

# Effect of maternal overweight and obesity on pregnancy outcomes

## ABSTRACT

**Background:** Maternal overweight and obesity are reported as a risk factor for many antepartum, intrapartum, postpartum and neonatal complications. Maternal complications, such as hypertensive disorders, diabetes and venous thromboembolism, are associated with maternal overweight and obesity. Foetal and neonatal complications including miscarriage and stillbirth, foetal anomalies, macrosomia, preterm birth, prolonged pregnancy, Caesarean delivery and postpartum haemorrhage were also recorded as complications of maternal overweight and obesity.

**Comment [AHP1]:** This is too long. You may slightly summarize it.

**Aim:** To determine the adverse pregnancy outcomes associated with maternal overweight and obesity.

**Study design:** A prospective case-control study

**Place and duration of study:** The study was carried out in Bint AL-Huda hospital in Thi-Qar governorate- Iraq, from 1 May 2021 until the end of June 2021.

**Methodology:** The pregnant women were categorized to be non-obese when their body mass index (BMI) was 19.8-24.9 kg/m<sup>2</sup>, overweight when their BMI was 25-29.9 kg/m<sup>2</sup> and obese when their BMI was 30 kg/m<sup>2</sup> or more. The total studied cases were 432 (141 normal weight, 156 overweight and 135 obese pregnant women). After measuring BMI in the first booking visit, all data was taken by questionnaire (Maternal: age, gestational hypertension, gestational diabetes, hydramnios, preterm delivery, induction of labor, Caesarean delivery; Fetal and neonatal complications: macrosomia LGA, SGA, neonatal hyperbilirubinemia, abortion, congenital defects, admission in NICU, fetal death).

**Comment [AHP2]:** All abbreviations should be clarified at their first appearance in the text of the paper. You also may collect all of them under title abbreviations at the end of discussion and clarify them again.

**Results:** Gestational hypertension and gestational diabetes were significantly increased in overweight and obese compared with normal weight pregnant women. Induction of labor and Caesarean delivery were significantly increased in obese only compare with normal weight women. Furthermore, LGA and macrosomia were significantly increased in both overweight and obese in comparison with normal weight pregnant women, while SGA was significantly decreased in overweight and obese. Fetal admission in NICU and abortion were significantly increased in obese only.

**Comment [AHP3]:** compared

**Comment [AHP4]:** was

**Conclusions:** Pregnancy complications related to maternal BMI is a growing problem. Maternal overweight and obesity in pregnancy are important contributors to obstetric complications and adverse outcomes. Maternal obesity is a risk factor for antepartum, intrapartum and postpartum complications. Public health efforts are urgently required to promote weight management among women of reproductive age before conception and during pregnancy.

*Keywords: BMI, pregnancy; overweight; obese; pregnancy outcome; fetal; maternal; complications.*

## 1. INTRODUCTION

Overweight is defined by a BMI of  $\geq 25$ -29.9 and obesity by a BMI of  $\geq 30$  kg/m<sup>2</sup>[1]. Overweight and obesity represented a global health problems. They are the fifth leading cause of death worldwide. The causes of weight gain, which may eventually lead to overweight and obesity, are decreased physical activity, increased dietary fat intake, and genetic factors [2].

Comment [AHP5]: delete.

Comment [AHP6]: factors [2].

Maternal overweight and obesity are reported as a risk factor for many antepartum, intrapartum, postpartum and neonatal complications. Maternal complications, such as hypertensive disorders, diabetes and venous thromboembolism, are associated with maternal overweight and obesity. Foetal and neonatal complications including miscarriage and stillbirth, foetal anomalies, macrosomia, preterm birth, prolonged pregnancy, Caesarean delivery and postpartum haemorrhage were also recorded as complications of maternal overweight and obesity [3-6].

Seeniammal et al., mentioned that overweight mothers are at increased risk of adverse materno-fetal outcomes in India (gestational hypertension, gestational diabetes, induction of labour, Cesarean section, macrosomia, perineal lacerations, wound infection and prolonged hospital stay) [7].

Adani et al., noted that obesity affected the outcomes of pregnant in Saudi Arabia women. An associations is recorded between obesity and preeclampsia, perineal tears, and episiotomy variables [8].

Comment [AHP7]: association

Safarzadeh et al., showed that overweight of Iranian women associated with a higher risk for gestational hypertension, gestational diabetes, preterm labor, preeclampsia, caesarian section and fetal macrosomia [9].

Ahmad et al., found that hypertensive disorders were nine folds more among obese Egyptian women compared to non-obese. They were significantly more prone to have gestational diabetes. Anemia was also significantly more amongst obese women and partum hemorrhage was significantly more in obese compared to normal weight women [10].

In a systematic review carried out in USA by D'Souza et al., which included analysis of 13 studies (described 3,722,477 pregnancies), it appeared that overweight was associated with increased risk for gestational diabetes mellitus, hypertensive disorders of pregnancy, and cesarean delivery. Babies were at increased risk for hypoglycemia, macrosomia, infection, birth trauma, respiratory distress, death, and neonatal intensive care unit admission [11].

In a study performed in the Gynecology and Obstetrics Teaching Hospital of the University of Poznan, Poland, Lewandowska et al., found that both the youngest and the oldest obese women displayed higher ratios of preeclampsia, intrauterine growth restriction, and preterm birth <37th week. In the oldest obese  $\leq 40$  years, compared to

the youngest age 18–24 years, there was higher risk of gestational hypertension, gestational diabetes, cesarean section, and low birth weight as well as macrosomia [12].

In comparing the data of 249,650 women aged 35 years or older with women aged less than 35 years old in Finland. It appeared that Maternal overweight and obesity along with advanced maternal age significantly increased the risks of preterm delivery, preeclampsia, fetal death, gestational age and Cesarean as compared to women of average weight aged <35 years. When comparing overweight and obese women aged  $\geq 35$  years to normal weight women of the same age, the rates of preeclampsia, preterm delivery <28 weeks, gestational age and low Apgar score were significantly increased. When observing overweight and obese women <35 years as a reference group, the risks of preterm delivery and fetal death were significantly increased [13].

An Australian survey performed on 1661 women revealed that Obese women were at increased risk of pre-eclampsia and gestational diabetes compared with women with a normal BMI. Obese and overweight women were more likely to be induced labor, and require a caesarean section compared with women of normal BMI. Babies of women who were obese were more likely to be large for gestational age and macrosomic compared with those of women with a normal BMI [14].

In Al-Yarmouk Teaching Hospital, Baghdad- Iraq, Al-Kubaisy et al., recorded high rate of Cesarean section in primigravida and multigravida women with high BMI compared with normal weight pregnant [15]. While, in a prospective controlled study in Ibn Al-Balady obstetrics hospital, it was recorded that obese needed more emergency Cesarean section as a mode of delivery than normal BMI patients. They also had longer second stage of labor and delivered babies with higher birth weight than the normal group [16].

The current study was designed to determine the adverse pregnancy outcomes associated with maternal overweight and obesity.

## 2. MATERIALS AND METHODS

This study is a prospective case-control original research. It was conducted in Bint AL-Huda hospital in Thi-Qar governorate- Iraq, from 1 May 2021 until 15 June 2021. Women with chronic diseases like hypertension, diabetes, heart disease, epilepsy, TB, bronchial asthma were also excluded (in the first booking visit, a time of recording the weight). The pregnant women were categorized to be non-obese when their body mass index (BMI) was 19.8-24.9 kg/m<sup>2</sup>, overweight when their BMI was 25-29.9 kg/m<sup>2</sup> and obese when their BMI was 30 kg/m<sup>2</sup> or more [1, 10].

The total studied cases were 432 (141 normal weight, 156 overweight and 135 obese pregnant women). The study was approved by the ethical committee of health directorate of Thi-Qar governorate and the ethical board of the College of Medicine – Thi qar university-Iraq. After measuring BMI in the first booking visit, all data was taken by questionnaire (Maternal: age, gestational hypertension, gestational diabetes, hydramnios, preterm delivery, induction of labor, Cesarean delivery; Fetal and

Comment [AHP8]: macrosomia

neonatal complications: macrosomia LGA, SGA, neonatal hyperbilirubinemia, abortion, congenital defects, admission in NICU, fetal death) [4, 6-8]. The significance of the results were assessed using Chi square test. It is a suitable statistical test to analyze the percent data.

### 3. RESULT AND DISCUSSION

In studying of the maternal complications of overweight and obese pregnant women, the results revealed that gestational hypertension was significantly increased in overweight (16.03%, Chi square,  $P < 0.05$ ) and obese (28.89%, Chi square,  $P < 0.05$ ) compared with normal weight pregnant women (7.09%). Gestational diabetes was also significantly increased in overweight (5.13%, Chi square,  $P < 0.05$ ) and obese (10.37%, Chi square,  $P < 0.05$ ) in comparison with normal weight women (2.13%). Hydramnios, preterm delivery and induction of labor were insignificantly increased in both obese and overweight compare with normal weight pregnant women, while, induction of labor and Caesarean delivery were significantly increased in obese only (16.30%, Chi square,  $P < 0.05$ ) and (51.85%, Chi square,  $P < 0.05$ ) compare with normal weight women (14.18 and 41.13%) respectively (table 1).

In the current study, (141 out of 432 pregnant women) were obese (33.41%), and (156 out of 432 pregnant women) were overweight (36.11%). The National Health and Nutrition Examination Survey found that more than one third of women are obese, more than one half of pregnant women are overweight or obese, and 8% of reproductive-aged women are extremely obese [17]. Overweight and obesity represented a global health problems. The results of the current study revealed that increasing maternal BMI was associated with adverse health outcomes for both the mothers and neonates. Overweight and obese women have a higher risk of gestational hypertension, gestational diabetes, abortion, large-for gestational-age (LGA), and infant admission to the NICU. These findings are consistent with many previous reports [18-25].

Previous investigations revealed that gestational hypertension and preeclampsia were significantly increased in overweight and obese women. The risk was doubled with each 5–7 kg/m<sup>2</sup> increase in pre-pregnancy BMI [26-27].

A systematic review of the literature calculated that for each 1 kg/m<sup>2</sup> increase in BMI, the prevalence of gestational diabetes mellitus increased by 0.92% [6, 28-30].

Many studies reported an increased incidence of induced labors and emergency Caesarean sections in obese mothers compared with mothers of normal weight ( $<0.05$ ). Reasons reported for surgery included macrosomia-associated cephalopelvic disproportion, fetal distress, and stagnation of induced labor [31-35].

In studying of the fetal and neonatal complications of overweight and obese pregnant women, it appeared that macrosomia was significantly increased in both overweight (6.41%,  $P < 0.05$ ) and obese (6.67%,  $P < 0.05$ ) in comparison with normal weight pregnant women (2.84%). LGA was also significantly increased in overweight (6.41%,  $P < 0.05$ ) and obese (4.67%,  $P < 0.05$ ) compared with normal weight pregnant women (2.84%), while SGA was significantly decreased in overweight (3.85%,  $P < 0.05$ ) and obese (3.93%,  $P < 0.05$ ) compared with normal weight pregnant women (7.80%). No significant changes were recorded in neonatal hyperbilirubinemia, abortion, congenital defects, admission in NICU and fetal death, in overweight in comparison with normal weight women. However, admission in NICU was significantly increased in obese (19.26,  $P < 0.05$  vs 14.89% in normal weight

Comment [AHP9]: problem

women). In addition abortion was also significantly increased in obese (39.26%,  $P < 0.05$ ) compared with normal weight women (29.08%) (table 2).

Comment [AHP10]: addition,

Neonates of obese mothers had statistically significant more hospital stay and reported 7.07% neonatal hyperbilirubinemia, respiratory distress (7.07%), macrosomia (1.01%), in addition to increase the risk of abortion and admission in NICU [32, 36-37].

Athukorala et al, also recorded that the mean birth weight of babies born to overweight and obese mothers were significantly greater than babies born to women with a normal BMI [14, 38].

According to the previous studies, there was a strong association between obese maternal environment pregnancy and oxidative stress, compared with normal weight. Maternal and neonates' adverse effect could be attributed to obesity induced mitochondrial dysfunction with an increase in mitochondrial reactive oxygen species and oxidative stress in oocytes, zygotes and embryonic development [39-41].

Furthermore, overweight and obesity were linked with circulating inflammation markers. C-reactive protein, cytokines, tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), interleukin-6 (IL-6), and interleukin-8 (IL-8) were elevated in obese pregnant women [42-43]. Inflammatory markers in obesity were causally linked to insulin resistance. Several studies have examined the association between circulating maternal inflammatory markers and maternal and neonatal adverse effects. Recent studies indicated that the inflammatory state extends to the fetal side. A gene expression study of umbilical cord tissue in term infants from healthy lean and obese women identified a proinflammatory signature characterized by upregulation of acute phase response genes, including *EGR1* and *FOSB*. However, the contribution of inflammation to developmental programming is mainly associative and definitive mechanistic studies are lacking [44-47].

**Table 1: Maternal complications of overweight and obese pregnant women compared with those with normal weight**

Parameters (%)	Normal weight BMI: 9.8-24.9 kg/m <sup>2</sup>	Overweight BMI: 25- 29.9 kg/m <sup>2</sup>	Obese BMI: 30 kg/ m <sup>2</sup> or more	Significancy of each parameter	
				Overweight vs normal	Obese vs normal
gestational hypertension	7.09	16.03	28.89	( $P < 0.05$ )	( $P < 0.05$ )
gestational diabetes	2.13	5.13	10.37	( $P < 0.05$ )	( $P < 0.05$ )
Hydramnios	4.26	5.13	7.41	NS	NS
preterm delivery	9.22	10.26	12.59	NS	NS
induction of labor	14.18	14.82	16.30	NS	( $P < 0.05$ )
Caesarean delivery	41.13	44.31	51.85	NS	( $P < 0.05$ )

Comment [AHP11]: Gestational

NS: means not significant

**Table 2: Fetal and neonatal complications of overweight and obese pregnant women compared with those with normal weight**

Parameters (%)	Normal weight BMI: 9.8-24.9 kg/m <sup>2</sup>	Overweight BMI: 25-29.9 kg/m <sup>2</sup>	Obese BMI: 30 kg/m <sup>2</sup> or more	Significance of each parameter	
				Overweight vs normal	Obese vs normal
Macrosomia	2.84	6.41	6.67	(P < 0.05)	(P < 0.05)
LGA	4.96	6.41	6.67	(P < 0.05)	(P < 0.05)
SGA	7.80	3.85	3.93	(P < 0.05)	(P < 0.05)
neonatal hyper-bilirubinemia	29.08	28.21	30.37	NS	NS
abortion	29.08	33.33	39.26	NS	(P < 0.05)
congenital defects	2.82	3.21	3.70	NS	NS
admission in NICU	14.89	14.90	19.26	NS	(P < 0.05)
fetal death	10.64	10.13	14.81	NS	NS

NS: means not significant

#### 4. CONCLUSION

Pregnancy complications related to maternal BMI is a growing problem. Maternal overweight and obesity in pregnancy are important contributors to obstetric complications and adverse outcomes. Maternal obesity is a risk factor for antepartum, intrapartum and postpartum complications. Public health efforts are urgently required to promote weight management among women of reproductive age before conception and during pregnancy.

#### ACKNOWLEDGMENT

The authors appreciate the efforts of the reviewers.

#### CONSENT

The manuscript didn't contain any individual person's data.

#### ETHICAL APPROVAL

The study was approved by the ethical committee of health directorate of Thi-Qar governorate and the ethical board of the College of Medicine – Thi qar university-Iraq.

#### REFERENCES

1. Melchor I, Burgos J, Campo A, Aiartzaguena A, Gutiérrez J, Melchor JC. Effect of maternal obesity on pregnancy outcomes in women delivering

- singleton babies: a historical cohort study. *J Perinat. Med.* 2019; 47(6): 625–630.
2. DeNicola E, Aburizaiza OS, Siddique A, Khwaja H, Carpenter DO. Obesity and public health in the Kingdom of Saudi Arabia. *Rev. Environ. Health.* 2015; 30: 191–205.
  3. Mission J, Marshall N, Caughey A. Obesity in pregnancy: a big problem and getting bigger. *Obstet Gynecol Surv.* 2013;68:389-99.
  4. Bhattacharya S, Campbell DM, Liston WA. Effect of body mass index on pregnancy outcomes in nulliparous women delivering singleton babies. *BMC Public Health.* 2007;24(7):168.
  5. Anna-Maria Siega-Riz, Barbaria, Laraia. The implications of maternal overweight and obesity on the course of pregnancy and birth outcomes. *Matern Child Health J.* 2006; 10: S153-156.
  6. Sebire NJ, Jolly M, Harris JP. Maternal obesity and pregnancy outcome: a study of 287, 213 pregnancies in London. *Int J Obes.* 2001;25:1175-82.
  7. Seeniammal P, Chellamma VK, Umadevi N. A comparative study of the effect of body mass index on pregnancy outcomes in normal and overweight women. *Int J Reprod Contracept Obstet Gynecol.* 2017;6(4):1550-1554.
  8. Adani N, Fouly H, Omer T. Assessing the impact of obesity on pregnancy and neonatal outcomes among Saudi women. *Nurs Rep.* 2021; 11: 279–290.
  9. Safarzadeh A, Zare S, Khorshid MR, Piran F. Etiology of adverse prenatal Outcome in overweight women. *International Journal of Medical Research & Health Sciences.* 2016; 5: 9:96-101.
  10. Ahmed SR, Ellah MA, Mohamed OA, Eid HM. Prepregnancy obesity and pregnancy outcome. *International Journal of Health Sciences, Qassim University.* 2009; 3(2): 203-208.
  11. D'Souza R, Horyn I, Pavalagantharajah S, Zaffar N, Jacob CE. Maternal body mass index and pregnancy outcomes: a systematic review and metaanalysis. *AJOG.* 2019;1(4):100041.
  12. Lewandowska M, Sajdak S, Wieckowska B, Manevska N, Lubinski J. The influence of maternal BMI on adverse pregnancy outcomes in older women. *Nutrients.* 2020; 12: 2838.
  13. Lamminp R, Vehvilinen-Julkunen K, Gissler M, Selander T, Heinonen S. Pregnancy outcomes of overweight and obese women aged 35 years or older - A registry-based study in Finland. *Obesity Research & Clinical Practice.* 2016; 10: 133—142.
  14. Athukorala C, Rumbold AR, Willson KJ, Crowther CA. The risk of adverse pregnancy outcomes in women who are overweight or obese. *BMC Pregnancy and Childbirth.* 2010; 10:56.
  15. Al-Kubaisy W, Al-Rubaey M, Al-Naggar R, Karim B, Mohd Noor NA. Maternal obesity and its relation with the cesarean section: A hospital based cross sectional study in Iraq. *BMC Pregnancy and Childbirth* 2014; 14:235.

**Comment [AHP12]:** older women

16. Mahmood BD. Effect of obesity on the outcome of pregnancy in primigravida patients: an Iraqi experience. *Int J Reprod Contracept Obstet Gynecol.* 2019;8(3): 1-5.
17. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *JAMA.* 2012; 307:491–7.
18. Marchi J, Berg M, Dencker A, Olander EK, Begley C. Risks associated with obesity in pregnancy, for the mother and baby: a systematic review of reviews. *Obes Rev.* 2015;16:621–628.
19. Wang Z, Wang P, Liu H, He X, Zhang J, Yan H. Maternal adiposity as an independent risk factor for pre-eclampsia: a meta-analysis of prospective cohort studies. *Obes Rev.* 2013;14:508–521.
20. Heslehurst N, Vieira R, Hayes L, Crowe L, Jones D, Robalino S. Maternal body mass index and post-term birth: a systematic review and meta-analysis. *Obes Rev.* 2017;18:293–308.
21. Manzanares S, Santalla A, Vico I, López MS, Pineda A, Gallo JL. Abnormal maternal body mass index and obstetric and neonatal outcome. *J Matern Fetal Neonatal Med.* 2012;25:308–312.
22. Aune D, Saugstad OD, Henriksen T, Tonstad S. Maternal body mass index and the risk of fetal death, stillbirth, and infant mortality: a systematic review and meta-analysis. *J Am Med Assoc.* 2014;311:1536–46.
23. Gaudet L, Ferraro ZM, Wen SW, Walker M. Maternal obesity and occurrence of fetal macrosomia: a systematic review and metaanalysis. *Biomed Res Int.* 2014; 2014: 640291.
24. Schummers L, Hutcheon JA, Bodnar LM, Lieberman E, Himes KP. Risk of adverse pregnancy outcomes by prepregnancy body mass index: a population-based study to inform prepregnancy weight loss counseling. *Obstet Gynecol.* 2015;125:133–143.
25. Kim SS, Zhu Y, Grantz KL, Hinkle SN, Chen Z, Wallace ME. Obstetric and neonatal risks among obese women without chronic disease. *Obstet Gynecol.* 2016;128:104–112.
26. Sara Sukalich, Mingione MJ, Glantz JC. obstetric outcomes in overweight and obese adolescents *AJOG.* 2006;195:851-855.
27. O'Brien TE, Ray JG, Chan WS. Maternal body mass index and the risk of preeclampsia: A systematic overview. *Epidemiology.* 2003;14:368–74.
28. Torloni MR, Betran AP, Horta BL, Nakamura MU, Atallah AN, Moron AF. Prepregnancy BMI and the risk of gestational diabetes: a systematic review of the literature with meta-analysis. *Obes Rev.* 2009;10:194–203.
29. Catalano P. Editorial. Obesity and pregnancy-the propagation of a vicious cycle? *J Clin Endocrinol Metab.* 2003;88(8):3505-3506.
30. Callaway LK, Prins JB, Chang AM, McIntyre HD. The prevalence and impact of overweight and obesity in an Australian obstetric population. *Med J Aust.* 2006;184:56-59.
31. Hendler I, Goldenberg RL, Mercer BM, Iams JD, Meis PJ, Moawad AH. The Preterm Prediction Study: association between maternal body mass index and spontaneous and indicated preterm birth. *Am J Obstet Gynecol.* 2005;192:882-6.
32. Vanlalfeli Z. Study of maternal and fetal outcome in obesity complicating pregnancy. *International Journal of Contemporary Medical Research Section: Obstetrics and Gynaecology.* 2020; 7(2):1-5.

**Comment [AHP13]:** delete and write its abbreviation following the second name



33. Usha Kiran TS, Hemmadi S, Bethel J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. *Usha Kiran TS; Hemmadi S; Bethel J; Evans J BJOG*. 2005;112(6):768-772.
34. Ekblad U, Grenman S. Maternal weight, weight gain during pregnancy and pregnancy outcome. *Int J Gynaecol Obstet*. 1992;39:277-83.
35. Brost BC, Goldenberg RL, Mercer BM, Iams JD, Meis PJ, Moawad AH. The Preterm Prediction Study: association of cesarean delivery with increases in maternal weight and body mass index. *Am J Obstet Gynecol*. 1997;177:333-7.
36. Radhakrishnan U, Kolar G, Nirmalan PK. Cross-sectional study of gestational weight gain and perinatal outcomes in pregnant women at a tertiary care center in southern India. *J Obstet Gynaecol Res*. 2014;40:25-31.
37. Baeten JM, Bukusi EA, Lambe M. Pregnancy complications and outcomes among overweight and obese nulliparous women. *Am J Public Health*. 2001;91:436-440.
38. Ramachenderan J, Bradford J, McLean M. Maternal obesity and pregnancy complications: a review. *Aust N Z J Obstet Gynaecol*. 2008; 48: 228–235.
39. Heerwagen, M.J.R., Miller, M.R., Barbour, L.A., and Friedman, J.E. Maternal obesity and fetal metabolic programming: a fertile epigenetic soil. *Am J Physiol Regul Integr Comp Physiol*. 2010; 299:711–722
40. Malti,N. Merzouk H. MerzoukS.A. Loukidi,B. Karaouzene, N. Malti,A. Narce M. Oxidative stress and maternal obesity: Feto-placental unit interaction. *Placenta*. 35 2014; 411-416.
41. Dennery, P.A. Effects of oxidative stress on embryonic development. *Birth Defects Res Embryo Today*. 2007; 81: 155–162.
42. Redman CW, Sargent IL. Placental stress and pre-eclampsia: a revised view. *Placenta*. 2009;30 (Suppl A): S38-42.
43. Ribatti, D., Conconi, M.T., and Nussdorfer, G.G. Nonclassic endogenous novel regulators of angiogenesis. *Pharmacol Rev*. 2007; 59: 185–205.
44. Friis CM, Paasche Roland MC, Godang K, et al. Adiposity-related inflammation: effects of pregnancy. *Obesity*. 2013;356:E124-30.
45. Gaillard R, Rifas-Shiman S, Perng W, Oken E, Gillman MW. Maternal inflammation during pregnancy and childhood adiposity. *Obesity*. 2016;356:1320-7.
46. Radaelli T, Lepercq J, Varastehpour A, Basu S, Catalano PM, Hauguel-De Mouzon S. Differential regulation of genes for fetoplacental lipid pathways in pregnancy with gestational and type 1 diabetes mellitus. *Am J Obstet Gynecol*. 2009;356:209.
47. Thakali KM, Saben J, Faske JB. Maternal pregravid obesity changes gene expression profiles toward greater inflammation and reduced insulin sensitivity in umbilical cord. *Pediatr Res*. 2014;356:202-210.

**Comment [AHP14]:** write these names in same form as the previous references.