



The Association Between the Maternal Body Mass Index and the Birth Weight of Infants Born

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Abstract

Background: Birth weight is one of the most important and reliable indicators of neonatal survival, physical and mental development of the neonate and is influenced by various factors including genetics, socio-cultural and demographic factors of the mother and one of the most important factors is mother's body mass index (BMI) which directly and indirectly reflects the health and well-being of the mother and her nutritional status.

Objectives: The relationship between maternal body mass index and birth weight of neonates born in hospitals of Islamic Azad University, Tehran Medical Sciences from 2021 to 2022.

Methods: In this cross-sectional descriptive study, 288 neonates born in hospitals of Azad University are selected. Information about neonates (gender and birth weight) and maternal information (BMI, age, occupation, education, type of delivery, gestational age, parity and history of preeclampsia) and family income are included in the designed questionnaire.

Results: The mean age and BMI of the studied pregnant mothers were 30 and 29, respectively, and the mean weight of the newborns born from these mothers was estimated to be 3200 g. Among the mothers studied, 232 had abnormal body mass index, of which 41% were overweight and about 40% were obese. Among the neonates studied, 25 had abnormal weight, of which 11 were low birth weight and 14 were macrosomic. Analysis of the data of this study showed that maternal BMI can affect pregnancy outcome and birth weight of neonates. Between the mother's BMI and the baby's birth weight, there is a significant relationship.

Conclusions: Due to the high mean BMI in pregnant women in this study and the possibility of giving birth to overweight neonate in obese mothers and the complications and risks of macrosomia and the possibility of weight gain and obesity in adulthood, it is necessary to pay attention to overweight pregnant women.

Keywords: Maternal Body Mass Index, Birth Weight, Gestational Weight Gain, Pregnancy

1. Background

A pregnant women's body mass index (BMI) plays a significant role in the outcome of the pregnancy and the birth weight of infants. BMI is the relative measurement of the percentage of fat and muscle mass in the human body, which is calculated by dividing weight in kilograms divided by the square of height in meters (1). High body mass index is also associated with increased blood pressure, gestational diabetes, postpartum hemorrhage, induction of labor, cesarean section, and macrosomic fetus, and conversely, the lowest maternal mortality rate during pregnancy is related to women who had a normal BMI before pregnancy (2, 3). Infants weighing more or less than the usual range is at a greater risk of death and physical and neurological impairment (4). The need to pay more attention to the examination and measurement of mothers' BMI

and weight gain during pregnancy care, as well as to try as hard as possible to improve mothers' nutritional status and family education, is stressed in this field due to the relatively high prevalence of abnormal BMI and abnormal weight gain during pregnancy (weight gain more or less than the recommended amount) (5).

2. Objectives

Considering the consequences that the birth of babies with low weight imposes on the society, the objective of the current research is to ascertain the association between the mother's BMI during pregnancy and the birth weight of infants delivered in affiliated hospitals of Islamic Azad University, Tehran Medical Sciences between the years 2020 and 2021.

3. Methods

The present study is a cross-sectional descriptive study that consisted of infants born in affiliated hospitals of Islamic Azad University, Tehran Medical Sciences from 2020 to 2021. According to the objectives and type of study, and referring to previous studies (6) in this field that showed the prevalence of low birth weight to be 7.5% ($P = 0.075$), and taking into account the error of 5% ($= 0.05$) and the maximum error of 5% sampling ($d = 0.05$), 288 samples were included in the study. Methods of sampling was simple random sampling. The data collection form was designed as a checklist, including baby's birth weight, mother's age, baby's gender, delivery type, mother's body mass index, mother's preeclampsia, mother's parity, gestational age, mother's occupation, mother's education, family income. The inclusion criteria included singleton pregnancies, while the exclusion criteria were delivery of infants with birth defects. Information about infants, including gender and birth weight, as well as the women's information were entered into the checklist. The analysis of the obtained data was performed by the SPSS software version 26, and the level of statistical significance was set at $P < 0.05$. The Kolmogorov-Smirnov test was utilized to examine whether the data were normally distributed. The procedures of the present research were confirmed by the Ethic Committee of Islamic Azad University, Tehran Medical Sciences and in accordance with Helsinki Declaration. The information of patients has been kept confidential, and the checklist was coded and will be delivered to them if needed. Subjects voluntarily participated in the study, no cost was imposed on people, and no change was made in the routine course of treatment of patients. This research was conducted with the ethics code of IR.IAU.TMU.REC.1399.502 at Islamic Azad University, Tehran Medical Sciences.

4. Results

This research included 288 women mean age was 30.26 ± 5.9 years (Table 1).

The frequency distribution of characteristics of women and their newborns based on women's BMI is presented in Table 2 according to the chi-square test.

According to Table 3, the mean values of BMI were calculated in different subgroups of the studied samples. The highest BMI values were found in women 40 years old and older (P value = 0.001), family income (P value = 0.038), cesarean deliveries (P value ≤ 0.001) and no history of preeclampsia (P value = 0.007). Regarding the normality of BMI distribution, the t -test and ANOVA was used to analyze the data.

The mean birth weight values of infants according to the variables examined in this study are depicted in Table

Table 1. Demographic Characteristics of Women and Their Infants^a

Variables	Values
Age of women	
20 >	7 (2.4)
20 - 29	118 (41)
30 - 39	148 (51.4)
40 \geq	15 (5.2)
BMI of women	
Normal weight	56 (19.4)
Overweight	118 (41)
Obese	114 (39.6)
Educational status of women	
High school degree	54 (18.8)
Diploma	118 (41)
Bachelor's degree	102 (35.4)
Master's degree	14 (4.9)
Occupation of women	
Housewives	243 (84.4)
Part-time Job	44 (15.3)
Full-time job	1 (0.3)
Parity	
Nulliparous	133 (46.2)
Multiparous	155 (53.8)
Gestational age	
Preterm	4 (1.4)
Term	284 (96.8)
Type of delivery	
Natural	77 (26.7)
Cesarean section	211 (73.3)
History of preeclampsia	
Yes	17 (5.9)
No	271 (94.1)
Family income	
Under poverty line	142 (49.3)
Sufficient	146 (50.7)
Gender of infant	
Female	133 (46.2)
Male	155 (53.8)
Birth weight of infants	
LBW	11 (3.8)
Normal	263 (91.3)
Macrosomia	14 (4.9)
Weight of women (kg)	76.06 \pm 13.5
Height of women (m)	161.79 \pm 6.1
BMI of women	29.03 \pm 4.8
Birth weight of babies (grams)	3262.86 \pm 419.1

^a Values are expressed as No. (%) or mean \pm SD.

4 by the t -test and ANOVA. The mean weight of infants was significant correlated to educational levels of women, parity, gestational age, gender of infant and BMI of women (P value ≤ 0.05). Based on the significant level mentioned be-

Table 2. Frequency Distribution of the Studied Variables According to Women's BMI

Variables	Normal (n = 56)	Overweight (n = 118)	Obese (n = 114)	P Value ^a
Age of women				0.017 *
< 20	4 (7.1)	2 (1.7)	1 (0.9)	
20 - 29	27 (48.2)	55 (46.6)	36 (31.6)	
30 - 39	23 (41.1)	57 (48.3)	68 (59.6)	
> 40	2 (3.6)	4 (3.4)	9 (7.9)	
Educational levels of women				0.109
High school degree	17 (30.4)	16 (13.6)	21 (18.4)	
Diploma	21 (37.5)	53 (44.9)	44 (38.6)	
Bachelors' degree	15 (26.8)	46 (39)	41 (36)	
Master's degree	3 (5.40)	3 (2.5)	8 (7)	
Occupation of women				0.281
Housewives	47 (83.9)	103 (87.3)	93 (81.6)	
Part-time job	8 (14.3)	15 (12.7)	21 (18.4)	
Full-time job	1 (1.8)	0	0	
Parity				0.398
Nulliparous	25 (44.6)	60 (50.8)	48 (42.1)	
Multiparous	31 (55.4)	58 (49.2)	66 (57.9)	
Family income				0.082
Under poverty line	35 (62.5)	56 (47.5)	51 (44.7)	
Sufficient	21 (37.5)	62 (52.5)	63 (55.3)	
Type of delivery				0.001 *
Natural	25 (44.6)	31 (26.3)	21 (18.4)	
Cesarean section	31 (55.4)	87 (73.7)	93 (81.6)	
Preeclampsia				0.334
No	55 (98.2)	111 (94.1)	105 (92.1)	
Yes	1 (1.8)	7 (5.9)	9 (7.9)	
Gestational age				0.685
Preterm	1 (1.8)	1 (0.8)	2 (1.8)	
Term	55 (98.2)	117 (99.2)	112 (98.2)	
Gender of infants				0.224
Female	20 (35.7)	57 (48.3)	56 (49.1)	
Male	36 (64.3)	61 (51.7)	58 (50.9)	
Birth weight of infants				0.238
Underweight	1 (1.8)	7 (5.9)	3 (2.6)	
Normal	53 (94.6)	108 (91.5)	102 (89.5)	
Macrosomia	2 (3.6)	3 (2.5)	9 (7.9)	

^a Chi-square test.

tween the mother's BMI and the baby's birth weight, there is a significant relationship between these two variables and it is proven that the mother's BMI is effective on the

baby's birth weight.

Table 5 displays Pearson's correlation coefficients between several research factors and infant birth weight.

Table 3. Women's Mean BMI Based on Other Variables

Variables	Means ± SD	P Value ^a
Age of women		0.001 *
> 20	25.02 ± 3.90	
20 - 29	27.94 ± 4.15	
30 - 39	29.89 ± 5.03	
40 <	31.06 ± 4.96	
Educational levels of women		0.415
High school degree	29.24 ± 4.81	
Diploma	29.04 ± 4.96	
Bachelor's degree	29.22 ± 4.34	
Master's degree	30.03 ± 6.20	
Occupation of women		0.385
Housewives	28.93 ± 4.71	
Part-time job	29.70 ± 5.23	
Full-time job	24.97	
Parity		0.940
Nulliparous	29.06 ± 4.76	
Multiparous	29.00 ± 4.83	
Family income		0.038 *
Under poverty line	28.44 ± 4.73	
Sufficient	29.61 ± 4.80	
Type of delivery		< 0.001 *
Natural	4.55 ± 27.09	
Cesarean section	4.69 ± 29.74	
Preeclampsia		0.007 *
No	28.84 ± 4.71	
Yes	32.05 ± 5.15	
Gestational age		0.911
Preterm	28.49 ± 8.07	
Term	29.04 ± 4.75	
Gender of infants		0.129
Female	29.49 ± 4.82	
Male	28.63 ± 4.74	
Birth weight of infants		0.283
Underweight	28.65 ± 4.51	
Normal	28.96 ± 4.80	
Macrosomic	30.69 ± 4.86	

^a t-test and ANOVA.

Table 4. The Mean Birth Weight of Infants Based on the Other Analyzed Variables

Variables	Means ± SD	P Value ^a
Age of women		0.15
< 20	3379.29 ± 338.1	
20 - 29	3233.91 ± 416.9	
30 - 39	3297.84 ± 429.9	
> 40	419.1 ± 3091.27	
Educational levels of women		0.03 *
High school degree	392.4 ± 3381.57	
Diploma	3175.77 ± 409.9	
Bachelor's degree	3292.83 ± 420.7	
Master's degree	3320.71 ± 474.1	
Occupational of women		0.993
Housewives	422.2 ± 3259.96	
Part-time job	3280.34 ± 410.6	
Full-time job	3200	
Parity		0.028 *
Nulliparous	3203.91 ± 438.3	
Multiparous	396.3 ± 3313.45	
Family income		0.706
Under poverty line	3249.61 ± 402.6	
Sufficient	3275.75 ± 435.5	
Type of delivery		0.237
Natural	3293.77 ± 410.7	
Cesarean section	3251.59 ± 422.5	
Preeclampsia		0.173
No	3268.19 ± 409.1	
Yes	563.7 ± 3177.94	
Gestational age		0.001 *
Preterm	2432.50 ± 249.5	
Term	3274.56 ± 409.4	
Gender of infant		0.002 *
Female	388.8 ± 3179.51	
Male	3334.39 ± 431.9	
BMI of women		0.018 *
Normal	3231.70 ± 384.8	
Overweight	418.7 ± 3191.48	
Obese	422.1 ± 3352.06	

^a t-test and ANOVA.

According to the linear model (Table 6), the four variables, women's BMI, gestational age, infant's gender, and parity, play a role in predicting the birth weight of infants

in such a way that normal weight or overweight women give birth to infants with lower weight than obese women. Also, infants of nulliparous women, female newborns, and

Table 5. The Correlation Coefficient Between the Analyzed Variables and the Birth Weight of Infants

Variables	r	P Value ^a
Women's weight	0.173	0.003 *
Women's BMI	0.133	0.024 *
Maternal parity	0.131	0.027 *
Gestational age	0.236	< 0.001 *
Gender of infant	0.185	0.002 *

^a Pearson's correlation.

preterm infants have lower birth weights than their counterparts.

5. Discussion

The examination of the data from this study revealed that women's BMI might influence the result of pregnancy and newborns' birth weight, such that most infants with macrosomia are born to obese women. Furthermore, the findings of this study on the mode of birth revealed that the incidence of cesarean section increased with the women's BMI. According to the generalized linear model, among the predictors of newborn weight, we can refer to women's BMI, gestational age, gender of infant and parity. In summary, the present research found that aberrant maternal BMI, particularly obesity, is related to poor maternal and newborn outcomes, which is consistent with the findings of previous studies in this area, which will be discussed more below. A significant conclusion of this research is that women in the population have a BMI of 29, which indicates a high propensity to be overweight in women of reproductive age and is a risk factor for both women of reproductive age and adolescents. Given that obesity has become a worldwide issue, the findings of this research and related studies may serve as a warning and a source of information for developing strategies to combat obesity in society. In the study by Upadhyay et al., which examined 206 pregnant women with an mean BMI of about 21, the mean birth weight of newborns was 3250 grams (7), which is numerically close to the mean birth weight of newborns studied in our study, and the results obtained were also completely consistent with our study. In addition, both studies demonstrate a statistically significant correlation between a woman's BMI and the birth weight of infants. In a comparable study conducted in Nigeria by Singh et al., the population of pregnant and reproductive-age women tended to be obese and overweight, and there was a strong correlation between maternal BMI and weight in both studies (8). The same outcomes were observed during the delivery of newborns in two genetically and environmentally distinct populations. Therefore, based on

these findings, it may be concluded that a woman's weight and BMI before becoming pregnant are crucial. The findings demonstrated a strong correlation between the nutritional state of the woman, the health of the fetus, and the birth weight of the infant. It should be noted that the nutritional health of pregnant women affects the growth and development of the fetus. The women's weight and BMI may be used to estimate the weight of the infant at birth since, as previously discussed, the women's BMI before or at the initiation of pregnancy is also one of the markers of the women's nutritional health. Paprikar and Patole discovered that 72% of infants born to overweight women were large at gestational age (LGA) in a study of 150 pregnant women (9). According to the obtained results, it was explained that overweight women have a higher possibility of giving birth to infants with a higher weight than women with a normal weight, and the results of this study were completely consistent with the findings even in the presence of fundamental discrepancies, such as the difference in mean age and BMI. Similar to our findings, Zhao et al. demonstrated a strong association between maternal overweight or obesity and the delivery of LGA infants (10). In the study of Mohammadi et al., who examined 4397 pregnant mothers, it was reported that obese women have a higher risk of giving birth to macrosomic newborns (11). It was also proven that increasing the women's BMI decreases the possibility of giving birth to an underweight newborn. In the study of Nemmati et al., a significant relationship was observed between women's BMI and the birth weight of the baby (12). However, there was no statistically significant relationship between the women's age and birth weight, which is completely consistent with our study from both perspectives. Given that both studies were conducted in Iran and the relative similarity of ethnicity and genetics, the results of these two studies could be considered for further consideration.

Bahrami Taghanaki et al. showed that women's BMI significantly influences birth weight, and the frequency of macrosomia is higher in obese women (13), which is similar and consistent with our results. Also, similar to the results of our study, a significant association was found between increasing BMI values and preeclampsia. Maleki et al. demonstrated a significant linear association between an increase in BMI values of women from before to after pregnancy and the birth weight of infants (14). Also, similar to our study, Yu et al. exhibited the presence of a significant correlation between the increased risk of having an infant born with a higher weight than a woman with a higher BMI (15). Low birth weight women are at increased risk of delivering LBW babies. Therefore, both extreme ranges of maternal BMI may influence the risk of adverse neonatal outcomes (16). According to the obtained results, Yu et al. stated that maternal overweight or obesity increases

Table 6. The Results of the Generalized Linear Model for Predicting the Birth Weight of Infants

Variables	B	t	Confidence Interval	P Value
Women's BMI				
Normal	-141.141	-2.198	(-14.717) - (-267.566)	0.029 *
Overweight	-161.981	-3.137	(-60.332) - (-263.630)	0.002 *
Obese ^a	0	-	-	-
Gestational age				
Preterm	-871.259	-4.398	(-481.342) - (-1261.176)	< 0.0001 *
Term ^a	0	-	-	-
Gender of infant				
Female	-174.136	-3.735	(-82.361) - (-265.911)	< 0.0001 *
Male ^a	0	-	-	-
Parity				
Nulliparous	-90.634	-1.945	(-1.069) - (-182.337)	0.05 *
Multiparous ^a	0	-	-	-

^a The basis for the calculation of the data.

the risk of LGA and macrosomia as well as overweight and obesity in adulthood (15). Terada et al. performed a multiple regression analysis to identify factors affecting birth weight. They concluded that nulliparity, smoking, and low BMI women are related to low birth weight, women's age, women's height, pregnancy weight gain, maternal BMI, use of in-vitro fertilization, induction of labor, and duration of pregnancy with high birth weight (17). In terms of the relationship between low birth weight and nulliparity and female gender, as well as the association between high weight and women's BMI, their findings are similar to the results of our study. In a study conducted by Ørskou et al., a significant relationship was detected between high birth weight, giving birth to the male gender, high maternal weight before pregnancy, gestational age over 42 weeks, and parity over 2, proving the correlation of these factors with high weight (18). In our research, the reversal of these characteristics with low weight was shown, indicating that the weight distribution of newborns differs between these two studies. In a systematic study and meta-analysis conducted on more than 1.6 million Chinese mothers, the effect of maternal BMI on adverse neonatal outcomes was investigated. In summary, this study found that maternal overweight or obesity was associated with preterm birth and infant suffocation, while maternal underweight was associated with low birth weight (19). A meta-analysis conducted in 2019 showed that as the mother's BMI increases, the chance of obesity in children increases significantly (20).

Since the sample of this study was examined only in a few hospitals, it cannot be generalized to the whole society and there is a need to conduct wider studies at the commu-

nity level.

This study have limitations. Demographic information of the father may also affect the growth parameters of the babies, but it was not presented in this study. To collect data related to the mother's demographics, since there is no national health registry system, we have to rely on the information provided by the mother because.

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Footnotes

Authors' Contribution: MM, MK and PS contributed to study design. PS and MK analyzed and interpreted the data. PS and MK was the major contributor in writing the manuscript. MK facilitated data gathering. All authors read and approved the final manuscript.

Conflict of Interests: There is no conflict of interest.

Ethical Approval: This research was conducted with the ethics code of [IR.IAU.TMU.REC.1399.502](https://doi.org/10.2196/iaur.1399.502) at Islamic Azad University of Medical Sciences.

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References

- Voigt M, Straube S, Olbertz D, Hauser B, Schneider KT. [The relationship between body weight, body height, body mass index and weight gain during pregnancy]. *Z Geburtshilfe Neonatol.* 2007;**211**(4):147-52. German. [PubMed ID: 17729200]. <https://doi.org/10.1055/s-2007-981236>.
- Bergholt T, Lim LK, Jorgensen JS, Robson MS. Maternal body mass index in the first trimester and risk of cesarean delivery in nulliparous women in spontaneous labor. *Am J Obstet Gynecol.* 2007;**196**(2):163-E1-5. [PubMed ID: 17306665]. <https://doi.org/10.1016/j.ajog.2006.09.026>.
- Voigt M, Heineck G, Hesse V. The relationship between maternal characteristics, birth weight and pre-term delivery: evidence from Germany at the end of the 20th century. *Econ Hum Biol.* 2004;**2**(2):265-80. [PubMed ID: 15464006]. <https://doi.org/10.1016/j.ehb.2004.04.005>.
- Barau G, Robillard PY, Hulsey TC, Dedecker F, Laffite A, Gerardin P, et al. Linear association between maternal pre-pregnancy body mass index and risk of cesarean section in term deliveries. *BJOG.* 2006;**113**(10):1173-7. [PubMed ID: 16972860]. <https://doi.org/10.1111/j.1471-0528.2006.01038.x>.
- Vaktskjold A, Tri DV, Odland JO, Sandanger T. Parity and Birth Weight in the Khanh Hoa Province, Vietnam. *Open Women's Health J.* 2010;**4**(1):1-4. <https://doi.org/10.2174/1874291201004010001>.
- Rezaeian M, Goujani R, Sheikh Fathollahi M, Vaziri Nejad R, Manshori A, Razi S. [A Comparative Study on Prevalence of Preterm Birth and Low Birth Weight in Iranians and Afghans Races in Rafsanjan Nik-Nafs Hospital in 2011-2012]. *J Rafsanjan Univ Med Sci.* 2014;**13**(1):67-82. Persian.
- Upadhyay, Biccha RP, Sherpa MT, Shrestha R, Panta PP. Association between maternal body mass index and the birth weight of neonates. *Nepal Med Coll J.* 2011;**13**(1):42-5. [PubMed ID: 21991701].
- Singh S, Shehu C, Nnadi D. The relationship between maternal body mass index and the birth weight of neonates in North-West Nigeria. *Sahel Med J.* 2016;**19**(4):185. <https://doi.org/10.4103/1118-8561.196359>.
- Paprikar DS, Patole KP. To study the correlation between maternal body mass index and birth weight of the baby. *MVP J Med Sci.* 2018;**5**(2):222-5. <https://doi.org/10.18311/mvpjms/2018/v5i2/18672>.
- Zhao R, Xu L, Wu ML, Huang SH, Cao XJ. Maternal pre-pregnancy body mass index, gestational weight gain influence birth weight. *Women Birth.* 2018;**31**(1):e20-5. [PubMed ID: 28716548]. <https://doi.org/10.1016/j.wombi.2017.06.003>.
- Mohammadi M, Maroufizadeh S, Omani-Samani R, Almasi-Hashiani A, Amini P. The effect of prepregnancy body mass index on birth weight, preterm birth, cesarean section, and preeclampsia in pregnant women. *J Matern Fetal Neonatal Med.* 2019;**32**(22):3818-23. [PubMed ID: 29768986]. <https://doi.org/10.1080/14767058.2018.1473366>.
- Nemmati A, Refahi S, Barak M, Jafari M, Ettehad G. [The Relationship between Some of Maternal Anthropometric Measurements with Neonatal Birth Weight of Alavi Hospital, Ardebil]. *J Ardabil Univ Med Sci.* 2007;**7**(1):84-9. Persian.
- Bahrami Taghanaki H, Hashemian M, Lotfalizadeh M, Noras M. [The relationship between Body Mass Index (BMI) and birth weight and some pregnancy outcomes]. *Iran J Obstet Gynecol Infertil.* 2016;**19**(30):1-8. Persian. <https://doi.org/10.22038/ijogi.2016.7926>.
- Maleki Z, Dehghani S, Mobasheri F. [The relationship between maternal weight gain during pregnancy and birth weight in patients referred to the gynecology and obstetrics ward]. *J Prevent Med.* 2020;**7**(2):1-10. Persian. <https://doi.org/10.29252/jpm.7.2.1>.
- Yu Z, Han S, Zhu J, Sun X, Ji C, Guo X. Pre-pregnancy body mass index in relation to infant birth weight and offspring overweight/obesity: a systematic review and meta-analysis. *PLoS One.* 2013;**8**(4). e61627. [PubMed ID: 23613888]. [PubMed Central ID: PMC3628788]. <https://doi.org/10.1371/journal.pone.0061627>.
- Catalano PM, Shankar K. Obesity and pregnancy: mechanisms of short term and long term adverse consequences for mother and child. *BMJ.* 2017;**356**:j1. [PubMed ID: 28179267]. [PubMed Central ID: PMC6888512]. <https://doi.org/10.1136/bmj.j1>.
- Terada M, Matsuda Y, Ogawa M, Matsui H, Satoh S. Effects of maternal factors on birth weight in Japan. *J Pregnancy.* 2013;**2013**:172395. [PubMed ID: 24349781]. [PubMed Central ID: PMC3857850]. <https://doi.org/10.1155/2013/172395>.
- Ørskou J, Henriksen TB, Kesmodel U, Secher NJ. Maternal characteristics and lifestyle factors and the risk of delivering high birth weight infants. *Obstet Gynecol.* 2003;**102**(1):115-20. [https://doi.org/10.1016/s0029-7844\(03\)00402-2](https://doi.org/10.1016/s0029-7844(03)00402-2).
- 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. [PubMed ID: 30922244]. [PubMed Central ID: PMC6440121]. <https://doi.org/10.1186/s12884-019-2249-z>.
- Heslehurst N, Vieira R, Akhter Z, Bailey H, Slack E, Ngongalah L, et al. The association between maternal body mass index and child obesity: A systematic review and meta-analysis. *PLoS Med.* 2019;**16**(6). e1002817. [PubMed ID: 31185012]. [PubMed Central ID: PMC6559702]. <https://doi.org/10.1371/journal.pmed.1002817>.