scores indicating “full PTSD diagnosis”. The questionnaire is valid and reliable to use in the Chinese populations [14]. The reliability results of PCL-C show that the Cronbach’s alpha coefficient is 0.94 [14]. In this survey, the instructions provided to the respondents are as follows: “Referring to the current situation of COVID-19 outbreak, indicate how you feel for each of the following questions in the past month”.

The coping strategies of participants consist of 10 items, also using a 5-point scoring standard, with scores ranging from “completely unable to do” to “fully able to do” in ascending order, with a total score ranging from 10 to 50. The reliability results of coping strategies score show that the Cronbach’s alpha coefficient is 0.81. Please refer to the supplementary file for detailed content.

Statistical analysis

A descriptive analysis was conducted, revealing demographic profiles, PTSD scores, coping strategies, and potential influencing factors. Categorical variables are presented as frequencies and percentages, while continuous variables are expressed as the means and standard deviations for normally distributed data or medians and interquartile ranges for data with a skewed distribution. Univariate analysis was used to analyze the correlation between potential risk factors and outcome variables, and chi-square tests were employed to compare differences between PTSD positive and negative group.

Additionally, we employed analysis of covariance (ANCOVA) for multivariate analysis to control for potential confounding variables. ANCOVA is a multivariate statistical technique that combines the features of ANOVA and regression analysis, used to compare the means of two or more groups on a continuous dependent variable while adjusting for one or more continuous covariates. Prior to conducting ANCOVA, we first performed normality tests and homogeneity of variance tests on all continuous variables to ensure that the prerequisites for analysis are met. During the model-building process, the main independent variables and covariates was included, and maximum likelihood estimation to fit the model was used. The overall significance of the model was assessed through an F-test and test the significance of each independent variable and covariate through a t-test. Additionally, effect sizes was calculated to evaluate the proportion of variance in the dependent variable explained by each variable. To control for the increase in Type I error rate due to multiple comparisons, Bonferroni correction was employed. All analysis were conducted using SPSS version 18.0 (SPSS, Inc., Chicago, Illinois, USA). All reported p-values were two-tailed, with a significance level of 0.05 indicating statistical significance.

This study adheres to the principles of the Declaration of Helsinki, and the study protocol were approved by the ethical review boards of China-Japan Friendship Hospital. Informed consent was obtained prior to inclusion. In case of any participant under the age of 16 was enrolled in the study, informed consent to participate was obtained from their parents or legal guardians.

Results

The study enrolled a total of 450 pregnant women and their newborns, with exclusions of 4 cases of twins, 13 cases of premature or low birth weight, and 3 cases of neonatal asphyxia. By the time of the 3-month follow-up, 8 cases were lost to follow-up, resulting in a total of 422 cases. The reasons for loss to follow-up included refusal to participate in follow-up (4 cases), relocation of the child to another area (3 cases), and inability to contact the parturient or family (1 case). There was no statistically significant difference in sociodemographic characteristics between participants in the follow-up study and those lost to follow-up. Seventy-two participants tested positive for PTSD Group and 350 participants tested negative for non-PTSD Group. Sample sizes of 72 and 350 achieve 100.000% power to reject the null hypothesis of equal means with a significance level (alpha) of 0.050 using a two-sided two-sample equal-variance t-test.

Sociodemographic characteristics of the participants

The demographic characteristics, perinatal information, and feeding methods of the study subjects in the two groups are detailed in Table 1.

The total PTSD score for pregnant women was 29.07 ± 9.53 (median 28) points, with 72 participants testing positive for PTSD, resulting in a positive rate (≥ 38 points) of 17.06%. Among these, the scores for the three symptom clusters of avoidance, re-experiencing, and hyperarousal were 11.24 ± 4.00 (range 7–24), 7.82 ± 3.47 (range 4–18), and 10.00 ± 4.00 (range 6–23) points, respectively.

Comparison of weight percentiles at 3 months of age between the two groups of infants

The study compared the weight percentiles of infants at 3 months of age in both groups, finding that the weight of infants in the PTSD positive group was significantly lower than that in the PTSD negative group, with a statistically significant difference ($P < 0.001$) (Tables 2).

Univariate comparison of factors influencing infant weight in the two groups

Further comparison of different influencing factors on the weight of infants in the two groups revealed that boys, non-exclusive breastfeeding, multiparous mothers, and vaginal delivery were associated with higher weight

Table 1 Demographic characteristics of participants ¹

	PTSD positive group (n=72)	PTSD negative group (n=350)	Statistic value ³	P-value	Normality tests ⁴
Age (years)	31.17(3.14)	32.34(3.75)	2.778	0.006	0.140
Birth weight of the infant (gram)	3277.22(367.30)	3337.36(385.43)	1.215	0.225	0.088
Gestational weeks of the infants (week)	39.25(1.07)	39.12(0.98)	1.000	0.318	0.154
days of hospitalization(day)	4.42(1.51)	4.48(1.55)	0.332	0.740	0.091
postpartum blood loss (ml)	377.08(158.65)	425.54(204.97)	1.892	0.059	0.032
maternal weight gain during pregnancy (kg)	14.10(4.26)	13.26(3.37)	1.589	0.115	0.381
Score of coping strategies	41.81(4.72)	44.02(5.05)	3.436	0.001	0.069
Sex of the infants			6.011	0.014	-
boy	47(65.3%)	177(49.4%)			
girl	25(34.7%)	173(50.6%)			
Mode of delivery			3.564	0.168	-
vaginal delivery	28(38.9%)	159(45.4%)			
cesarean section	42(58.3%)	168(48.0%)			
forceps delivery	2(2.8%)	23(6.6%)			
Feeding method			13.852	0.001	-
exclusive breastfeeding	52(72.2%)	190(54.3%)			
Mixed feeding	14(19.4%)	145(41.4%)			
formula feeding	6(8.3%)	15(4.3%)			
Parity			9.202	0.002	-
nullipara	59(81.9%)	222(63.4%)			
multipara	13(18.1%)	128(36.6%)			
Family caregiver during hospitalization ²					
maternity nanny	27(37.5%)	155(44.3%)	1.121	0.290	-
husband	58(80.6%)	317(90.6%)	6.053	0.014	-
mother	33(45.8%)	178(50.9%)	0.603	0.437	-
mother-in-law	25(34.7%)	124(35.4%)	0.013	0.909	-
others	2(2.8%)	17(4.9%)	0.214	0.643	-
whether infected with COVID-19 during this period			1.397	0.546	-
yes	64(88.9%)	322(92.0%)			
no	0(0.0%)	2(0.6%)			
uncertain	8(11.1%)	26(7.4%)			

¹ Data in the table are presented as mean (SD) or n (%)² This option allows multiple selections³ t-values or Chi-square values are provided⁴ Significance of Shapiro-Wilk**Table 2** T-test for weight percentiles at 3 months of age in infants

	n	Mean±SD	Median(IQR)	t-value	P-value
PTSD positive group	72	48.79±23.27	46(31)	4.38	<0.001
PTSD negative group	350	63.45±26.35	69(44.25)		

at 3 months of age. In contrast, girls, exclusive breastfeeding, primiparous mothers, and cesarean section or forceps delivery were associated with lower weight at 3 months. Additionally, infants with higher birth weight and mothers with better coping strategies had higher weight at 3 months ($P < 0.05$). Following Bonferroni correction (0.05/6), sex of infant, parity, birth weight of the

infant, and score of coping strategies were associated with weight at 3 months (Table 3).

Multivariate analysis of factors influencing infant weight in the two groups

This study employed multivariate analysis of covariance to assess the impact of PTSD-positive mothers on their infants' weight at 3 months of age after adjusting for birth weight, feeding method, and coping strategies. The regression lines for the covariates and dependent variables within each group were parallel ($F = 3.686$, $P = 0.056$). The Shapiro-Wilk test indicated that the residuals of the dependent variables within each group approximated a normal distribution ($P > 0.05$). Scatter plots and Levene's test revealed that the residuals of the dependent variables within and between groups

Table 3 Univariate analysis of factors influencing infant weight at 3 months of age in the two groups

Weight percentiles at 3 months of age in infants	n	Mean±SD/r	Statistic value ¹	P-value
Sex of the infants				
boy	220	57.7±26.91	2.65	0.008
girl	202	64.48±25.45		
Exclusive breastfeeding or not				
yes	242	58.23±27.68	2.52	0.012
no	180	64.60±24.19		
Primiparous or not				
yes	281	57.58±26.86	3.76	<0.001
no	141	67.66±24.22		
Vaginal delivery or not				
yes	187	64.26±25.19	2.32	0.021
no	235	58.30±27.10		
Birth weight of the infant	422	0.559	190.53	<0.001
Score of coping strategies	422	0.177	13.55	<0.001

¹ Statistical value are t-value or F-value

were homoscedastic. Additionally, the study data did not exhibit standardized residuals greater than 3, indicating no significant outliers. The results showed that after adjusting for birth weight, feeding method, and coping strategies, the weight percentiles of newborns at 3 months of age differed between the two groups ($F=19.915$, $P<0.001$). Infants in the PTSD-positive group had a weight percentile at 3 months that was 9.44 points lower than that of the PTSD-negative group (95% CI: 4.01–14.87, $P=0.001$) (Table 4).

Discussion

The findings of this study provide compelling evidence that PTSD in pregnant women during the COVID-19 pandemic is associated with compromised physical growth in their infants. This relationship underscores the critical need for mental health interventions tailored to this vulnerable population, aiming to mitigate the adverse effects of PTSD on both maternal well-being and infant development.

The data suggest that PTSD-positive mothers are more likely to have infants with lower weight percentiles, a

finding that aligns with existing literature on the impact of maternal stress on fetal development and infant neurodevelopment [15–17]. The psychological stressors unique to the pandemic, such as isolation and healthcare uncertainties, may exacerbate PTSD symptoms, thereby influencing the intrauterine environment and early post-natal care practices [18]. Interventions that address these stressors, such as psychosocial support programs and stress management techniques, could be pivotal in reducing PTSD incidence and severity among pregnant women [19].

During the pandemic, pregnant women and mothers of young children were at risk for experiencing worse psychological outcomes. First, they experienced heightened parenting stress. During the pandemic, due to lockdown measures and restrictive policies, parenting activities became increasingly complex and stressful, particularly for mothers who had to work full-time from home. This dual burden could result in parental burnout. Second, they experienced alexithymia, a difficulty in identifying and describing emotions. Mothers with higher levels of alexithymia may experience a decrease in their perceived self-efficacy as parents. Mothers with lower self-efficacy feel more helpless and burned out when confronted with parenting challenges. Additionally, alexithymia also predicts increased parental burnout through reduced psychological resilience. Mothers with lower resilience are more likely to feel overwhelmed by the stresses associated with their parenting responsibilities. Furthermore, alexithymia may diminish individuals' ability to cope adaptively with stressful situations. Especially during the pandemic, when mothers need to juggle work and childcare simultaneously, those with alexithymia are more likely to feel stressed and burned out.

Besides, the literature indicates that after COVID-19 infection, pregnant women face a higher risk of psychological disorders, especially PTSD and depression, which echoes our findings [19]. Studies have pointed out that birth-related traumatization and postpartum depression associated with PTSD may cause difficulties for mothers in feeding and soothing their infants, thereby affecting the infants' feeding and sleeping patterns. This demonstrates the potential impact of mental health issues on maternal behavior and mother-infant interaction. Data

Table 4 Analysis of covariance (ANCOVA) of factors influencing infant weight percentiles at 3 months of age in the two groups

	N	Crude model				Adjusted model ¹				
		Levene's Test of Equality of Error Variances	Adjusted means ²	SE	95%CI	Partial η^2	Levene's Test of Equality of Error Variances	Adjusted means	SE	95%CI
PTSD positive group	72	0.552	50.90	2.47	46.04–55.76	0.045	0.846	53.12	2.50	48.20–58.03
PTSD negative group	350		63.56	1.11	60.38–64.73			62.56	1.11	60.38–64.73

¹Adjusted for birth weight, feeding method, maternal coping strategies, child's gender, mode of delivery, and parity. ² Adjustment for multiple comparisons: Bonferroni

from Peru shows that women who experience general anxiety during pregnancy are more likely to give birth to infants with low birth weight and preterm birth. Particularly, pregnant women with PTSD are more prone to preterm delivery, although there is no direct link between PTSD and low birth weight or gestational duration [8]. These findings highlight how mental health disorders can affect maternal and infant health through different pathways.

A PTSD diagnosis requires exposure to a traumatic event, followed by persistent symptoms such as intrusive memories of the event, avoidance of reminders of the event, alterations in cognition, hyperarousal, or emotional numbing [20]. During the COVID-19 pandemic, pregnant women may have experienced persistent concerns about their own health and the health of their unborn children. For example, worrying about contracting COVID-19 during hospital childbirth or being unable to receive adequate medical support during the pandemic. To avoid infection risks, pregnant women may have experienced isolation from family and friends, leading to feelings of loneliness and anxiety. These emotions may repeatedly surface in their minds, forming intrusive memories. Besides, pregnant women may be overly concerned about their own and their children's health conditions, frequently checking their temperature, breathing, and other symptoms to ensure they have not contracted COVID-19. This continuous health monitoring may lead to hyperarousal and anxiety. More than that, during the pandemic, pregnant women may be highly sensitive to any changes in their surroundings, such as hearing a cough or seeing others wearing masks, which may trigger their alertness and anxiety responses. All of above-mentioned made COVID-19 pandemic a potential source of trauma.

The study's inclusion of coping strategies as a variable provides insight into potential mechanisms through which PTSD affects infant growth. Maternal coping strategies may mediate the relationship between PTSD and infant outcomes, suggesting that enhancing coping skills could be a strategic approach in intervention programs. Additionally, the role of social support cannot be understated, as it has been consistently linked to better mental health outcomes. Public health policies should prioritize the provision of social support networks for pregnant women, including family, community, and professional support [21].

We employ univariate analyses before multivariate analysis as a strategic measure to identify key variables, streamlining the analytical process and enhancing result interpretability. Recognizing the increased risk of Type I errors from multiple univariate tests, we've implemented statistical measures like adjusting significance levels using Bonferroni correction to control the family-wise

error rate. These measures ensure the integrity of our research findings and reflect our commitment to rigorous scientific inquiry, balancing comprehensive screening with error control to enhance the study's credibility.

The limitation should be noted. First, the current study primarily examined infant growth at the 3-month postpartum mark. However, the implications of early growth deficits extend beyond this period [21]. Longitudinal studies are essential to understand the trajectory of growth and development in infants of PTSD-positive mothers [22]. Such research could reveal critical windows of intervention and inform the design of follow-up care to ensure the long-term health and well-being of these children. Second, the study's findings may be subject to selection bias, as the sample may not be fully representative of all pregnant women and their infants. We excluded lost-to-follow-up participants from subsequent data analysis. Although we compared the sociodemographic characteristics of the follow-up and lost-to-follow-up participants and found no statistically significant differences, the potential for selection bias remains. Future research should aim to replicate these findings in diverse populations to ensure generalizability. Third, the reliance on self-reported data introduces potential biases, such as recall bias and social desirability bias. Future studies should consider using objective measures and multiple data sources to enhance the validity and reliability of the findings. Moreover, the study did not account for additional variables such as socioeconomic status, cultural factors, and the quality of prenatal care. Including these variables in future research could provide a more comprehensive understanding of the factors influencing infant growth and development in PTSD-positive mothers.

Conclusion

The findings of this study underscore the significant impact of PTSD on the physical development of infants born to pregnant women during the COVID-19 pandemic. It is imperative to provide robust mental health support for pregnant women, which could include specific policy changes such as increased access to mental health services and the integration of mental health assessments into prenatal care. These measures are essential to foster optimal infant development and to guide public health policies and clinical practices, ensuring that the mental well-being of pregnant women is prioritized to protect the health of the next generation.

Abbreviations

ANCOVA	Analysis of Covariance
CI	Confidence Interval
PCL-C	PTSD Checklist-Civilian version
PTSD	Post-Traumatic Stress Disorder
SD	Standard Deviation
IQR	Interquartile Range

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12887-024-05244-6>.

Supplementary Material 1

Supplementary Material 2

Acknowledgements

We thank all participants in this research.

Author contributions

F.Y. and Q.Z. designed this research, F.Y., X.G., H.L., J.L., Q.S. and J.C. collected the clinical information of all participants, F.Y. drafted this manuscript, Y.C. analyzed the clinical data. X.G., H.L., J.L., Q.S., and Q.Z. revised the whole manuscript. Each author approved this manuscript.

Funding

This work was supported by the grants from Clinical Research Project for the Construction of Research Wards in Beijing (2022-YIXBF-04-01-03), National Key Clinical Specialties Project (2022-zdjk-001), Chinese Academy of Medical Sciences Innovation fund for Medical Sciences (2018-12 M-2-002), Clinical Research Fund of Chinese Academy of Medical Sciences (2021-12 M-C&T-B-089), National High Level Hospital Clinical Research (2022-NHLHCRF-LX-01-0301) funding supported this study.

Data availability

Data used in this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study adheres to the principles of the Declaration of Helsinki, and the study protocol were approved by the ethical review boards of China-Japan Friendship Hospital. Informed consent to participate was obtained from the parents or legal guardians of any participant under the age of 16.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 26 July 2024 / Accepted: 12 November 2024

Published online: 27 November 2024

References

1. The Lancet P. COVID-19 and mental health. *Lancet Psychiatry*. 2021;8(2):87. [https://doi.org/10.1016/s2215-0366\(21\)00005-5](https://doi.org/10.1016/s2215-0366(21)00005-5).
2. Bridle L, Walton L, van der Vord T, Adebayo O, Hall S, Finlayson E, Easter A, Silverio SA. Supporting Perinatal Mental Health and Wellbeing during COVID-19. *Int J Environ Res Public Health* 2022, 19(3) <https://doi.org/10.3390/ijerph19031777>
3. Mayopoulos GA, Ein-Dor T, Li KG, Chan SJ, Dekel S. COVID-19 positivity associated with traumatic stress response to childbirth and no visitors and infant separation in the hospital. *Sci Rep* 2021, 11(1):13535 <https://doi.org/10.1038/s41598-021-92985-4>
4. Maercker A, Cloitre M, Bachem R, Schlumpf YR, Khoury B, Hitchcock C, Bohus M. Complex post-traumatic stress disorder. *Lancet*. 2022;400(10345):60–72. [https://doi.org/10.1016/s0140-6736\(22\)00821-2](https://doi.org/10.1016/s0140-6736(22)00821-2).
5. Sato K, Fukai T, Fujisawa KK, Nakamuro M. Association between the COVID-19 pandemic and early Childhood Development. *JAMA Pediatr*. 2023;177(9):930–8. <https://doi.org/10.1001/jamapediatrics.2023.2096>.
6. Nordahl D, Rognmo K, Bohne A, Landsem IP, Moe V, Wang CEA, Høifødt RS. Adult attachment style and maternal-infant bonding: the indirect path of parenting stress. *BMC Psychol*. 2020;8(1):58. <https://doi.org/10.1186/s40359-020-00424-2>.
7. Pazzagli C, Buratta L, Coletti E, Mazzeschi C. Mother-to-infant bonding mediates the effects of depressive and anxious postpartum symptoms on parenting stress. *J Psychosom Obstet Gynaecol*. 2023;44(1):2264487. <https://doi.org/10.1080/0167482x.2023.2264487>.
8. O'Dea GA, Youssef GJ, Hagg LJ, Francis LM, Spry EA, Rossen L, Smith I, Teague SJ, Mansour K, Booth A, et al. Associations between maternal psychological distress and mother-infant bonding: a systematic review and meta-analysis. *Arch Womens Ment Health*. 2023;26(4):441–52. <https://doi.org/10.1007/s00737-023-01332-1>.
9. Brooks SK, Webster RK, Smith LE, Woodland L, Wessely S, Greenberg N, Rubin GJ. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *Lancet* 2020, 395(10227):912–20 [https://doi.org/10.1016/s0140-6736\(20\)30460-8](https://doi.org/10.1016/s0140-6736(20)30460-8)
10. Elshafeey F, Magdi R, Hindi N, Elshebiny M, Farrag N, Mahdy S, Sabbour M, Gebriel S, Nasser M, Kamel M, et al. A systematic scoping review of COVID-19 during pregnancy and childbirth. *Int J Gynaecol Obstet*. 2020;150(1):47–52. <https://doi.org/10.1002/ijgo.13182>.
11. Heneka MT, Golenbock D, Latz E, Morgan D, Brown R. Immediate and long-term consequences of COVID-19 infections for the development of neurological disease. *Alzheimers Res Ther* 2020, 12(1):69 <https://doi.org/10.1186/s13195-020-00640-3>
12. Rogers JP, Chesney E, Oliver D, Pollak TA, McGuire P, Fusar-Poli P, Zandi MS, Lewis G, David AS. Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: a systematic review and meta-analysis with comparison to the COVID-19 pandemic. *Lancet Psychiatry*. 2020;7(7):611–27. [https://doi.org/10.1016/s2215-0366\(20\)30203-0](https://doi.org/10.1016/s2215-0366(20)30203-0).
13. Weathers FW, Bovin MJ, Lee DJ, Sloan DM, Schnurr PP, Kaloupek DG, Keane TM, Marx BP. The clinician-administered PTSD scale for DSM-5 (CAPS-5): development and initial psychometric evaluation in military veterans. *Psychol Assess*. 2018;30(3):383–95. <https://doi.org/10.1037/pas0000486>.
14. Shi L, Wang L, Jia X, Li Z, Mu H, Liu X, Peng B, Li A, Fan L. Prevalence and correlates of symptoms of post-traumatic stress disorder among Chinese healthcare workers exposed to physical violence: a cross-sectional study. *BMJ Open*. 2017;7(7):e016810. <https://doi.org/10.1136/bmjopen-2017-016810>.
15. Oyetunji A, Chandra P. Postpartum stress and infant outcome: a review of current literature. *Psychiatry Res*. 2020;284:112769. <https://doi.org/10.1016/j.psychres.2020.112769>.
16. Wang Y, Chen L, Wu T, Shi H, Li Q, Jiang H, Zheng D, Wang X, Wei Y, Zhao Y, et al. Impact of Covid-19 in pregnancy on mother's psychological status and infant's neurobehavioral development: a longitudinal cohort study in China. *BMC Med*. 2020;18(1):347. <https://doi.org/10.1186/s12916-020-01825-1>.
17. Serrano-Castro PJ, Estivill-Torrús G, Cabezudo-García P, Reyes-Bueno JA, Ciano Petersen N, Aguilar-Castillo MJ, Suárez-Pérez J, Jiménez-Hernández MD, Moya-Molina M, Oliver-Martos B et al. Impact of SARS-CoV-2 infection on neurodegenerative and neuropsychiatric diseases: a delayed pandemic? *Neurologia (Engl Ed)* 2020, 35(4):245–51 <https://doi.org/10.1016/j.nrl.2020.04.002>
18. Xie L, Li J. Association of Perinatal Depressive Symptoms with breastfeeding. *Alpha Psychiatry*. 2024;25(2):277–81. <https://doi.org/10.5152/alphapsychiatry.2024.231308>.
19. Penna AL, de Aquino CM, Pinheiro MSN, do Nascimento RLF, Farias-Antúnez S, Araújo D, Mita C, Machado MMT, Castro MC. Impact of the COVID-19 pandemic on maternal mental health, early childhood development, and parental practices: a global scoping review. *BMC Public Health*. 2023;23(1):388. <https://doi.org/10.1186/s12889-023-15003-4>.
20. Badenes-Ribera L, Molla-Esparza C, Longobardi C, Sánchez-Meca J, Fabris MA. Homicide as a source of posttraumatic stress? A Meta-analysis of the prevalence of posttraumatic stress disorder after committing Homicide. *J Trauma Stress*. 2021;34(2):345–56. <https://doi.org/10.1002/jts.22630>.
21. Pollock A, Campbell P, Cheyne J, Cowie J, Davis B, McCallum J, McGill K, Elders A, Hagen S, McClurg D, et al. Interventions to support the resilience and mental health of frontline health and social care professionals during and after a disease outbreak, epidemic or pandemic: a mixed methods systematic review. *Cochrane Database Syst Rev*. 2020;11(1):Cd013779. <https://doi.org/10.1002/14651858.Cd013779>.

22. Clark EC, Neumann S, Hopkins S, Kostopoulos A, Hagerman L, Dobbins M. Changes to Public Health Surveillance Methods due to the COVID-19 pandemic: scoping review. *JMIR Public Health Surveill.* 2024;10:e49185. <https://doi.org/10.2196/49185>.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.