

ASSOCIATION OF MATERNAL BODY MASS INDEX WITH PREGNANCY OUTCOMES IN ANTENATAL MOTHERS: A PROSPECTIVE LONGITUDINAL STUDY

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ABSTRACT

Introduction: Maternal body mass index (BMI) is an important indicator of nutritional status and can significantly influence the course and outcome of pregnancy. Both low and high maternal BMI are associated with increased risks of adverse maternal and neonatal outcomes. **Objectives:** To assess the effect of maternal body mass index (BMI) on pregnancy outcomes and to determine the association between booking BMI and maternal and neonatal outcomes among antenatal mothers.

Method: A prospective longitudinal research was performed including 263 antenatal mothers with a singleton pregnancy at a tertiary care facility in Dadra & Nagar Haveli. Participants were classified according to their booking BMI (underweight, normal, overweight, obese) utilizing Asian-Indian standards. Data were gathered from the initial trimester to 48 hours post-delivery. The statistical analysis encompassed both descriptive and inferential statistics, specifically the chi-square test. Maternal outcomes encompassed hypertensive diseases (preeclampsia, gestational hypertension), anemia, premature labor, and intrapartum problems (induction, cesarean section). Neonatal outcomes encompassed low birth weight (LBW), an Apgar score of less than 7, hospitalization to the NICU, and perinatal mortality.

Results: The majority of subjects had a normal BMI (71.4%), with subsequent classifications of underweight (19.7%), overweight (7.6%), and obese (1.14%). Negative results were more common at BMI extremes. Mothers who were overweight or obese were more likely to have preeclampsia (33.3%), gestational hypertension (33.3%), and caesarean delivery (up to 100%). Mothers who were underweight were more likely to have anaemia, oligohydramnios, fetal discomfort, and low birth weight. There were significant links between booking BMI and important outcomes such as preeclampsia, prenatal hypertension, anaemia, premature labor, oligohydramnios, caesarean section, LBW, Apgar score <7, and NICU hospitalization ($p \leq 0.05$).

Conclusions: Maternal BMI at reserving is a major predictor of negative maternal and neonatal outcomes. Both not getting sufficient nourishment and getting too much nourishment raise the risk of high blood pressure and bad outcomes for babies. Early detection and modification of body mass index (BMI) may enhance pregnancy outcomes.

KEYWORDS: Body Mass Index, Hypertension, Pregnancy Induced, Pre-Eclampsia, Infant, Low Birth Weight, Pregnancy Outcome, Risk Factors

INTRODUCTION

Maternal body mass index (BMI) is a significant factor influencing pregnancy outcomes and indicates maternal nutritional health. Both underweight and overweight situations correlate with detrimental maternal and new-born outcomes, especially hypertensive diseases such as preeclampsia and gestational hypertension, which are primary contributors to maternal morbidity and mortality globally [1,4,21].

The global increase in abnormal BMI among women of reproductive age has greatly exacerbated the incidence of pregnancy-related problems. In poor nations such as India, there exists a combined burden of under nutrition and obesity, which further complicates maternal health outcomes [3,7]. Maternal underweight has been correlated with anaemia, intrauterine growth restriction (IUGR), and low birth weight (LBW), whereas overweight and obesity are connected with hypertensive problems, gestational diabetes, and elevated caesarean section rates [5,6,19].

Hypertensive disorders of pregnancy are significantly correlated with maternal obesity, attributable to mechanisms including endothelial dysfunction, chronic inflammation, and insulin resistance [12,13,25]. Recent research, including articles in Pregnancy Hypertension, has underscored the enduring cardiovascular consequences of these disorders for both mothers and their offspring [14,23].

Although there is increasing evidence, prospective data from Indian contexts investigating BMI and total pregnancy outcomes are still scarce. Consequently, the current study sought to evaluate the impact of maternal BMI on pregnancy outcomes and ascertain its correlation with maternal and neonatal results.

METHODS

Study design and Study population

A prospective longitudinal study was carried out with 263 prenatal mothers at a tertiary care facility in Dadra and Nagar Haveli, India. Participants were chosen in the first trimester (≤ 12 weeks of gestation) and monitored until 48 hours postpartum. The sample size was calculated based on the estimated prevalence of adverse pregnancy outcomes in women with abnormal BMI from earlier research, utilizing a 95% confidence level and a 5% margin of error, along with a provision for potential attrition, resulting in a final sample of 263 participants. Pregnant women with singleton pregnancies who registered early in gestation were included, but those with multiple pregnancies, a history of caesarean section, or pre-existing medical issues were omitted. The Institutional Ethics Committee (IEC No.: DMHS/IEC/2016/214/6103) granted ethical approval, and all participants provided signed informed consent. We figured out the mother's BMI when she made her appointment and put it into one of four groups based on Asian-Indian standards: underweight (< 18.5 kg/m²), normal (18.5–22.9 kg/m²), overweight (23–24.9 kg/m²), and obese (≥ 25 kg/m²). The main outcomes were hypertensive disorders, anaemia, and problems throughout pregnancy. The secondary outcomes were the way the baby was born, problems after birth, and neonatal outcomes such low birth weight, an Apgar score of less than 7, NICU hospitalization, and perinatal death. Data were gathered utilizing a standardized, pre-tested questionnaire and clinical records, guaranteeing content validity via expert evaluation and dependability through pilot testing.

Statistical analysis

Statistical analysis was performed using appropriate descriptive and inferential statistical methods. Demographic, clinical, and outcome characteristics were summarized using descriptive statistics such as frequency, percentage, mean, and standard deviation. The Chi-square test (χ^2 test) was used for inferential analysis to look at the link between maternal BMI categories and pregnancy outcomes. Fisher's exact test was utilized for variables with minimal predicted cell counts when applicable. A p-value of ≤ 0.05 was regarded as statistically significant. No data imputation techniques were utilized, as the percentage of missing data for the majority of variables did not surpass 5%.

RESULTS

Participant demographic, Obstetric and Behavioral and Clinical Characteristics

There were 263 antenatal mothers in the study, most of them were between the ages of 20 and 25 (47.14%) and from Scheduled Tribe communities (52.85%). A lot of them were first-time mothers (44.86%), unemployed (58.17%), and lived in Dadra and Nagar Haveli (66.53%). Most of them (71.4%) had a normal BMI. The others were underweight (19.7%), overweight (7.6%), or obese (1.14%). Haemoglobin levels decreased progressively during pregnancy, with mild anaemia most common in the second (41.44%) and third trimesters (36.12%), and only 25.09% exhibiting normal haemoglobin levels postpartum. The study included 263 mothers who were pregnant at the time. The majority of participants were Among 263 antenatal mothers, most of them (71.4%) had a normal BMI. The others were underweight (19.7%), overweight (7.6%), or obese (1.14%).

Antenatal Outcomes According to Maternal BMI

Hypertensive disorders were more common in mothers who were overweight or obese, with the greatest rates seen in the obese group. Conversely, anaemia, oligohydramnios, and intrauterine growth restriction were more prevalent among underweight moms. Overall, negative outcomes during pregnancy were more common toward the ends of the maternal BMI range (Table 1).

Table 1: Antenatal Outcomes According to Maternal BMI

Outcome	Total (n = 263) n (%)	Underweight (n = 52) n (%)	Normal (n = 188) n (%)	Overweight (n = 20) n (%)	Obese (n = 3) n (%)
Preeclampsia	14 (5.3)	3 (5.7)	8 (4.2)	2 (10.0)	1 (33.3)
Eclampsia	7 (2.6)	1 (1.9)	5 (2.6)	2 (10.0)	0 (0)
Gestational hypertension	29 (11.0)	6 (11.5)	18 (9.5)	4 (20.0)	1 (33.3)
Gestational diabetes	2 (0.7)	0 (0)	1 (0.5)	1 (5.0)	0 (0)
Anemia	163 (61.9)	28 (53.8)	133 (70.7)	2 (10.0)	0 (0)
Abruptio placenta	1 (0.3)	0 (0)	1 (0.5)	0 (0)	0 (0)
Placenta previa	3 (1.1)	1 (1.9)	2 (1.1)	0 (0)	0 (0)
Preterm labor	24 (9.1)	6 (11.5)	15 (7.9)	2 (10.0)	1 (33.3)
Postdatism	3 (1.1)	1 (1.9)	2 (1.1)	0 (0)	0 (0)
IUGR	8 (3.0)	3 (5.7)	4 (2.1)	1 (5.0)	0 (0)
Macrosomia	1 (0.3)	0 (0)	0 (0)	1 (5.0)	0 (0)
Oligohydramnios	33 (12.5)	12 (23.1)	18 (9.5)	3 (15.0)	0 (0)
Polyhydramnios	2 (0.7)	0 (0)	2 (1.1)	0 (0)	0 (0)
Abortion	6 (2.2)	1 (1.9)	5 (2.6)	0 (0)	0 (0)

Data presented as n (%), BMI: Body Mass Index; IUGR: Intrauterine Growth Restriction

Intranatal Outcomes According to Maternal BMI

Intranatal outcomes differed among BMI categories, revealing elevated caesarean section rates in overweight (90%) and obese (100%) mothers. Fetal distress, labor induction, and oxytocin administration were more prevalent in abnormal BMI groups. Overall, negative intranatal outcomes were more prominent at the extremes of maternal BMI (Table 2).

Table 2. Intranatal outcomes according to maternal BMI (n = 263)

Outcome	Total (n = 263) n (%)	Underweight (n = 52) n (%)	Normal (n = 188) n (%)	Overweight (n = 20) n (%)	Obese (n = 3) n (%)
Normal vaginal delivery	148 (56.2)	24 (46.1)	122 (64.8)	2 (10.0)	0 (0)
PROM	11 (4.1)	2 (8.3)	8 (6.5)	1 (5.0)	0 (0)
Induction of labor	34 (12.9)	9 (17.3)	17 (9.0)	7 (35.0)	0 (0)
Delayed 1st stage of labor	6 (2.2)	1 (4.1)	5 (2.7)	0 (0)	0 (0)
Delayed 2nd stage of labor	1 (0.3)	0 (0)	1 (0.5)	0 (0)	0 (0)
Hypotonic contraction	2 (0.7)	0 (0)	1 (0.5)	0 (0)	1 (33.3)
Hypertonic contraction	3 (1.1)	1 (1.9)	2 (1.1)	0 (0)	0 (0)
Oxytocin use	173 (65.7)	42 (80.7)	111 (59.0)	17 (85.0)	3 (100)
Fetal distress	84 (31.9)	21 (40.3)	61 (32.4)	2 (10.0)	0 (0)
Cesarean section	115 (43.7)	27 (51.9)	61 (32.4)	18 (90.0)	3 (100)
Obstructed/prolonged labor	2 (0.7)	0 (0)	2 (1.1)	0 (0)	0 (0)
Blood transfusion	14 (5.3)	5 (9.6)	8 (4.2)	1 (5.0)	0 (0)

Neonatal Outcomes According to Maternal BMI

Neonatal outcomes differed among maternal BMI categories, with low birth weight (9.8%) and NICU hospitalization (47.9%) being the most prevalent. Adverse outcomes, like as low Apgar scores, were more prevalent at BMI extremes, especially among underweight and obese mothers. In general, both low and high maternal BMI were linked to worse outcomes for new-borns. (Table 3).

Table 3. Neonatal outcomes according to maternal BMI (n = 263)

Outcome	Total (n = 263) n (%)	Underweight (n = 52) n (%)	Normal (n = 188) n (%)	Overweight (n = 20) n (%)	Obese (n = 3) n (%)
Low birth weight	26 (9.8)	6 (11.5)	17 (9.0)	2 (10.0)	1 (33.3)
Apgar score <7	23 (8.7)	6 (11.5)	13 (6.9)	3 (15.0)	1 (33.3)
Resuscitation required	5 (1.9)	1 (1.9)	4 (2.1)	0 (0)	0 (0)
NICU admission	126 (47.9)	20 (38.4)	101 (53.7)	4 (20.0)	1 (33.3)
Stillbirth	7 (2.6)	2 (3.8)	4 (2.1)	1 (5.0)	0 (0)
Neonatal death	3 (1.1)	1 (1.9)	2 (1.1)	0 (0)	0 (0)

Data presented as n (%) , □ NICU: Neonatal Intensive Care Unit

Postnatal Outcomes According to Maternal BMI

Postnatal outcomes were rare across BMI categories, with blood transfusion (3.8%) and postpartum haemorrhage (1.9%) being the most prevalent. There were also small differences, such as greater blood transfusion rates in the normal and underweight groups and more uterine sub-involution in overweight moms. In general, there was no discernible pattern among the BMI groups (Table 4).

Table 4. Postnatal Outcomes According to Maternal BMI (n = 263)

Variable	Total (n = 263) n (%)	Underweight (n = 52) n (%)	Normal (n = 188) n (%)	Overweight (n = 20) n (%)	Obese (n = 3) n (%)
Postpartum hemorrhage	5 (1.9)	1 (1.9)	4 (2.1)	0 (0)	0 (0)
Puerperal sepsis	1 (0.3)	0 (0)	1 (0.5)	0 (0)	0 (0)
Uterine sub-involution	3 (1.1)	1 (1.9)	1 (0.5)	1 (5.0)	0 (0)
Blood transfusion	10 (3.8)	2 (3.8)	8 (4.2)	0 (0)	0 (0)

Association between Maternal BMI and Pregnancy Outcomes

Maternal BMI was significantly correlated with various maternal and new-born outcomes (Table 5). Hypertensive diseases were more prevalent among overweight and obese moms, whereas anaemia, oligohydramnios, and intrauterine growth restriction (IUGR) were more prevalent in underweight women. Moreover, a greater BMI correlated with an elevated incidence of caesarean deliveries and labor interventions, whereas negative neonatal outcomes were more pronounced at BMI extremes.

Table 5. Association between maternal BMI and pregnancy outcomes (n = 263)

Outcome	Total (n = 263) n (%)	Underweight (n = 52) n (%)	Normal (n = 188) n (%)	Overweight (n = 20) n (%)	Obese (n = 3) n (%)	χ^2 value	p-value
Preeclampsia	14 (5.3)	3 (5.7)	8 (4.2)	2 (10.0)	1 (33.3)	9.60	0.05*
Gestational hypertension	29 (11.0)	6 (11.5)	18 (9.5)	4 (20.0)	1 (33.3)	9.55	0.05*
Anemia	163 (61.9)	28 (53.8)	133 (70.7)	2 (10.0)	0 (0)	10.02	0.05*
Preterm labor	24 (9.1)	6 (11.5)	15 (7.9)	2 (10.0)	1 (33.3)	9.49	0.05*
IUGR	8 (3.0)	3 (5.7)	4 (2.1)	1 (5.0)	0 (0)	10.80	0.05*
Oligohydramnios	33 (12.5)	12 (23.1)	18 (9.5)	3 (15.0)	0 (0)	14.53	0.01*
PROM	11 (4.1)	2 (3.8)	8 (4.2)	1 (5.0)	0 (0)	9.87	0.05*
Induction of labor	34 (12.9)	9 (17.3)	17 (9.0)	7 (35.0)	1 (33.3)	11.34	0.02*
Cesarean section	115 (43.7)	27 (51.9)	61 (32.4)	18 (90.0)	3 (100)	13.06	0.02*
Blood transfusion (Intranatal)	14 (5.3)	5 (9.6)	8 (4.2)	1 (5.0)	0 (0)	9.70	0.05*
Postpartum hemorrhage	5 (1.9)	1 (1.9)	4 (2.1)	0 (0)	0 (0)	9.48	0.05*
Low birth weight	26 (9.8)	6 (11.5)	17 (9.0)	2 (10.0)	1 (33.3)	9.89	0.05*
Apgar score <7	23 (8.7)	6 (11.5)	13 (6.9)	3 (15.0)	1 (33.3)	9.51	0.05*
NICU admission	126 (47.9)	20 (38.4)	101 (53.7)	4 (20.0)	1 (33.3)	16.16	0.01*

Data presented as n (%), *p ≤ 0.05 considered statistically significant

BMI: Body Mass Index; IUGR: Intrauterine Growth Restriction; PROM: Premature Rupture of Membranes; NICU: Neonatal Intensive Care Unit

DISCUSSION

This study demonstrates that a maternal body mass index (BMI) is a key factor in how well her pregnancy goes, with both low and high BMI linked to higher risks. Our data reveal a U-shaped connection that aligns with recent studies demonstrating that deviations from normal BMI markedly elevate the risk of unfavourable maternal and new-born outcomes [1, 18,20].

This study found that overweight and obese moms were more likely to have hypertensive diseases such as preeclampsia and gestational hypertension. This data aligns with contemporary literature indicating that elevated maternal obesity leads to endothelial dysfunction, systemic inflammation, and insulin resistance, which are critical factors in the onset of hypertensive diseases during pregnancy [4, 11, 12]. Research published in Pregnancy Hypertension has underscored the significance of decreased placental perfusion and vascular maladaptation in obese mothers, hence heightening their vulnerability to preeclampsia [14]. On the other hand, moms in our research who were underweight had increased incidences of anaemia, oligohydramnios, and intrauterine growth restriction (IUGR). These findings may be attributed to insufficient maternal nutritional reserves and impaired placental function, resulting in constrained fetal growth. Recent studies have similarly documented the effects of maternal under nutrition on fetal development and delivery outcomes [5, 8].

The study revealed markedly elevated caesarean section rates among overweight and obese moms concerning intranatal outcomes. This corresponds with research indicating that maternal obesity correlates with an elevated risk of labor problems, such as fetal microsomal, diminished uterine contractility, and extended labor, frequently requiring surgical intervention [6, 16, 24]. Moreover, elevated rates of fetal distress and labor induction reported in aberrant BMI groups substantiate the impact of maternal BMI on intrapartum outcomes [13]. In our study, neonatal outcomes also differed among BMI groups. Mothers at both ends of the BMI spectrum were more likely to have babies with low birth weight, low Apgar scores, and more NICU admissions. These findings align with recent studies indicating that maternal BMI significantly influences the intrauterine environment and neonatal health outcomes [5, 15, 17]. Moreover, research indicates that the association between maternal BMI and

pregnancy outcomes is continuous rather than threshold-dependent, underscoring the necessity for an ideal BMI during pregnancy^[18].

In the current investigation, postnatal problems were rather uncommon and did not exhibit a consistent pattern across BMI groups. Recent evidence corroborates this conclusion, demonstrating that the influence of maternal BMI is more significant during the prenatal and intranatal periods than in the postnatal phase^[3,22].

In general, the results of this study show that maternal BMI is a major risk factor that may be changed and that affects pregnancy outcomes. Both underweight and overweight women have heightened risks of problems, underscoring the necessity for early BMI evaluation and suitable therapies. Adding dietary counseling, weight management techniques, and thorough monitoring to normal antenatal care may help lower bad outcomes and make mothers and babies healthier.

Strengths and Limitations

The strength of this study lies in its prospective longitudinal design and comprehensive assessment of antenatal, Intranatal, postnatal, and neonatal outcomes in relation to maternal BMI. However, the study has certain limitations. The relatively small number of obese participants may limit the generalizability of findings to this group. Additionally, the study was conducted in a single tertiary care center, which may affect external validity.

Conclusions

Maternal body mass index is a major factor that affects the outcome of a pregnancy. Both underweight and overweight/obese moms face heightened risks of negative maternal and new-born outcomes, especially hypertensive diseases. Recognizing and properly treating an abnormal BMI early in pregnancy may assist improve the health of both the mother and the baby.

Author Contributions

All authors participated in the formulation and design of the study. The main author was in charge of gathering and analysing the data. All authors participated in data interpretation, paper preparation, and revisions, and have endorsed the final version for publication.

Declaration of Competing Interest

The authors declare that they have no identifiable conflicting financial interests or personal affiliations that would have influenced the work presented in this study.

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Financial Interests

The authors declare they have no financial interests.

Ethics Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee (IEC), Directorate of Medical and Health Services (DMHS), Dadra and Nagar Haveli (IEC No.: DMHS/IEC/2016/214/6103). Written informed consent was obtained from all participants prior to inclusion in the study.

Availability of Data and Material

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

REFERENCES

1. Goldstein, R. F., Abell, S. K., Ranasinha, S., Misso, M., Boyle, J. A., Black, M. H., Li, N., Hu, G., Corrado, F., Rode, L., Kim, Y. J., Haugen, M., Song, W. O., Kim, M. H., Bogaerts, A., Devlieger, R., Chung, J. H., & Teede, H. J. (2017). Association of Gestational Weight Gain With Maternal and Infant Outcomes: A Systematic Review and Meta-analysis. *JAMA*, 317(21), 2207–2225. <https://doi.org/10.1001/jama.2017.3635>
2. Santos, S., Voerman, E., Amiano, P., Barros, H., Beilin, L. J., Bergström, A., Charles, M. A., Chatzi, L., Chevrier, C., Chrousos, G. P., Corpeleijn, E., Costa, O., Costet, N., Crozier, S., Devereux, G., Doyon, M., Eggesbø, M., Fantini, M. P., Farchi, S., Forastiere, F., ... Jaddoe, V. (2019). Impact of maternal body mass index and gestational weight gain on pregnancy complications: an individual participant data meta-analysis of European, North American and Australian cohorts. *BJOG : an international journal of obstetrics and gynaecology*, 126(8), 984–995. <https://doi.org/10.1111/1471-0528.15661>
3. Deputy NP, Dub B, Sharma AJ. Prevalence and Trends in Prepregnancy Normal Weight - 48 States, New York City, and District of Columbia, 2011-2015. *MMWR Morb Mortal Wkly Rep*. 2018;66(51-52):1402-1407. Published 2018 Jan 5. doi:10.15585/mmwr.mm665152a3
4. He XJ, Dai RX, Hu CL. Maternal prepregnancy overweight and obesity and the risk of preeclampsia: A meta-analysis of cohort studies. *Obes Res Clin Pract*. 2020;14(1):27-33. doi:10.1016/j.orcp.2020.01.004
5. Lewandowska M, Sajdak S, Więckowska B, Manevska N, Lubiński J. The Influence of Maternal BMI on Adverse Pregnancy Outcomes in Older Women. *Nutrients*. 2020;12(9):2838. Published 2020 Sep 16. <https://doi.org/10.3390/nu12092838>

6. Liu L, Ma Y, Wang N, Lin W, Liu Y, Wen D. Maternal body mass index and risk of neonatal adverse outcomes in China: a systematic review and meta-analysis. *BMC Pregnancy Childbirth*. 2019;19(1):105. Published 2019 Mar 29. doi: 10.1186/s12884-019-2249-z
7. Chen C, Xu X, Yan Y (2018) Estimated global overweight and obesity burden in pregnant women based on panel data model. *PLoS ONE* 13(8): e0202183. <https://doi.org/10.1371/journal.pone.0202183>
8. Ju AC, Heyman MB, Garber AK, Wojcicki JM. Maternal Obesity and Risk of Preterm Birth and Low Birthweight in Hawaii PRAMS, 2000-2011. *Matern Child Health J*. 2018;22(6):893-902. doi:10.1007/s10995-018-2464-7
9. Xie D, Yang W, Wang A, et al. Effects of pre-pregnancy body mass index on pregnancy and perinatal outcomes in women based on a retrospective cohort. *Sci Rep*. 2021;11(1):19863. Published 2021 Oct 6. doi:10.1038/s41598-021-98892-y
10. Lisonkova S, Muraca GM, Potts J, et al. Association Between Prepregnancy Body Mass Index and Severe Maternal Morbidity. *JAMA*. 2017;318(18):1777-1786. <https://doi.org/10.1001/jama.2017.16191>
11. Xiang C, Sui L, Ding X, Cao M, Li G, Du Z. Maternal adiposity measures and hypertensive disorders of pregnancy: a meta-analysis. *BMC Pregnancy Childbirth*. 2024;24(1):675. Published 2024 Oct 16. <https://doi.org/10.1186/s12884-024-06788-2>
12. Wang Y, Min C, Song X, et al. The dose-response relationship between BMI and hypertension based on restricted cubic spline functions in children and adolescents: A cross-sectional study. *Front Public Health*. 2022;10:870568. Published 2022 Dec 19. doi:10.3389/fpubh.2022.870568
13. Álvarez D, Muñoz Y, Ortiz M, Maliqueo M, Chouinard-Watkins R, Valenzuela R. Impact of Maternal Obesity on the Metabolism and Bioavailability of Polyunsaturated Fatty Acids during Pregnancy and Breastfeeding. *Nutrients*. 2021; 13(1):19. <https://doi.org/10.3390/nul13010019>
14. Lazzari C, Bosco M, Garzon S, et al. The impact of maternal age and body mass index on hypertensive disorders of pregnancy: Moving beyond the cut-off effect. *Pregnancy Hypertens*. 2025;40:101219. doi:10.1016/j.preghy.2025.101219
15. Nikolova Z, Sandeva M, Uchikova E, Kirkova-Bogdanova A, Taneva D, Vladimirova M, Georgieva L. Impact of Maternal Overweight and Obesity on Pregnancy Outcomes Following Cesarean Delivery: A Retrospective Cohort Study. *Healthcare*. 2025; 13(15):1893. <https://doi.org/10.3390/healthcare13151893>
16. Saadia Z. Association Between Maternal Obesity and Cesarean Delivery Complications. *Cureus*. 2020;12(3):e7163. Published 2020 Mar 2. doi:10.7759/cureus.7163
17. Eltayeb RA, Khalifa AA. Impact of Maternal Body Mass Index on Maternal and Neonatal Outcomes Among Sudanese Women. *Cureus*. 2021;13(9):e18365. Published 2021 Sep 28. doi:10.7759/cureus.18365
18. Kim, Y.J., Shin, J., Kim, TE. *et al.* Association of maternal pre-pregnancy body mass index with neonatal respiratory outcomes: a nationwide population-based cohort study. *Sci Rep* 15, 38680 (2025). <https://doi.org/10.1038/s41598-025-22497-y>
19. Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstet Gynecol*. 2004;103(2):219-224. doi:10.1097/01.AOG.0000107291.46159.00
20. Knight M, Kurinczuk JJ, Spark P, Brocklehurst P; UK Obstetric Surveillance System. Extreme obesity in pregnancy in the United Kingdom. *Obstet Gynecol*. 2010;115(5):989-997. doi:10.1097/AOG.0b013e3181da8f09
21. Shao Y, Qiu J, Huang H, et al. Pre-pregnancy BMI, gestational weight gain and risk of preeclampsia: a birth cohort study in Lanzhou, China. *BMC Pregnancy Childbirth*. 2017;17(1):400. Published 2017 Dec 1. doi:10.1186/s12884-017-1567-2
22. Santos S, Voerman E, Amiano P, et al. Impact of maternal body mass index and gestational weight gain on pregnancy complications: an individual participant data meta-analysis of European, North American and Australian cohorts. *BJOG*. 2019;126(8):984-995. doi:10.1111/1471-0528.15661
23. Gaillard R, Santos S, Duijts L, Felix JF. Childhood Health Consequences of Maternal Obesity during Pregnancy: A Narrative Review. *Ann Nutr Metab*. 2016;69(3-4):171-180. doi:10.1159/000453077
24. Timur BB, Timur H, Tokmak A, Isik H, Eyi EGY. The Influence of Maternal Obesity on Pregnancy Complications and Neonatal Outcomes in Diabetic and Nondiabetic Women. *Geburtshilfe Frauenheilkd*. 2018;78(4):400-406. doi:10.1055/a-0589-2833
25. Catalano PM, Shankar K. Obesity and pregnancy: mechanisms of short term and long term adverse consequences for mother and child. *BMJ*. 2017;356:j1. Published 2017 Feb 8. doi:10.1136/bmj.j1