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The association between maternal cortisol levels and anxiety during labour with neonatal outcome: a cross-sectional study

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ABSTRACT

Objective. This study aims to investigate the association of maternal cortisol levels and anxiety during labour with neonatal outcome in primigravida women.

Materials and Methods. A total of 147 pairs of primigravida with their neonates included in the study. The study was conducted from January to May 2023 using cross-sectional design. Labour anxiety was assessed using the Labor Anxiety Questionnaire Kwestionariusz Lęku Porodowego-II (KLP-II). The maternal cortisol was measured using the ELISA at active phase of labour. Data were analysed using the Chi-Square test and Mann-Whitney test.

Results. The mean age and birth weight of 24.52 ± 4.21 years and 2,992 ± 377.68 gr, respectively. The median serum cortisol concentration was 58.35 ng/ml with an interquartile range of 22.19-70.98 ng/ml. There was no association between maternal cortisol levels and anxiety during labour with neonatal outcome (anthropometry and APGAR score) ($p > 0.05$). Labour duration also was not influenced by cortisol levels and anxiety during labour, instead of by birthweight ($p < 0.05$).

Conclusions. Both maternal cortisol levels and anxiety during primigravida labour was not associated with neonatal outcome. Further research is needed with a larger sample size to confirm whether acute stress anxiety can influence the neonatal outcome.

INTRODUCTION

Childbirth is a stressful event that can trigger anxiety, fear of birth and even tokophobia [1-3]. Some of the suggested reasons contributing to this phenomenon include a lack of trust in the attending obstetrical staff during delivery, incapability of giving birth, fear of suffering injury, fear of the death of themselves or their infant, and intolerance of physical pain [4]. Anxiety and fear of childbirth are more common in primigravida who have never experienced childbirth before and lack of knowledge [5, 6]. These issues pose a significant problem for women as they can lead to mothers avoiding pregnancy, causing harm for both the mother and the foetus, and increasing the demand for caesarean sections [7]. Reck *et al.* found that fear of giving birth was the strongest predictor of labour duration

[8], and in general it increases the risk of dystocia in pregnant women [2].
Anxiety and fear of birth are associated with an increase in cortisol level [9,10]. Maternal cortisol levels are controlled by the hypothalamic-pituitary-adrenal (HPA) axis. When the body perceives physical or psychological stress, it triggers a stress response that activates the HPA axis. This activation process begins with the release of corticotropin-releasing hormone (CRH) from the hypothalamus, which then stimulates the pituitary gland to release adrenocorticotropic hormone (ACTH). Ultimately, this leads to the adrenal cortex releasing cortisol [11]. Previous studies have shown that cortisol affect neonatal outcomes including gestational age, birth weight, and neonatal outcomes [10, 12-18]. Understanding the relationship between maternal anxiety and neonatal outcomes is essential for healthcare providers to provide comprehensive care during pregnancy. By recognizing the impact of maternal anxiety, healthcare professionals can implement interventions to support expectant mothers and mitigate any potential negative consequences on the newborn. Even though relationships between maternal anxiety and cortisol level have been found, most of the study was measured the cortisol level in pregnancy not in the labour. Therefore, this study was conducted to analyse association of maternal anxiety and cortisol levels during primigravida labour with neonatal outcome.

MATERIALS AND METHODS

This cross-sectional was conducted at Khadijah Mother and Child Hospital in Makassar, Indonesia, in January-May 2023. The study was approved by Hasanuddin University Clinical Research Ethics Committee with the protocol number 813/UN4.6.4.5.31/PP36/2022 and informed consent was obtained from all participants.
Data related to subject characteristics of respondents and study were collected using a questionnaire through direct interviews. Data was taken from pregnant woman during the first stage of labour at a cervical dilatation of 4-6 cm. The inclusion criteria were singleton pregnancy, vaginal birth, gestational age between 37 and 42 weeks, not taking medications that interfere with cortisol levels, and no chronic diseases or hormonal disorders such as Cushing Syndrome, Cushing disease, and Addison's disease. Exclusion criteria were foetal with congenital anomalies, malpresentation, or premature rupture of membranes.
Labour anxiety was assessed using the Labor Anxiety Questionnaire Kwestionariusz Lęku Porodowego-II (KLP-II), consisting of 9 Likert scale questions with point values ranging from 0 to 3. Scores could vary from 0 to 27 points, with different ranges indicating varying levels of anxiety. Cortisol levels were measured via the ELISA method at the Clinical Pathology Laboratory of Hasanuddin University Hospital, with samples collected in EDTA tubes.
Statistical analysis was performed using SPSS 24.0 for Windows software, with KLP-II scores and cortisol levels presented as mean ± standard deviation. Baseline characteristics were reported as frequencies and percentages. Differences in KLP-II scores and cortisol levels among groups were analysed using the Mann-Whitney U test for non-normally distributed data, while differences in baseline characteristics were assessed using the chi-square test. Statistical significance was set at a P-value of < 0.05.

RESULTS

A total of 147 primigravida women and their neonates were included in the study, with a mean age and a mean birth weight of 24.52 ± 4.21 years and 2,992 ± 377.68 gr, respectively. Cortisol was not associated with KLP-II score ($r = 0.03$, P-value = 0.715) (**Figure 1**). The median serum cortisol concentration was 58.35 nmol/L with an interquartile range of 22.19-70.98 ng/ml (**Figure 2**). The cortisol concentration did not differ between low birth weight (< 2,500 gr) (57.62 ± 5.02 nmol/L) and normal birth weight (≥ 2,500 gr) (56.80 ± 9.18 nmol/L) ($p = 0.925$).

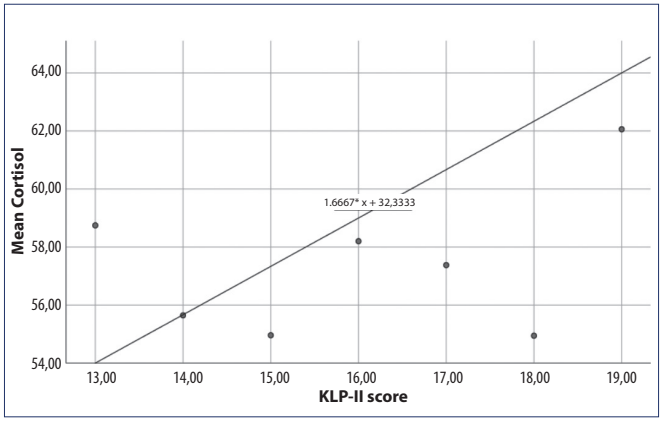

Figure 1. *Correlation KLP-II score and mean of cortisol level.*

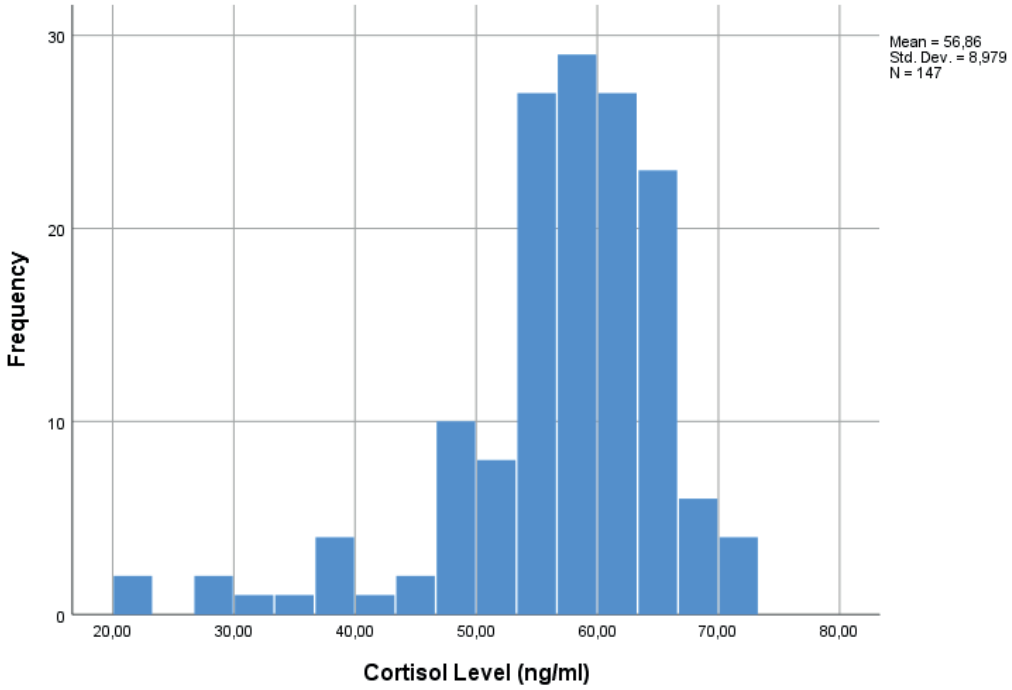

Figure 2. *Distribution of maternal serum cortisol concentration that were obtained at active phase.*

Based on the median serum concentration, patients were categorized into low (< 58.35 ng/ml) or high (≥ 58.35 ng/ml) cortisol groups. Maternal and perinatal characteristics not associated with maternal cortisol level (**Table 1**). Neonatal outcomes and duration of labour are also not associated with cortisol levels. In addition, anxiety (KLP score) is not associated with neonatal outcomes or the duration of labour (**Table 2**).

Duration of labour (Stage 1 and Stage 2) only influenced by birth weight ($p = 0.01$ and $p = 0.045$, respectively). Birth weight was influenced by birth length ($p < 0.001$), and APGAR at 1 minute was influenced by the frequency of antenatal care ($p = 0.041$).

DISCUSSION

This study provided the first insights about association of maternal cortisol levels and anxiety during labour with neonatal outcome. Anxiety during labour can have significant implications for both the mother and the newborn. Maternal anxiety can impact the health and well-being of the foetus and subsequently the newborn. Maternal anxiety is a complex issue that can lead to adverse effects on pregnancy and childbirth. It is crucial to address maternal anxiety not only for the mother's mental health but also for the optimal development and health of the newborn [19].

Based on median of cortisol, there is no significant demographic differences in low and high cortisol, so the potential impact of confounding factors was reduced [20, 21]. Gestational age and gravidity were controlled on inclusion sampling. In the study, there was no association between anxiety and neonatal anthropometry both birth weight and birth length as found in the study of Gregor *et al*. [22]. The meta-analysis study showed that chronic stress is associated with a statistically significant risk of low birth weight (OR = 1.50, 95%CI 1.13-1.99, $p \leq 0.02$) which was supported by five of nine studies. However, this meta-analysis did not exclusively assess anxiety in pregnant women, but used several questionnaires that also assessed levels of depression and stress [23]. Previous study also found that higher scores on the Perceived Stress Survey (PSS) throughout pregnancy were not associated with alterations in neonatal anthropometry including birth weight, length, head and abdominal circumferences, even after accounting for important confounders [24]. Large data cohort studies showed no association was found for maternal prenatal anxiety with birth weight after multiple covariates and family environment were controlled. However, there was an association between prenatal maternal anxiety at 30th week only with gestational age, suggesting a timing effect for maternal anxiety in the third trimester [25].

Table 1. *Maternal and neonatal characteristics and their association with maternal cortisol levels.*

Perinatal characteristics	Categories	Serum cortisol concentration < 58.35 ng/ml (n = 73)	Serum cortisol concentration ≥ 58.35 ng/ml (n = 74)	P-value
Maternal Age	Continuous (Mean ± SD)	25 ± 5	24.5 ± 5	0.793
Maternal Age	< 20 years	10 (6.8)	11 (7.5)	1
	20-35 years	63 (42.9)	63 (42.9)	
Employment status	Not employed	72 (49)	74 (50.3)	0.497
	Employed	1 (0.7)	0 (0)	
Education	Junior High School	3 (2)	7 (4.8)	0.368
	Senior High School	64 (43.5)	63 (42.9)	
	Diploma	6 (4.1)	4 (2.7)	
Income	< Minimum wage	71 (48.3)	74 (50.3)	0.245
	≥ Minimum wage	2 (1.4)	0 (0)	
ANC Frequencies	< 4	16 (10.9)	20 (13.6)	0,761
	4-7	49 (33.3)	47 (32)	
	> 8	8 (5.4)	7 (4.8)	
Anxiety	Normal	11 (7.5)	9 (6.1)	0.827
	Elevated	28 (19)	28 (19)	
	High	21 (14.3)	26 (17.7)	
	Very high	13 (8.8)	11 (7.5)	
KLP Score	Continuous (Median ± IQR)	15 ± 3	15.5 ± 3	0.796
Gender	Male	33 (22.4)	39 (26.5)	0.457
	Female	40 (27.2)	35 (23.8)	
First phase duration	Continuous (Median, Min-max), hours	8 (2-15)	8 (3-14)	0.846
Second phase duration	Continuous (Median, Min-max), minute	15 (10-120)	15 (10-35)	0.99
Neonates Birth Weight	Continuous (Median, Min-max), gr	2,950 (1,750-3,950)	3,000 (2,300-4,200)	0.473
Neonates Birth length	Continuous (Median, Min-max), cm	48 (42-51)	48 (44-52)	0.115
1st minute APGAR	Continuous (Median, Min-max)	8 (4-8)	8 (6-8)	0.543
5th minute APGAR	Continuous (Median, Min-max)	10 (6-10)	10 (7-10)	0.948

Table 2. *Neonatal characteristics and their association with maternal anxiety.*

Perinatal characteristics	Categories	Normal-increased anxiety (n = 76)	High and Very high Anxiety (n = 71)	P-value
Gender	Male	37 (25.2)	35 (23.8)	1
	Female	39 (26.5)	36 (24.5)	
First phase duration	Continous (Median ± IQR), hours	8 (2-15)	8 (2-14)	0.413
Second phase duration	Continous (Median ± IQR), minute	15 (10-90)	15 (10-120)	0.558
Neonates Birth Weight	Continous (Median ± IQR), gr	2,950 (1,750-4,100)	3,000 (2,250 -4,200)	0.726
Neonates Birth length	Continous (Median ± IQR), cm	48 (42-52)	48 (43-52)	0.645
1st minute APGAR	Continous (Median ± IQR)	8 (4-8)	8 (4-8)	0.486
5th minute APGAR	Continous (Median ± IQR)	10 (6-10)	10 (6-10)	0.484

Various theories exist regarding the impact of maternal anxiety on foetal growth. One proposed mechanism involves alterations in maternal hypothalamic-pituitary-adrenal (HPA) axis activity. Specifically, it is postulated that maternal anxiety during pregnancy may elevate the production of stress hormones like cortisol and catecholamines. Research using animal models has demonstrated that these stress hormones can affect uterine blood flow and immune system functioning, potentially

leading to a higher likelihood of shortened gestational periods and reduced foetal growth [26, 27]. Another possible explanation for this association could be the increased susceptibility to infections resulting from stress. Studies have indicated that heightened stress levels may compromise immune function, thereby raising the risk of infections during pregnancy that could contribute to shortened gestation [25].

Cortisol, which is considered a stress hormone, also did not affect neonatal anthropometry. Previous research has conflicting views on the impact of cortisol on foetal weight. Some studies suggest that high levels of cortisol in pregnant women may increase the risk of low birth weight in newborns [15, 28-35], while other studies have reported contradictory findings [36-38]. During pregnancy, a woman's baseline cortisol secretion increases significantly, up to four times higher than non-pregnancy levels, with the peak levels typically observed in the third trimester in anticipation of childbirth [39]. This natural elevation in cortisol is essential to support foetal growth and development, yet external stressors, both physiological and psychological, can lead to abrupt short-term fluctuations in cortisol levels [40]. While in the uterus, the placental enzyme 11β-hydroxysteroid dehydrogenase type 2 (11β-HSD2) keeps the foetus blocked from maternal cortisol by converting it into an inactive form. Despite this protective mechanism, a small fraction of maternal cortisol is able to cross the placental barrier and reach the foetus, which has been associated with adverse effects on foetal development such as reduced birth weight and shortened gestation period due to compromised blood flow essential for oxygen and nutrient delivery [38]. The lack of association between anxiety, cortisol levels, and neonatal anthropometry observed in this study could be attributed to the acute nature of anxiety experienced during delivery. It is suggested that chronic anxiety and prolonged exposure to cortisol are necessary to impact neonatal outcomes.

Duration of labour (stage 1 and stage 2) was not influenced by anxiety and maternal cortisol in this study. Studies in pregnant women < 20 weeks showed no relationship between anxiety and the prolongation of the stage 1 [41]. While another study involving women at less than 20 weeks and 34 weeks of gestation did not find a significant correlation between anxiety and labour duration [42]. A study by Adams *et al*. involving 2,206 pregnant women at 32 weeks of gestation reported that women experiencing fear of childbirth had a longer duration of labour compared to those without such fears [43]. Studies in women with COVID-19 infection who are known to be at risk for anxiety also showed no difference in the duration of delivery [44-46].

Various techniques have been developed to alleviate stress during childbirth, such as the Lamaze relaxation method, hydrotherapy, emotional support, and the inclusion of family members or partners in the delivery process [47]. WHO recommends that pregnant women should be accompanied by someone they trust and feel safe with, such as friends, spouses, midwives, or family [48]. A study involving 114 pregnant women indicated that having family members (such as mothers, sisters, friends, or husbands) present and providing support during labour can help in managing pain, instill a sense of security, and enhance satisfaction among pregnant women. This support system may also mitigate the challenges of childbirth, improve both mental and physical well-being, and boost maternal contentment with the birthing experience [49].

This study shows the importance of appropriate timing of cortisol sampling to predict maternal and neonatal outcomes. Anxiety is associated with elevated cortisol but it seems that cortisol is not an acute marker because of the blunted cortisol response in pregnant women. In addition, suppression of HPA-axis reactivity during pregnancy makes non-severe stressors not evoke cortisol so in educating a doctor can explain how the long-term impact of cortisol is [50].

Limitations

The variation observed may be due to disparities in gestational age, the types of questionnaires utilized, and the methodologies employed for sampling. This investigation focused on evaluating anxiety levels during the active phase of labour, where labour pain can increase patient anxiety. Furthermore, the subjective nature of anxiety poses challenges in its precise measurement and may be subject to cultural influences, thereby limiting generalizability across diverse regions. Consequently, it is imperative to approach this issue from an alternative standpoint. Moreover, relying solely on clinical studies to examine the relationship between anxiety, and duration of labour may prove inadequate, as such studies predominantly rely on interviews with expectant mothers, which are susceptible to various

biases including recall bias, selection bias, non-conformist bias, and active co-operator bias. Additionally, the circadian rhythm can impact blood cortisol levels, serving as a potential confounding variable.

CONCLUSIONS

The correlation between maternal anxiety and neonatal outcomes underscores the need for a holistic approach to maternal healthcare during pregnancy. But in study, maternal anxiety and cortisol levels during primigravida labour was not associated with neonatal outcome and labour duration. Maternal cortisol level and anxiety was not a reliable indicator that was predictive of adverse neonatal outcomes.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' contribution
E.C.J.: Conceptualization, data curation, investigation, formal analysis, validation, visualization. M.G.H., M.S.: Formal analysis, validation, visualization.

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Study registration
N/A.

Disclosure of interests
The authors declare that they have no conflict of interests.

Ethical approval
This study was approved by the Ethics Committee of Hasanuddin University of Medical Sciences (No. 813/UN4.6.4.5.31/PP36/2022).

Informed consent
Informed consent was obtained from all participants.

Data sharing
The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Abdollahi S, Faramarzi M, Delavar MA, Bakouei F, Chehrazi M, Gholinia H. Effect of Psychotherapy on Reduction of Fear of Childbirth and Pregnancy Stress: A Randomized Controlled Trial. Front Psychol. 2020;11:787. doi: 10.3389/fpsyg.2020.00787.
2. Hishikawa K, Kusaka T, Fukuda T, Kohata Y, Inoue H. Anxiety or nervousness disturbs the progress of birth based on human behavioral evolutionary biology. J Perinat Educ. 2019;28(4):218-23. doi: 10.1891/1058-1243.28.4.218.
3. Hofberg K, Ward M. Tokophobia Tokophobia: A Profound Dread and Avoidance of Childbirth (When Pathological Fear Effects the Consultation). In: Cockburn J, Pawson ME, editors. Psychological Challenges in Obstetrics and Gynecology. London: Springer London; 2007 [cited 2024 Feb 19]. p. 165-72. doi: 10.1007/978–1–84628–808–1_16.
4. Sjögren B. Reasons for anxiety about childbirth in 100 pregnant women. J Psychosom Obstet Gynecol. 1997;18(4):266-72. doi: 10.3109/01674829709080698.
5. Hassanzadeh R, Abbas-Alizadeh F, Meedya S, Mohammad-Alizadeh–Charandabi S, Mirghafourvand M. Fear of childbirth, anxiety and depression in three groups of primiparous pregnant women not attending, irregularly attending and regularly attending childbirth preparation classes. BMC Women's Health. 2020;20(180). doi: 10.1186/s12905-020-01048-9.
6. Hendrix YMGA, Baas MAM, Vanhommerig JW, de Jongh A, Van Pampus MG. Fear of Childbirth in Nulliparous Women. Front Psychol. 2022;13:923819. doi: 10.3389/fpsyg.2022.923819.
7. Aksoy M, Aksoy AN, Dostbil A, Celik MG, Ince I. The Relationship between Fear of Childbirth and Women's Knowledge about Painless Childbirth. Obstet Gynecol Int. 2014;2014:1–7. doi: 10.1155/2014/274303.
8. Reck C, Zimmer K, Dubber S, Zipser B, Schlehe B, Gawlik S. The influence of general anxiety and childbirth–specific anxiety on birth outcome. Arch Womens Ment Health. 2013;16(5):363–9. doi: 10.1007/s00737–013–0344–0.
9. Kane HS, Dunkel Schetter C, Glynn LM, Hobel CJ, Sandman CA. Pregnancy anxiety and prenatal cortisol trajectories. Biol Psychol. 2014;100:13–9. doi: 10.1016/j.biopsycho.2014.04.003.

10. Fan F, Zou Y, Zhang Y, Ma X, Zhang J, Liu C, et al. The relationship between maternal anxiety and cortisol during pregnancy and birth weight of chinese neonates. BMC Pregnancy Childbirth. 2018;18(1):265. doi: 10.1186/s12884–018–1798–x.
11. Field T, Diego M. Cortisol: the culprit prenatal stress variable. Int J Neurosci. 2008;118(8):1181. doi: 10.1080/00207450701820944.
12. Shriyan P, Sudhir P, van Schayck OCP, Babu GR. Association of high cortisol levels in pregnancy and altered fetal growth. Results from the MAAS-THI, a prospective cohort study, Bengaluru. Lancet Reg Health Southeast Asia. 2023;14:100196. doi: 10.1016/j.lansea.2023.100196.
13. Zijlmans MA, Riksen-Walraven JM, de Weerth C. Associations between maternal prenatal cortisol concentrations and child outcomes: A systematic review. Neurosci Biobehav Rev. 2015;53:1-24. doi: 10.1016/j.neubiorev.2015.02.015.
14. van den Heuvel MI, van Assen MALM, Glover V, Claes S, Van den Bergh BRH. Associations between maternal psychological distress and salivary cortisol during pregnancy: A mixed-models approach. Psychoneuroendocrinology. 2018;96:52-60. doi: 10.1016/j.psyneuen.2018.06.005.
15. Bolten MI, Wurmser H, Buske-Kirschbaum A, Papoušek M, Pirke KM, Hellhammer D. Cortisol levels in pregnancy as a psychobiological predictor for birth weight. Arch Womens Ment Health. 2011;14(1):33-41. doi: 10.1007/s00737-010-0183-1.
16. Nath A, Murthy GVS, Babu GR, Di Renzo GC. Effect of prenatal exposure to maternal cortisol and psychological distress on infant development in Bengaluru, southern India: a prospective cohort study. BMC Psychiatry. 2017;17(1):255. doi: 10.1186/s12888-017-1424-x.
17. Field T, Hernandez-Reif M, Diego M, Figueiredo B, Schanberg S, Kuhn C. Prenatal cortisol, prematurity and low birthweight. Infant Behav Dev. 2006;29(2):268-75. doi: 10.1016/j.infbeh.2005.12.010.
18. Cherak SJ, Giesbrecht GF, Metcalfe A, Ronksley PE, Malebranche ME. The effect of gestational period on the association between maternal prenatal salivary cortisol and birth weight: A systematic review and meta-analysis. Psychoneuroendocrinology. 2018;94:49-62. doi: 10.1016/j.psyneuen.2018.04.023.
19. Azizi S. Correlation of maternal anxiety and some of neonatal outcomes. Int J Pregnancy Child Birth. 2018;4(4). doi: 10.15406/ipcb.2018.04.00107.
20. Manyeh AK, Kukula V, Odonkor G, Ekey RA, Adjei A, Narh–Bana S, et al. Socioeconomic and demographic determinants of birth weight in southern rural Ghana: evidence from Dodowa Health and Demographic Surveillance System. BMC Pregnancy Childbirth. 2016;16(1):160. doi: 10.1186/s12884–016–0956–2.
21. Jeena PM, Asharam K, Mitku AA, Naidoo P, Naidoo RN. Maternal demographic and antenatal factors, low birth weight and preterm birth: findings from the mother and child in the environment (MACE) birth cohort, Durban, South Africa. BMC Pregnancy Childbirth. 2020;20(1):628. doi: 10.1186/s12884–020–03328–6.
22. Gregor K, Banaś E, Malec M, Ilska M, Jagielska A, Rak K, et al. Labor anxiety – risk factors and impact on the course of labor, puerperium and neonatal condition. GinPolMedProject. 2019;1(51):009-013.
23. Matsas A, Panopoulou P, Antoniou N, Bargiota A, Gryparis A, Vrachnis N, et al. Chronic Stress in Pregnancy Is Associated with Low Birth Weight: A Meta–Analysis. J Clin Med. 2023;12(24):7686. doi: 10.3390/jcm12247686.
24. Wing DA, Ortega–Villa AM, Grobman WA, Hediger ML, Grewal J, Pugh SJ, et al. Maternal stress and neonatal anthropometry: the NICHD Fetal Growth Studies. Am J Obstet Gynecol. 2017;217(1):82.e1–82.e7. doi: 10.1016/j.ajog.2017.02.039.
25. Bekkhus M, Lee Y, Brandlistuen RE, Samuelsen SO, Magnus P. Maternal Anxiety and Infants Birthweight and Length of Gestation. A sibling design. BMC Psychiatry. 2021;21(1):609. doi: 10.1186/s12888–021–03620–5.
26. Coussons–Read ME, Lobel M, Carey JC, Kreither MO, D'Anna K, Argys L, et al. The occurrence of preterm delivery is linked to pregnancy–specific distress and elevated inflammatory markers across gestation. Brain Behav Immun. 2012;26(4):650–9. doi: 10.1016/j.bbi.2012.02.009.
27. Dunkel Schetter C, Tanner L. Anxiety, depression and stress in pregnancy: implications for mothers, children, research, and practice. Curr Opin Psychiatry. 2012;25(2):141–8. doi: 10.1097/YCO.0b013e3283503680.
28. Spicer J, Werner E, Zhao Y, Choi CW, Lopez–Pintado S, Feng T, et al. Ambulatory assessments of psychological and peripheral stress–markers predict birth outcomes in teen pregnancy. J Psychosom Res. 2013;75(4):305–13. doi: 10.1016/j.jpsychores.2013.07.001.

29. Kivlighan KT, DiPietro JA, Costigan KA, Laudenslager ML. Diurnal rhythm of cortisol during late pregnancy: Associations with maternal psychological well–being and fetal growth. Psychoneuroendocrinology. 2008;33(9):1225–35. doi: 10.1016/j.psyneuen.2008.06.008.
30. Hompes T, Vrieze E, Fieuws S, Simons A, Jaspers L, Van Bussel J, et al. The influence of maternal cortisol and emotional state during pregnancy on fetal intrauterine growth. Pediatr Res. 2012 Sep;72(3):305–15. doi: 10.1038/pr.2012.70.
31. Guardino CM, Schetter CD, Saxbe DE, Adam EK, Ramey SL, Shalowitz MU, et al. Diurnal salivary cortisol patterns prior to pregnancy predict infant birth weight. Health Psychol. 2016;35(6):625–33. doi: 10.1037/hea0000313.
32. Gilles M, Otto H, Wolf IAC, Scharnholz B, Peus V, Schredl M, et al. Maternal hypothalamus–pituitary–adrenal (HPA) system activity and stress during pregnancy: Effects on gestational age and infant's anthropometric measures at birth. Psychoneuroendocrinology. 2018;94:152–61. doi: 10.1016/j.psyneuen.2018.04.022.
33. Giesbrecht GF, Campbell T, Letourneau N. Sexually dimorphic adaptations in basal maternal stress physiology during pregnancy and implications for fetal development. Psychoneuroendocrinology. 2015;56:168–78. doi: 10.1016/j.psyneuen.2015.03.013.
34. D'Anna–Hernandez KL, Hoffman MC, Zerbe GO, Coussons–Read M, Ross RG, Laudenslager ML. Acculturation, Maternal Cortisol, and Birth Outcomes in Women of Mexican Descent. Psychosom Med. 2012;74(3):296–304. doi: 10.1097/PSY.0b013e318244fbde.
35. Braithwaite EC, Hill J, Pickles A, Glover V, O'Donnell K, Sharp H. Associations between maternal prenatal cortisol and fetal growth are specific to infant sex: findings from the Wirral Child Health and Development Study. J Dev Orig Health Dis. 2018;9(4):425–31. doi: 10.1017/S2040174418000181.
36. Bublitz MH, Vergara–Lopez C, O'Reilly Treter M, Stroud LR. Association of Lower Socioeconomic Position in Pregnancy with Lower Diurnal Cortisol Production and Lower Birthweight in Male Infants. Clin Ther. 2016;38(2):265–74. doi: 10.1016/j.clinthera.2015.12.007.
37. Bublitz MH, Bourjeily G, D'Angelo C, Stroud LR. Maternal Sleep Quality and Diurnal Cortisol Regulation Over Pregnancy. Behav Sleep Med. 2018;16(3):282–93. doi: 10.1080/15402002.2016.1210147.
38. Peterson A, Toledo-Corral CM, Chavez T, Naya C, Johnson M, Eckel S, et al. Prenatal Maternal Cortisol Levels and Infant Birth Weight in a Predominately Low-Income Hispanic Cohort. Int J Environ Res Public Health. 2020;17(18):6896. doi: 10.3390/ijerph17186896.
39. Jung C, Ho JT, Torpy DJ, Rogers A, Doogue M, Lewis JG, et al. A Longitudinal Study of Plasma and Urinary Cortisol in Pregnancy and Postpartum. J Clin Endocrinol Metab. 2011;96(5):1533-40. doi: 10.1210/jc.2010-2395.
40. Johnson ML, Virostko A, Veldhuis JD, Evans WS. Deconvolution Analysis as a Hormone Pulse-Detection Algorithm. In: Methods in Enzymology [Internet]. Elsevier; 2004 [cited 2024 Apr 2]. p. 40–54. doi: 10.1016/S0076-6879(04)84004-7.
41. Slade P, Sheen K, Weeks A, Wray S, De Pascalis L, Lunt K, et al. Do stress and anxiety in early pregnancy affect the progress of labor: Evidence from the Wirral Child Health and Development Study. Acta Obstet Gynecol Scand. 2021;100(7):1288-96. doi: 10.1111/aogs.14063.
42. Sanni K-R, Eeva E, Noora SM, Laura KS, Linnea K, Hasse K. The influence of maternal psychological distress on the mode of birth and duration of labor: findings from the FinnBrain Birth Cohort Study. Arch Womens Ment Health. 2022;25(2):463-72. doi: 10.1007/s00737-022-01212-0.
43. Adams S, Eberhard-Gran M, Eskild A. Fear of childbirth and duration of labour: a study of 2206 women with intended vaginal delivery. BJOG Int J Obstet Gynaecol. 2012;119(10):1238-46. doi: 10.1111/j.1471-0528.2012.03433.x.
44. Libretti A, Troìa L, Cappello AM, Casarotti C, D'Amato AT, Dallarda G, et al. Pregnancy and neonatal outcomes of SARS-CoV-2 infection discovered at the time of delivery: a tertiary center experience in North Italy. J Perinat Med. 2024;52(2):215-21. doi: 10.1515/jpm-2023-0280.
45. Yazdi Moghaddam H, Karimi FZ, Jesmani E, Abdollahi M. Relationship between fear of COVID-19 and mental health in pregnant women. Ital J Gynaecol Obstet. 2024;36(2):151-8. doi: 10.36129/jog.2023.119.
46. Fernández-Alonso AM, Mayoral-César V, Díaz-Goicoechea M, Díaz-Goicoechea M, Vicente-García G, Rodríguez-Castillo C, et al. Expectations of childbirth and anxiety in at term pregnant women during the SARS-CoV-2 pandemic

in Spain: A pilot study. Ital J Gynaecol Obstet. 2023;35(4):503-10. doi: 10.36129/jog.2023.94.
47. Hodnett ED, Gates S, Hofmeyr GJ, Sakala C. Continuous support for women during childbirth. Cochrane Database Syst Rev. 2013;2013(7):CD003766. doi: 10.1002/14651858.CD003766.pub5.
48. Chaote P, Mwakatundu N, Dominico S, Mputa A, Mbanza A, Metta M, et al. Birth companionship in a government health system: a pilot study in Kigoma, Tanzania. BMC Pregnancy Childbirth. 2021;21(1):1-17. doi: 10.1186/s12884-021-03746-0.
49. Chunuan S, Somsap Y, Pinjaroen S, Thitimapong S, Nangham S, Ongpalanupat F. Effect of the Presence of Family Members, During the First Stage of Labor, on Childbirth Outcomes in a Provincial Hospital in Songkhla Province, Thailand. Pacific Rim Int J Nurs Res. 2009;13:16-27.
50. Evans LM, Myers MM, Monk C. Pregnant women's cortisol is elevated with anxiety and depression - but only when comorbid. Arch Womens Ment Health. 2008;11(3):239. doi: 10.1007/s00737-008-0019-4.