

DOI: [10.15419/bmrat.v5i8.468](https://doi.org/10.15419/bmrat.v5i8.468)

Review

**Article History:**

Received: 17 May 2018

Accepted: 17 June 2018

Published: 25 August 2018

**Keywords:**Cholesterol, HDL, LDL, Lipid profile,  
Preterm delivery, Triglycerides**Author for correspondence:**

Fatemeh Abdi

e-mail: [abdi@sbmu.ac.ir](mailto:abdi@sbmu.ac.ir)

## The relationship between lipid profiles in pregnancy and preterm delivery: a systematic review

Zohreh Aghaie<sup>1</sup>, Sepideh Hajian<sup>2</sup> and  
Fatemeh Abdi<sup>3</sup><sup>1</sup>MSc Student of Midwifery, Nursing and Midwifery  
Faculty, Shahid Beheshti University of Medical  
Sciences, Tehran, Iran<sup>2</sup>Assistant Professor, Department of Reproductive  
Health, Nursing and Midwifery Faculty, Shahid  
Beheshti University of Medical Sciences, Tehran, Iran<sup>3</sup>PhD., Student Research Committee, Nursing and  
Midwifery Faculty, Shahid Beheshti University of  
Medical Sciences, Tehran, Iran

### Abstract

**Background:** High-density lipoprotein (HDL), low-density lipoprotein (LDL), triglyceride (TG), and total cholesterol (TC) are associated with maternal hormonal changes which can lead to pregnancy complications. High lipid levels during pregnancy may be accompanied by an increased risk of spontaneous preterm labor. The purpose of this review was to determine the relationship between lipid profiles in pregnancy and preterm delivery. **Methods:** A systematic search was performed in PubMed, EMBASE, Web of Science, Scopus, and Science Direct databases to find cross-sectional, case-control, and cohort studies on the associations between lipid profiles in pregnancy and preterm delivery. The search results were limited to papers published during 2000-2018. The quality of the selected studies was assessed based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist. Finally, a total of 25 eligible high-quality papers were reviewed. **Results:** A high maternal TG level in the first trimester of pregnancy was identified as a significant risk factor for preterm delivery. Low TG, HDL-cholesterol (HDL-C) and LDL-cholesterol (LDL-C) levels were uniquely associated with an increased risk of preterm delivery. High TC, TG, and LDL-C levels increased the risk of spontaneous preterm labor. A further association was found between high TG and TC levels and an elevated risk of preterm labor before 34 weeks of gestation. The risk of preterm labor before 34 weeks and during the 34th-37th weeks of gestation increased with increasing TG and TC levels. Moreover, overweight women who had a delivery before 34 weeks exhibited significant increases in TC and LDL concentrations during early pregnancy. **Conclusion:** Lipid metabolism undergoes complicated changes in pregnancy. Lipid levels (LDL, HDL, TC, and TG) above or below the normal range during pregnancy increase the risk of preterm delivery. Considering the significance of maternal lipid metabolism in the incidence of preterm delivery, lipid profile screening in early pregnancy can largely contribute to the prevention of preterm delivery. Further studies are warranted to meticulously examine the effects of lipid profile on preterm delivery.

## 1. Background

Preterm delivery is one of the main causes of pre- and postnatal morbidity and mortality in developed countries. Preterm delivery accounts for 75-90% of neonatal and prenatal mortalities and serves as the main cause of short- and long-term neonatal defects [1]. About 13 million spontaneous preterm deliveries occur around the world each year. The incidence rates differ in different countries [2] and have been reported as 2.9% in Iran [3]. Preterm labor is associated with increased respiratory disorders, pulmonary edema, and impaired glucose tolerance in the newborn [4]. Premature infants may develop a number of short- and long-term conditions including respiratory distress syndrome, bronchopulmonary dysplasia, apnea of prematurity, hyperbilirubinemia, nosocomial infections, immunodeficiency, patent artery duct, intraventricular hemorrhage, bacterial and fungal sepsis, precocious retinopathy of prematurity, necrotizing enterocolitis, food intolerance, mental retardation, blindness, and hearing loss [5]. While approximately 10-15% of highly premature neonates show symptoms of neurodegenerative defects, such as cerebral palsy, more complications including learning disability and emotional problems may be seen in 50% of these infants [1].

Despite advancements in neonatal care, premature infants are at higher risk for mortality and those who survive may experience neurodevelopmental delay [6]. A variety of factors, some of which have not been clearly identified, may be responsible for spontaneous preterm delivery. Some studies have reported relationships between risk factors for maternal cardiopulmonary complications and undesirable pregnancy outcomes, such as low gestational age and low birth weight. Associations have also been established between HDL, LDL, TG, and TC levels and maternal hormonal changes, and in turn, pregnancy problems and changes in the fetal development process [7,8]. While the exact mechanisms through which these changes in the maternal plasma lipid profile affect fetal development and birth are not clear, recent studies have highlighted the significant biochemical and physiological effects of cholesterol on the function of fetal membranes and neonatal neurodevelopment.

The transfer of maternal cholesterol to the fetus through the umbilical cord might justify these effects. A previous study reported that low birth weight infants had lower HDL levels compared to their term counterparts [9,10]. There is still controversy over the association between maternal lipid profile and preterm delivery. In several studies, both high and low HDL, LDL, TG, and TC levels almost doubled the risk of spontaneous preterm delivery [11]. Some studies, on the other hand, have used maternal serum screening and rejected any relationships between the highest/lowest lipid levels and preterm labor [12]. A systematic review found that the risk of spontaneous preterm delivery could be increased by high TG levels, but was not affected by HDL-C and LDL-C levels [13]. Meanwhile, Heida *et al.* (2017) reported lower TC and LDL-C levels in women with spontaneous preterm delivery, but could not establish a significant relationship between undesirable lipid levels and preterm delivery [14]. Since changes in fat metabolism during pregnancy can be associated with adverse pregnancy outcomes, this review aimed to determine the association between lipid profiles during pregnancy and preterm delivery.

## 2. Methods

### (a) Search strategy

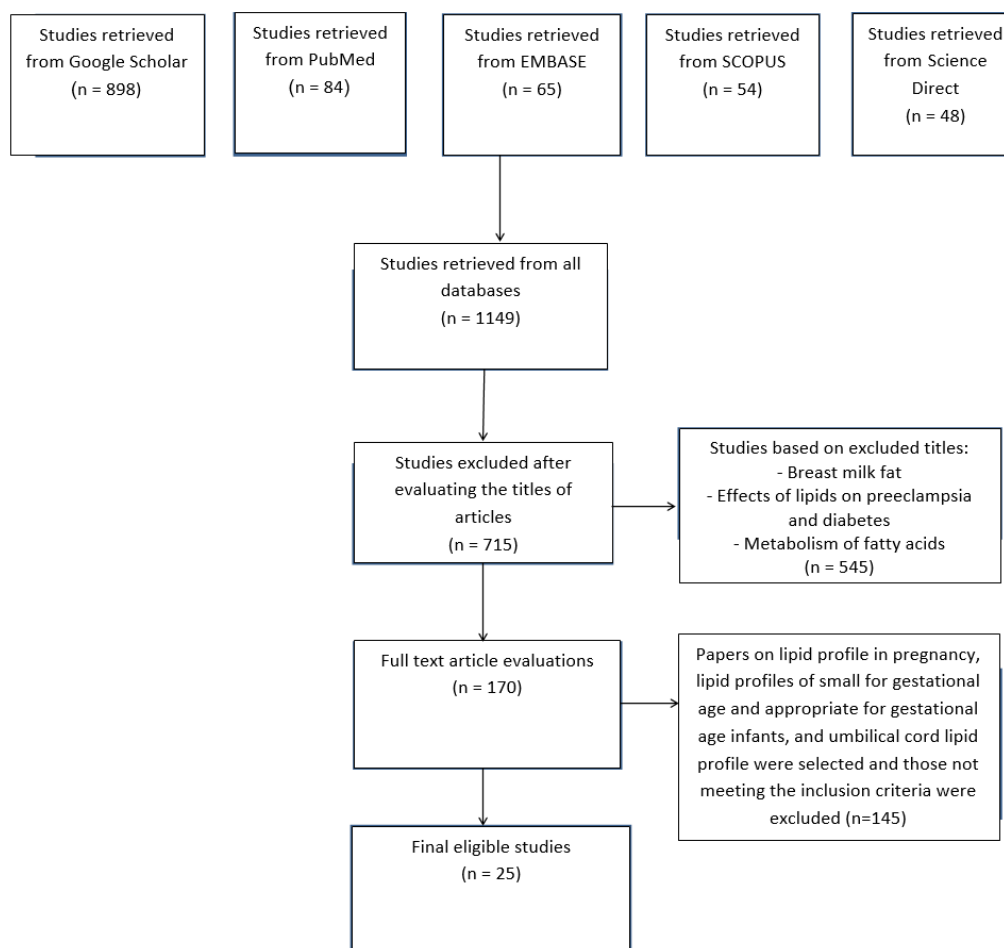
The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed in the report of this study [15]. The required data were collected by searching various combinations of a number of keywords, i.e. premature birth OR preterm delivery OR preterm labor AND lipid profile OR cholesterol OR high-density lipoprotein OR low-density lipoprotein OR triglyceride, in valid databases including MEDLINE, ISI Web of Science, PubMed, EMBASE, Scopus, ProQuest, and Science Direct.

## (b) Inclusion and exclusion criteria

Cohort and case-control studies published in English or Persian during 2000-2018 were included if they evaluated the relationship between lipid profiles during pregnancy and preterm labor (from the 28-37<sup>th</sup> week of gestation) in mothers who had no particular medical conditions (preeclampsia or diabetes), and gave birth to a singleton infant through vaginal delivery. Case report studies of infants with low Apgar score (<7), women with multifetal pregnancy, and studies with incomplete information were excluded.

## (c) Study selection

After the initial search, 1149 studies were extracted and independently evaluated by two authors to determine eligibility. Any cases of disagreement were resolved through a consensus. As a result, 434 irrelevant or duplicate articles were excluded. The titles and abstracts of the remaining 715 studies were then assessed and 545 more papers were excluded. Evaluating the full texts of the remaining 170 articles resulted in the exclusion of 145 ineligible articles and confirmed the eligibility of 25 papers (**Figure 1**).



**Figure 1. Search flow diagram**

#### (d) Quality assessment

The adherence of quantitative studies to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist [16,17] was evaluated as a measure of their quality. Studies were classified as high-, medium-, and low-quality if they adhered to all seven items, six items, and two or more items of the STROBE, respectively.

#### (e) Data extraction

Study selection and validity assessment were independently performed by two authors and cases of disagreement were resolved by consulting a third researcher. The required data included the first author's name, publication year, study design, country of study, sample size, gestational age at sampling and delivery, outcomes, odds ratio (OR), risk ratio (RR), mean, and standard deviation (SD) of TC, TG, HDL and LDL. The data were extracted from all studies and entered into the analysis.

### 3. Results

All the 25 studies selected after the search process met the inclusion criteria and showed high quality according to their adherence to the STROBE checklist (**Figure 1**). As seen in **Tables 1, 2, 3, 4, 5, 6 and 7**, the sample size of the selected studies ranged between 80 and 9938 women and provided a pool of 31833 women. These women were of different ages and were selected from different countries including USA (n=8), China (n=4), Iran (n=2), Japan (n=2), Netherlands (n=2), Turkey (n=1), India (n=1), Greece (n=1), Nigeria (n=1), Finland (n=1), Canada (n=1), and Spain (n=1). The selected studies had cohort or case-control designs (n=17 and n=8, respectively).

Evaluating the results of the selected studies suggested high maternal TG level in the first trimester of pregnancy as an important and significant factor in preterm delivery. Low TG, HDL-C and LDL-C levels were exclusively related to the increased risk of preterm delivery. High TC, TG and LDL-C levels were also associated with an elevated risk of spontaneous preterm labor. A further association was observed between high TG and TC levels and increased risk of preterm labor before the 34<sup>th</sup> week of pregnancy and during the 34<sup>th</sup>-37<sup>th</sup> weeks. Moreover, considerably high TC and LDL levels were found in overweight women who had a delivery before 34 weeks **Tables 8 and 9**.

Table 1: The characteristics of the studies included in the systematic review

Author (year)	Country	Design	Sample size	GA at sampling (week)	GA at delivery (week)
Emet (2013) [44]	Turkey	cohort	801	<14; >28	26-41
Jin1 (2016) [43]	China	cohort	934	28-37	<37; 37-42
Vrijkotte (2012) [7]	Netherlands	cohort	3912	13	24-36; >37
Kelishadia (2007) [45]	Iran	cohort	442	<37; 37-42; >42	<37; 37-42; >42
MUDD (2012) [46]	USA	cohort	1309	15-27	<37
Shoji (2013) [42]	Japan	case-control	80	≤35	≤35
Yonezawam (2009) [20]	Japan	case-control	103	Case: <37; Control: 37-42	Case: <37; Control: 37-42
Chen (2017) [24]	USA	case-control	559	20, 28	Case: <37; Control: 37-42
Catov (2007) [18]	USA	case control	289	<15	<34; 34-37; 37-42
Heida (2017) [14]	Netherlands	cohort	165	24-36	28-36
Grace (2017) [28]	USA	cohort	715	<20; 24-29	<37; 37-42
Qiu (2017) [29]	China	case-control	300	24-36	24-36
Li (2015) [30]	China	case-control	378	28-37	28-36; 37-42
Ghodke (2017) [21]	India	cohort	200	16-32	28-37
Catov (2017) [22]	USA	cohort	64	<18	28-36; 37-42
Wang (2017) [31]	China	cohort	5218	14	28-36; >37
Maymunah (2014) [32]	Nigeria	cohort	320	14	<37
L Chatzi (2009) [41]	Greece	cohort	74	15	>37
Catov (2010) [35]	USA	cohort	1010	<34; 34-37; >37	<34; 34-37; >37
Harville (2011) [33]	Finland	cohort	1142	NR	<37
NIROMANESH (2012) [23]	Iran	cohort	440	16-20	>37
Kramern (2009) [26]	Canada	case-control	651	24-26	<37
Edison (2007) [38]	USA	cohort	9938	13-23	<37
Bartha (2011) [34]	Spain	case-control	90	24-36	24-36; >37
Alleman (2013) [12]	USA	cohort	2699	20	24-36

## 4. Discussion

Given the significance of preterm delivery, we reviewed the results of high-quality studies on the associations between lipid levels during pregnancy and preterm birth. Our review indicated high maternal TG level in the first trimester of pregnancy as a significant risk factor for preterm delivery. In a case-control study, Catov *et al.* (2007) reported an association between lipid profile and preterm labor, i.e. high TG and cholesterol levels increased the risk of preterm labor before the 34<sup>th</sup> week and during the 34<sup>th</sup>-37<sup>th</sup> weeks of gestation. Overweight women who delivered before 34 weeks had particularly higher levels of cholesterol and LDL. TG levels were also increased in underweight women and these women showed lower TG responses during the first half of pregnancy [18]. Vrijkotte *et al.* (2012) investigated maternal lipid profile in early pregnancy and its association with pregnancy complications and concluded that high first trimester TG levels could be a significant risk factor for preterm delivery [19]. Yonezowa *et al.* (2009) examined umbilical cord lipids in preterm infants and confirmed low TG levels in preterm infants. They, thus, identified 34 weeks of pregnancy as a critical period for TG metabolism and reported considerable increments in umbilical cord TG levels during the 32<sup>th</sup>-34<sup>th</sup> weeks [20]. Ghodake *et al.* (2017) established an association between early pregnancy TG levels and preterm delivery. However, no such relations were found in cases of TC, LDL, and HDL levels [21]. Catov *et al.* (2017) examined the heterogeneity of lipoproteins during pregnancies leading to preterm delivery and showed that preterm labor was seen in women with high TG levels. However, LDL-C had no direct relation with preterm delivery [22]. Likewise, Niromanesh *et al.* (2012) underlined the positive association between hypertriglyceridemia and preterm delivery [23].

We also found evidence of the relationship between low TG, HDL-C, and LDL-C levels and increased risk of preterm delivery. Indeed, elevations in TC, TG, and LDL-C levels were also associated with an increased risk of spontaneous preterm labor. According to Chen *et al.* (2017), despite differences in lipid levels of different races and ethnicities, higher HDL-C levels during early pregnancy universally increased the risk of spontaneous preterm labor [24]. Catov *et al.* (2014) identified high HDL levels as a risk factor for spontaneous preterm labor [25]. Kramer *et al.* (2009) investigated the vasculopathic and thrombophilic risk factors for preterm delivery and highlighted the contribution of reductions in maternal lipids to the incidence of preterm labor. They further noted the associations between spontaneous preterm delivery and elevated TC and LDL levels. Their findings also suggested the protective role of high HDL levels in preterm delivery [26].

Kaser *et al.* (2001) evaluated lipid levels in infants and reported small for gestational age (SGA) neonates to have lower HDL, LDL, and TC levels, compared to appropriate for gestational age (AGA) infants [27]. Moreover, Heida *et al.* (2017) found no correlations between spontaneous preterm delivery and unfavourable lipid levels or cardiovascular biochemical risk factors in mothers [14]. Grace *et al.* (2017) examined the relationship between maternal serum lipoproteins and gestational age, and reported LDL and HDL concentrations to be independently related with gestational age at preterm delivery [28]. Qiu *et al.* (2017) studied maternal serum lipid profiles and homocysteine in late pregnancy and showed higher TC and LDL levels in mothers with preterm delivery than in those with term delivery. In contrast, mothers with term delivery had higher HDL levels compared to those with preterm delivery [29].

Moreover, Li *et al.* (2015) investigated the relationships between lipid levels and single-nucleotide polymorphisms of APOE, ABCA1, and HMGCR genes in women with preterm labor. They found that HDL, TG, and LDL levels decreased in mothers with preterm delivery. They also established relationships between maternal TG and LDL levels and HMGCR genotype, and concluded that HMGCR might be a suitable gene for preterm delivery [30]. Wang *et al.* (2017) found associations between elevations in first trimester TG, TC, LDL, and HDL levels and risk of preterm labor.

On the other hand, low LDL, TG, and TC levels and a high HDL level during pregnancy might have a protective role against preterm delivery [31]. Maymunah *et al.* (2014) studied hypercholesterolemia as one of the predictors of undesirable pregnancy outcomes and reported

Table 2. The characteristics of the studies included in the systematic review (continued)

Author (year)	Mean, SD, OR, RR				Outcome
	TC	LDL	HDL	TG	
Emet 2013	Trimester 1: M:166.20 SD:28.28	Trimester 1: M:93.75 SD:23.22	Trimester 1: M:53.37 SD:10.51	Trimester 1: M:93.09 SD:45.57	<ul style="list-style-type: none"> <li>- Lipid metabolism undergoes complex changes during pregnancy.</li> <li>- Lipid metabolism decreases in preterm pregnancies.</li> <li>- There was no significant relationship between changes in lipid metabolism during pregnancy and infant's weight in the third month after birth.</li> </ul>
	Trimester 3: M:271.28 SD: 47.81	Trimester 3: M: 154.5 SD :44.15	Trimester 3: M:63.54 SD:21.16	Trimester 3: M:274.10 SD: 101.89	
Jin1 2016	OR :0.80	OR: 0.83	OR: 1.05	OR: 1.04	- Maternal lipid metabolism plays an important role in preventing pregnancy complications and adverse birth outcomes.
Vrijkotte 2012	OR:0.93 M :5.01 SD:0.86	NR	NR	OR: 0.83 M : 1.36 SD: 0.55	- High maternal TG levels in the first trimester of pregnancy significantly increased the risk of induced preterm labor.
	Control: M :4.98 SD:0.87			Control: M : 1.33 SD: 0.55	
Kelishadia 2007	M:76.9 SD:28.9	M: 34.1 SD: 11.7	M: 30.1 SD: 9.4	M: 67.5 SD: 20.1	<ul style="list-style-type: none"> <li>- Found significant differences in the cord lipid profile of neonates with small for gestational age.</li> <li>- Low TC, LDL-C, and HDL-C levels independently resulted in modest elevations in the risk of medically indicated preterm delivery.</li> <li>- There were associations between high TC, LDL-C, and TG levels and elevated risk of SPTD.</li> </ul>
	SPTD: OR:1.30	SPTD OR: 1.50	SPTD OR: 1.14	SPTD OR: 1.0	
MUDD 2012	MIPTD: (Medically indicated preterm delivery) OR:2.09	MIPTD OR: 2.04	MIPTD OR:1.86	MIPTD OR: 1.0	
Shoji 2013	M :85 SD:24.8	M : 35.5 SD: 15.4	M : 29.0 SD: 8.6	M : 26.9 SD: 18.0	- Lipid and apolipoprotein metabolism, as well as atherogenic indices at birth, in preterm infants may be affected by prematurity and poor fetal growth.

Table 3. The characteristics of the studies included in the systematic review (continued)

Author (year)	Mean, SD, OR, RR				Outcome
	TC	LDL	HDL	TG	
Yonezawam 2009	Case M: 72.1 SD: 3.5 Control: M: 64.9 SD: 2.0	Case M: 25.4 SD: 1.7 Control: M: 20.7 SD: 0.8	Case M: 36.9 SD: 1.9 Control: M: 36.6 SD: 1.3	Case M: 23.5 SD: 3.1 Control: M: 26.3 SD: 2.1	<ul style="list-style-type: none"> <li>- 34 weeks of gestation was identified as a critical period for TG metabolism.</li> <li>- A dramatic increase in cord blood TG was observed during 32-34 weeks and the development of respiratory distress syndrome seemed to be inhibited afterwards.</li> <li>- Higher LDL-C levels were seen in preterm infants than in term neonates.</li> <li>- LDL-TG levels were significantly lower in preterm neonates than in term neonates.</li> <li>- Preterm and term neonates had no differences in terms of HDL-C and HDL-TG levels.</li> </ul>
	Case M: 4.448 SD: 0.074 Control: M: 4.361 SD: 0.051	Case M: 3.195 SD: 0.066 Control: M: 3.165 SD: 0.046	Case M: 1.275 SD: 0.024 Control: M: 1.204 SD: 0.016	Case M: 1.712 SD: 0.070 Control: M: 1.701 SD: 0.048	
Chen 2017	Case M: 188.0 SD: 33.6 34-37 M: 196.5 SD: 43.7 <34 M: 203.3 SD: 50.5	Case M: 104.7 SD: 28.6 34-37 M: 110.2 SD: 37.9 <34 M: 118.3 SD: 44.8	Case M: 65.1 SD: 16.2 34-37 M: 65.7 SD: 16.2 <34 M: 65.0 SD: 18.7	Case M: 90.6 SD: 41.5 34-37 M: 102.6 SD: 43.8 <34 M: 100.2 SD: 60.2	<ul style="list-style-type: none"> <li>- Maternal lipid levels differ between different ethnicities.</li> <li>- A more favorable lipid profile and thus better cardiovascular protection was observed in African-American women.</li> <li>- Higher HDL-C and apoA1 increased the risk of SPTD and this association was independent of ethnicity.</li> <li>- Increments in cholesterol and TG levels very early in pregnancy increased the risk of preterm delivery before 34 weeks (by 2.8 folds) and during 34-37 weeks (by 2 folds).</li> <li>- Early pregnancy elevations in TG were seen in normal-weight women who delivered moderately preterm.</li> <li>- Women who delivered at 34 weeks had an altered TG adaptation to pregnancy during the first 21 weeks.</li> </ul>
	Case M: 5.98 SD: 18.7	Case M: 3.24	Case M: 1.75	Case M: 2.29	
Heida 2017					<ul style="list-style-type: none"> <li>- SPTD had no significant associations with unfavorable lipid levels or cardiovascular biochemical risk factors.</li> </ul>



Table 4. The characteristics of the studies included in the systematic review (continued)

Author (year)	Mean, SD, OR, RR				Outcome
	TC	LDL	HDL	TG	
Grace 2017	Preterm: 20 wk: M: 198.02 SD: 37.55 24-29 wk: M: 235.76 SD: 49.77 Term: 20 wk: M: 203.12 SD: 35.86 24-28 wk: M: 244.49 SD: 46.64	Preterm: 20 wk: M: 21.66 SD: 0.86 24-28 wk: M: 73.97 SD: 74.87 Term: 20 wk: M: 21.85 SD: 0.74 24-28 wk: M: 21.92 SD: 0.75	Preterm: 20 wk: M: 9.64 SD: 0.40 24-28 wk: M: 12.87 SD: 3.23 Term: 20 wk: M: 9.70 SD: 0.37 24-28 wk: M: 9.77 SD: 0.37	Preterm: 20 wk: M: 131.55 SD: 70.72 24-28 wk: M: 175.28 SD: 82.15 Term: 20 wk: M: 121.05 SD: 51.01 24-28 wk: M: 166.63 SD: 64.76	- Particle concentrations of LDL and HDL were each independently associated with gestational age at delivery for all deliveries or spontaneous deliveries before 37 weeks of gestation.
	Preterm: M: 6.96 SD: 3.23 Term: M: 6.32 SD: 1.81	Preterm: M: 3.44 SD: 1.51 Term: M: 3.07 SD: 1.23	Preterm: M: 1.98 SD: 0.57 Term: M: 2.36 SD: 0.66	Preterm: M: 1.72 SD: 3.77 Term: M: 1.64 SD: 3.47	- The preterm group had higher maternal serum TG, TC, and LDL-C levels, compared to the control group. - Higher serum TC and LDL-C levels, but not HDL-C level, were seen in premature infants than in the control group.
	Preterm: M: 2.05 SD: 0.58 Term: M: 1.65 SD: 0.44	Preterm: M: 3.46 SD: 0.80 Term: M: 3.65 SD: 0.72	Preterm: M: 1.77 SD: 0.41 Term: M: 1.88 SD: 0.36	Preterm: M: 3.04 SD: 1.17 Term: M: 3.34 SD: 1.21	- Lower maternal TC, TG, HDL, and LDL levels and higher umbilical cord TC, HDL, and LDL levels were observed in cases of SPTD. - Maternal TG and LDL levels were associated with different genotypes of the HMGR gene rs12916 loci. Therefore, HMGR may be a susceptible gene for PTB.

Table 5. The characteristics of the studies included in the systematic review (continued)

Author (year)	TC	LDL	Mean, SD, OR, RR	HDL	TG	Outcome
Chodke 2017	Second Trimester	Second Trimester	Second Trimester	Second Trimester	Second Trimester	- Triglyceridemia during early pregnancy was associated with an increased risk of preterm labor. However, TC, HDL, and LDL levels cannot be used as predictors of preterm delivery.
	M: 213.33 SD: 20.23 Third Trimester	M: 84.50 SD: 6.12 Third Trimester	M: 49.00 SD: 6.13 Third Trimester	M: 212.83 SD: 11.99 Third Trimester	M: 212.83 SD: 11.99 Third Trimester	
Catov 2017	M: 243.66 SD: 27.200 Preterm:	M: 127.83 SD: 10.64 Preterm:	M: 45.50 SD: 4.03 Preterm:	M: 240.17 SD: 7.73 Preterm:	M: 74.0 SD: 56.0 Term:	- Early pregnancy levels of very low density lipoprotein (VLDL) were lower in women with subsequent PTB, especially those with high TG, than in women with term delivery. - There was no positive relationship between LDL-C and gestational age. - The impaired lipid response necessary for placentation and fetal growth might play a role in the pathogenesis of PTB.
	M: 158.4 SD: 35.7 Term:	M: 76.8 SD: 68.5 Term:	M: 50.4 SD: 15.1 Term:	M: 74.0 SD: 56.0 Term:	M: 84.9 SD: 63.2	
Wang 2017	Preterm M: 4.57 SD: 0.75 Term	Preterm M: 1.22 SD: 0.54 Term	Preterm M: 1.73 SD: 0.44 Term	Preterm M: 1.73 SD: 0.44 Term	Preterm M: 1.22 SD: 0.54 Term	- Elevations in early pregnancy TC, TG, and LDL-C levels, along with a reduction in first trimester HDL-C, increased the incidence of adverse pregnancy outcomes. - Low early pregnancy TC, TG, and LDL-C levels, along with a high HDL-C level, might prevent the incidence of adverse pregnancy outcomes. - The risk of PTB was higher in women with metabolic syndrome in early pregnancy.
	M: 4.47 SD: 0.80	M: 1.20 SD: 0.69	M: 1.73 SD: 0.46	M: 1.20 SD: 0.69	M: 1.20 SD: 0.69	
Maymunah 2014	M: 169.13 SD: 16.22	NR	NR	NR	NR	- Hypercholesterolemia which in turn is associated with preterm in full term neonates.
L Chatzi 2009	RR: 1.24	RR: 1.17	RR: 1.08	RR: 1.13	RR: 1.13	- Higher risk of PTB was observed in women with metabolic syndrome in early pregnancy.

Table 6. The characteristics of the studies included in the systematic review (continued)

Author (year)	Mean, SD, OR, RR			Outcome
	TC	LDL	HDL	
Catov 2010	Term M: 176.9 SD: 31.4	Term M: 108.0 SD: 29.6	Term M: 55.7 SD: 12.4	- Both elevations and reductions in pre-pregnancy cholesterol levels increase the risk of PTB and early PTB (before 34 weeks).
	Preterm (<34) M: 176.1 SD: 36.6	Preterm (<34) M: 107.9 SD: 34.3	Preterm (<34) M: 56.6 SD: 13.6	
Harville 2011	Preterm (34-36) M: 177.0 SD: 32.9	Preterm (34-36) M: 106.7 SD: 29.0	Preterm (34-36) M: 57.7 SD: 13.1	- High pre-pregnancy lipid levels can serve as predictors of cardiovascular disease and PTB risk.
	Term M: 5.1 SD: 0.9 RR: 1.10	Term M: 3.1 SD: 0.8 RR: 1.11	Term M: 1.6 SD: 0.3 RR: 0.96	
NIROMANESHM 2012	M: 11 SD: 24.4	M: 169.8 SD: 18.9	M: 48.5 SD: 9.8	- Hypertriglyceridemia had a positive relation with PTB. Further research is required to determine the cut-off lipid levels before and during pregnancy and clarify their associations with poor pregnancy outcomes. - PTB may share similar risk factors (high LDL and TC and low HDL) with adult coronary heart disease and stroke.
	NR	NR	NR	
Kramer 2009	Case M: 6.1 SD: 1.1	Case M: 3.0 SD: 0.8	Case M: 1.6 SD: 0.4	- TC 10th population percentile had a strong relationship with PTB in white women who had no other risk factors.
	Control M: 6.0 SD: 1.1	Control M: 3.1 SD: 0.8	Control M: 1.8 SD: 0.4	
Edison 2007	Low TC M: 17.4 SD: 1.5	NR	NR	
	Mid TC M: 17.8 SD: 1.3			
	High TC M: 17.6 SD: 1.2			

Table 7. The characteristics of the studies included in the systematic review (continued)

Author (year)	TC	LDL	HDL	TG	Outcome
Bartha 2011	Case: M: 219.55 SD: 32.29 Control: M: 240.38 SD:40.01	Case: M: 125.71 SD: 35.56 Control: M: 142.15 SD: 36.07	Case: M : 53.44 SD: 18.22 Control: M: 68.32 SD:18.38	Case: M :189.39 SD: 77.88 Control: M: 175.04 SD: 64.14	- Women with spontaneous pregnancy loss had low cholesterol to HDL-C ratio. Such a low ratio is also associated with inflammation.
Allem 2013	First trimester : OR: 1.14 Second trimester: OR: 1.03	First trimester: OR: 1.12 Second trimester: OR:1.01	First trimester : OR: 0.91 Second trimester: OR:0.96	First trimester : OR: 1.10 Second trimester: OR:1.02	- No significant associations were found between PTB and either the highest or the lowest quartile of any lipid measurements.

**Note:**

**TG:** Triglyceride; **TC:** Total cholesterol; **HDL-C:** High density lipoprotein-cholesterol; **LDL-C:** Low density lipoprotein-cholesterol; **GA:** Gestational age; **SGA:** Small for gestational age; **AGA:** Appropriate for gestational age; **NR:** None reported; **SPTD:** Spontaneous preterm delivery; **PTB:** Preterm birth

Table 8. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for the selected studies.

Study Ref	Emet 2013	Jin1 2016	Vrijkkotte 2012	Kelishadia 2007	MUDD 2012	Shoji 2013	Yonezawam 2009	Chen 2017	Catov 2007	Heida 2017	GRACE 2017	Qiu 2017	Li 2015
<b>Title &amp; abstract</b>													
A	+	+	+	+	+	+	+	+	+	+	+	+	+
B	+	+	-	+	+	+	+	+	-	+	-	+	+
<b>Introduction</b>													
Background	-	+	-	-	-	-	-	-	-	-	-	-	-
Objectives	-	-	+	-	+	-	-	+	+	+	+	-	-
Study design	+	+	+	+	+	+	+	+	+	+	+	+	+
Setting	+	+	+	+	+	+	+	+	+	+	+	+	+
Participants	+	+	+	+	+	+	+	+	+	+	+	+	+
Variables	+	+	+	+	+	+	+	+	+	+	+	+	+
Measurements	+	+	+	+	+	+	+	+	+	+	+	+	+
Bias	-	-	-	-	-	-	-	-	-	-	-	-	-
Study size	+	+	+	+	+	+	+	+	+	+	+	+	+
Quantitative variables	+	+	+	+	+	+	+	+	+	+	+	+	+
Statistical methods	+	+	+	+	+	+	+	+	+	+	+	+	+
Participants	+	+	+	+	+	+	+	+	+	+	+	+	+
Descriptive data	+	+	+	+	+	+	+	+	+	+	+	+	+
Outcome data	+	+	+	+	+	+	+	+	+	+	+	+	+
Main result	+	+	+	+	+	+	+	+	+	+	+	+	+
Key results	-	+	-	+	+	-	+	-	+	+/-	+	+	+
Limitations	-	-	-	+	+	+	-	+	+	-	-	-	-
Interpretation	-	-/+	+/-	+	+	+/-	+/-	+	+/-	+	+/-	+/-	+/-
Generalizability	-	+/-	+/-	+	+/-	+	+	+/-	+/-	+	+/-	+/-	+/-

Table 9. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for the selected studies. (continued)

Study Ref	Ghodke 2017	Catov 2017	Wang 2017	Maymunah 2014	Chatzi 2009	Catov 2010	Harville 2011	NIROMANESH 2012	Kramer 2009	Edison 2007	Bartha 2011	Alleman 2013
Title& abstract												
A	+	+	+	+	+	+	+	+	+	+	+	+
B	+	+	-	+	-	-	+	+	+	+	+	-
Introduction												
Background	-	+	-	+	-	-	+	+	+	-	+	-
Objectives	-	-	+	+	-	+	-	-	-	-	-	+
Study design	+	+	+	+	+	+	+	+	+	+	+	+
Setting	+	+	+	+	+	+	+	+	+	+	+	+
Participants	+	+	+	+	+	+	+	+	+	+	+	+
Variables	+	+	+	+	+	+	+	+	+	+	+	+
Measurements	+	+	+	+	+	+	+	+	+	+	+	+
Bias	-	-	-	-	-	-	-	-	-	-	-	-
Study size	+	+	+	+	+	+	+	+	+	+	+	+
Quantitative variables	+	+	+	+	+	+	+	+	+	+	+	+
Statistical methods	+	+	+	+	+	+	+	+	+	+	+	+
Participants	+	+	+	+	+	+	+	+	+	+	+	+
Descriptive data	+	+	+	+	+	+	+	+	+	+	+	+
Outcome data	+	+	+	+	+	+	+	+	+	+	+	+
Main result	+	+	+	+	+	+	+	+	+	+	+	+
Key results	-	-	+	+/-	+	-	+	+	+	+	+/-	+
Limitations	+	-	-	+	-	-	-	+	-	+	-	-
Interpretation	+/-	+/-	+/-	-	+/-	+/-	-	+	+/-	-	-	+/-
Generalizability	+/-	+/-	+/-	-	+/-	+/-	-	+	+/-	-	-	+/-

that both high maternal age and body mass index (BMI) increased maternal cholesterol levels and, thus, the risk of preterm delivery [32]. Harville *et al.* (2011) demonstrated that high LDL, TG and TC levels before pregnancy could increase the risk of cardiovascular diseases and premature labor [33]. Additionally, women with preterm labor reportedly had lower HDL-C concentrations [34].

Our review indicated associations between high TG and TC levels and increased risks of preterm delivery before 34 weeks and at 34-37 weeks of pregnancy. Catov *et al.* (2010) presented evidence of an association between pre-pregnancy cholesterol levels and the risk of preterm birth. This association was independent of age, race, parity, BMI, blood pressure, and physical activity during labor. There was also a relationship between cholesterol and labor before 34 weeks in women with normal blood pressure. No associations could be established between TG, HDL, and LDL concentrations, with preterm labor [35]. Steffen *et al.* (2007) examined changes in the cholesterol metabolism gene in infants born between 22 and 36 weeks and their mothers. They concluded that changes in the cholesterol metabolism gene in mothers and infants were associated with preterm labor and low birth weight [36]. These results indicate that genetic markers can help identify mothers who are at risk for dyslipidemia and preterm labor.

Toleikytei (2011) did not detect any differences in the risk of preterm labor between women with hypercholesterolemia and other women of childbearing age [37]. Edison *et al.* (2007) highlighted the involvement of low TC levels in the pathogenesis of preterm delivery. They explained that poor nutritional status contributed to low TC levels which, in turn, increased the risk of undesirable pregnancy outcomes and preterm labor [38]. Liu-x (2011) studied the effect of pre-pregnancy BMI on premature labor and concluded that high levels of TC may be accompanied by other risk factors, such as unfavourable lifestyle and dietary habits [39]. A study on the risk factors for spontaneous preterm delivery in adolescents [40] revealed that high BMI and elevated TC levels during pregnancy could have a protective effect against spontaneous premature labor in teen pregnancies [40].

According to our review, overweight women with preterm labor (before 34 weeks) presented with significantly higher TC and LDL concentrations during early pregnancy. Chatzi *et al.* (2009) examined the relationship between metabolic syndrome in pregnancy and the risk of preterm delivery. They showed that high early pregnancy cholesterol increased the risk of preterm delivery [41]. Shoji *et al.* (2014) stated that umbilical cord lipid profiles widely varied depending on maternal and infant weights and gestational age. Premature fetal development may affect lipid metabolism and atherogenic indices. A critical period for neonatal TG metabolism is 34 weeks during which premature infants have lower TG levels [42]. Late pregnancy TG concentrations have been stated to be independently associated with a reduced risk of SGA [43]. TC and LDL levels in AGA infants tend to be higher than those of SGA neonates [43]. Another study further reported that TC and LDL levels were higher in AGA infants than in SGA neonates (48). These observations signify the importance of maternal lipid profile screening for preventing pregnancy complications.

## 5. Conclusion

Lipid metabolism undergoes complicated changes in pregnancy. Lipid levels (LDL, HDL, TC and TG) above or below the normal range during pregnancy would increase the risk of preterm delivery. Considering the significance of maternal lipid metabolism in the incidence of preterm delivery, lipid profile screening in early pregnancy can largely contribute to the prevention of preterm delivery. Further studies are warranted to meticulously examine the effects of lipid profile on preterm delivery.

## 6. Limitations

A limitation of this study was the small number of studies about the effects of lipid profile on preterm delivery. Another limitation was the use of different designs and sample sizes in the

selected studies. A third limitation, which prevented us from performing a meta-analysis, was the difference of the measured indices in the selected studies.

2605

## 7. Open Access

This article is distributed under the terms of the Creative Commons Attribution License (CCBY4.0) which permits any use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

## 8. List of abbreviations

**AGA:** Appropriate for gestational age; **GA:** Gestational age; **HDL:** High density lipoprotein; **LDL:** Low density lipoprotein; **NR:** None reported; **SGA:** Small for gestational age; **SPTD:** Spontaneous preterm delivery; **PTB:** Preterm birth; **TC:** Total cholesterol; **TG:** Triglyceride

## 9. Competing interests

The authors declare no conflict of interest.

## 10. Authors' contributions

FA and ZA developed main idea. ZA is responsible for assessment of eligibility criteria of papers. FA is responsible for evaluation of full text and data gathering. All authors read and approved the final manuscript.

## 11. Acknowledgments

The study was approved by the Student Research Committee, Shahid Beheshti University of Medical Sciences, Tehran, Iran. The authors wish to express their gratitude to the mentioned committee.

## References

1. Beck S, Wojdyla D, Say L, Betran AP, Merialdi M, Requejo JH. The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity. *Bulletin of the World Health Organization*. 2010;88:31–8. Available from: [Doi:10.2471/blt.08.062554](https://doi.org/10.2471/blt.08.062554).
2. Shapiro-Mendoza CK, Lackritz EM. Epidemiology of late and moderate preterm birth. *Seminars in Fetal and Neonatal Medicine*. 2012;17(3):120–125. Available from: <https://doi.org/10.1016/j.siny.2012.01.007>.
3. Vakilian K, Ranjbaran M, Khorsandi M, Sharafkhani N, Khodadost M. Prevalence of preterm labor in Iran: A systematic review and meta-analysis. *International Journal of Reproductive Biomedicine (Yazd, Iran)*. 2015;13:743–8. Available from: [DOI:10.29252/ijrm.13.12.743](https://doi.org/10.29252/ijrm.13.12.743).
4. Conde-Agudelo A, Papageorghiou AT, Kennedy SH, Villar J. Novel biomarkers for the prediction of the spontaneous preterm birth phenotype: a systematic review and meta-analysis. *BJOG*. 2011;118:1042–54. Available from: [DOI:10.1111/j.1471-0528.2011.02923.x](https://doi.org/10.1111/j.1471-0528.2011.02923.x).
5. Cunningham F, Leveno K, Bloom S, Spong CY, Dashe J. *Williams obstetrics*. 24th ed. McGraw-hill; 2014.



- null.
6. Mathews T, MacDorman MF.  
Infant mortality statistics from the 2007 period linked birth/infant death data set. National vital statistics reports: from the Centers for Disease Control and Prevention, National Center for Health Statistics. 2011;59:1–30.
  7. Vrijkotte TG, Algra SJ, Brouwer IA, van Eijsden M, Twickler MB.  
Maternal triglyceride levels during early pregnancy are associated with birth weight and postnatal growth.  
The Journal of pediatrics. 2011;159:736–742. e1.
  8. Corton MM, Leveno KJ, Bloom SL, Spong CY, Dashe JS.  
Williams obstetrics 24/E.  
E (EBOOK): McGraw Hill Professional. 2014;.
  9. Vahratian A, Misra VK, Trudeau S, Misra DP.  
Prepregnancy body mass index and gestational age-dependent changes in lipid levels during pregnancy.  
Obstetrics and Gynecology. 2010;116:107–13.  
Available from: [DOI:10.1097/AOG.0b013e3181e45d23](https://doi.org/10.1097/AOG.0b013e3181e45d23).
  10. Kwiterovich PO, Cockrill SL, Virgil DG, Garrett ES, Otvos J, Knight-Gibson C.  
A large high-density lipoprotein enriched in apolipoprotein C-I: a novel biochemical marker in infants of lower birth weight and younger gestational age.  
Journal of the American Medical Association. 2005;293:1891–9.  
Available from: [DOI:10.1001/jama.293.15.1891](https://doi.org/10.1001/jama.293.15.1891).
  11. Jiang S, Jiang J, Xu H, Wang S, Liu Z, Li M.  
Maternal dyslipidemia during pregnancy may increase the risk of preterm birth: A meta-analysis.  
Taiwanese Journal of Obstetrics & Gynecology. 2017;56:9–15.  
Available from: [DOI:10.1016/j.tjog.2016.07.012](https://doi.org/10.1016/j.tjog.2016.07.012).
  12. Alleman BW, Smith AR, Byers HM, Bedell B, Ryckman KK, Murray JC, et al.  
A proposed method to predict preterm birth using clinical data, standard maternal serum screening, and cholesterol.  
American journal of obstetrics and gynecology. 2013;208:472. e1–472. e11.
  13. Moayeri M, Heida KY, Franx A, Spiering W, de Laat MW, Oudijk MA.  
Maternal lipid profile and the relation with spontaneous preterm delivery: a systematic review.  
Archives of Gynecology and Obstetrics. 2017;295:313–23.  
Available from: [DOI:10.1007/s00404-016-4216-5](https://doi.org/10.1007/s00404-016-4216-5).
  14. Heida KY, Kampman MA, Franx A, Laat MWD, Mulder BJ, der Post JAV, et al.  
Cardiovascular biochemical risk factors among women with spontaneous preterm delivery.  
International journal of gynecology & obstetrics. 2018;141:206–211.  
Available from: <https://doi.org/10.1002/ijgo.12423>.
  15. Roozbeh N, Abdi F, Amraee A, Kashani ZA, Darvish L.  
Influence of Radiofrequency Electromagnetic Fields on the Fertility System: Protocol for a Systematic Review and Meta-Analysis.  
JMIR Research Protocols. 2018;7:e33.  
Available from: [DOI:10.2196/resprot.9102](https://doi.org/10.2196/resprot.9102).
  16. Lo CKL, Mertz D, Loeb M.  
Newcastle-Ottawa Scale: comparing reviewers' to authors' assessments.  
BMC medical research methodology. 2014;14:45.
  17. Roozbeh N, Banihashemi F, Mehraban M, Abdi F.  
Potential role of Factor V Leiden mutation in adverse pregnancy outcomes: an updated systematic review.  
Biomedical Research and Therapy. 2017;4:1832.  
Available from: [DOI:10.15419/bmrat.v4i12.389](https://doi.org/10.15419/bmrat.v4i12.389).
  18. Catov JM, Bodnar LM, Kip KE, Hubel C, Ness RB, Harger G, et al.  
Early pregnancy lipid concentrations and spontaneous preterm birth.  
American journal of obstetrics and gynecology. 2007;197:610. e1–610. e7.
  19. Vrijkotte TG, Krukziener N, Hutten BA, Vollebregt KC, van Eijsden M, Twickler MB.  
Maternal lipid profile during early pregnancy and pregnancy complications and outcomes:

- the ABCD study.  
The Journal of Clinical Endocrinology and Metabolism. 2012;97:3917–25.  
Available from: [DOI:10.1210/jc.2012-1295](https://doi.org/10.1210/jc.2012-1295).
20. Yonezawa R, Okada T, Kitamura T, Fujita H, Inami I, Makimoto M.  
Very low-density lipoprotein in the cord blood of preterm neonates.  
Metabolism: Clinical and Experimental. 2009;58:704–7.  
Available from: [DOI:10.1016/j.metabol.2009.02.004](https://doi.org/10.1016/j.metabol.2009.02.004).
  21. Ghodke B, Pusukuru R, Mehta V.  
Association of Lipid Profile in Pregnancy with Preeclampsia, Gestational Diabetes Mellitus, and Preterm Delivery.  
Cureus. 2017;9:e1420.  
Available from: [10.7759/cureus.1420](https://doi.org/10.7759/cureus.1420).
  22. Catov JM, Mackey RH, Scifres CM, Bertolet M, Simhan HN.  
Lipoprotein Heterogeneity Early in Pregnancy and Preterm Birth.  
American Journal of Perinatology. 2017;34:1326–32.  
Available from: [DOI:10.1055/s-0037-1603471](https://doi.org/10.1055/s-0037-1603471).
  23. Niromanesh S, Shirazi M, Dastgerdy E, Sharbaf FR, Shirazi M, Khazaeipour Z.  
Association of hypertriglyceridaemia with pre-eclampsia, preterm birth, gestational diabetes and uterine artery pulsatility index.  
Natl Med J India. 2012;25:265–267.
  24. Chen X, Scholl TO, Stein TP, Steer RA, Williams KP.  
Maternal circulating lipid profile during early pregnancy: Racial/ethnic differences and association with spontaneous preterm delivery.  
Nutrients. 2017;9:19.  
Available from: [DOI:10.3390/nu9010019](https://doi.org/10.3390/nu9010019).
  25. Catov JM, Bertolet M, Chen YF, Evans RW, Hubel CA.  
Nonesterified fatty acids and spontaneous preterm birth: a factor analysis for identification of risk patterns.  
American Journal of Epidemiology. 2014;179:1208–15.  
Available from: [DOI:10.1093/aje/kwu037](https://doi.org/10.1093/aje/kwu037).
  26. Kramer MS, Kahn SR, Rozen R, Evans R, Platt RW, Chen MF.  
Vasculopathic and thrombophilic risk factors for spontaneous preterm birth.  
International Journal of Epidemiology. 2009;38:715–23.  
Available from: [DOI:10.1093/ije/dyp167](https://doi.org/10.1093/ije/dyp167).
  27. Kaser S, Ebenbichler CF, Wolf HJ, Sandhofer A, Stanzl U, Ritsch A.  
Lipoprotein profile and cholesteryl ester transfer protein in neonates.  
Metabolism: Clinical and Experimental. 2001;50:723–8.  
Available from: [DOI:10.1053/meta.2001.23307](https://doi.org/10.1053/meta.2001.23307).
  28. Grace MR, Vladutiu CJ, Nethery RC, Siega-Riz AM, Manuck TA, Herring AH.  
Lipoprotein particle concentration measured by nuclear magnetic resonance spectroscopy is associated with gestational age at delivery: a prospective cohort study.  
BJOG. 2017;.
  29. Qiu X, Gao F, Qiu Y, Bao J, Gu X, Long Y.  
Association of maternal serum homocysteine concentration levels in late stage of pregnancy with preterm births: a nested case-control study.  
The Journal of Maternal-Fetal & Neonatal Medicine. 2017;• • •:1–5.
  30. Li L, Hua J, Jian-Ping H, Yan L.  
Association between the lipid levels and single nucleotide polymorphisms of ABCA1, APOE and HMGCR genes in subjects with spontaneous preterm delivery.  
PLoS One. 2015;10:e0135785.  
Available from: [DOI:10.1371/journal.pone.0135785](https://doi.org/10.1371/journal.pone.0135785).
  31. Wang C, Zhu W, Wei Y, Su R, Feng H, Hadar E.  
The associations between early pregnancy lipid profiles and pregnancy outcomes.  
Journal of Perinatology. 2017;37:127–33.  
Available from: [DOI:10.1038/jp.2016.191](https://doi.org/10.1038/jp.2016.191).
  32. Maymunah AO, Kehinde O, Abidoye G, Oluwatosin A.  
Hypercholesterolaemia in pregnancy as a predictor of adverse pregnancy outcome.  
African Health Sciences. 2014;14:967–73.

- Available from: [DOI:10.4314/ahs.v14i4.28](https://doi.org/10.4314/ahs.v14i4.28).
33. Harville EW, Viikari JS, Raitakari OT.  
Preconception cardiovascular risk factors and pregnancy outcome.  
*Epidemiology (Cambridge, Mass)*. 2011;22:724–30.  
Available from: [DOI:10.1097/EDE.0b013e318225c960](https://doi.org/10.1097/EDE.0b013e318225c960).
  34. Bartha JL, Fernández-Deudero A, Bugatto F, Fajardo-Exposito MA, González-González N, Hervías-Vivancos B.  
Inflammation and cardiovascular risk in women with preterm labor.  
*Journal of Women's Health*. 2012;21:643–8.  
Available from: [DOI:10.1089/jwh.2011.3013](https://doi.org/10.1089/jwh.2011.3013).
  35. Catov JM, Ness RB, Wellons MF, Jacobs DR, Roberts JM, Gunderson EP.  
Prepregnancy lipids related to preterm birth risk: the coronary artery risk development in young adults study.  
*The Journal of Clinical Endocrinology and Metabolism*. 2010;95:3711–8.  
Available from: [DOI:10.1210/jc.2009-2028](https://doi.org/10.1210/jc.2009-2028).
  36. Steffen KM, Cooper ME, Shi M, Caprau D, Simhan HN, Dagle JM.  
Maternal and fetal variation in genes of cholesterol metabolism is associated with preterm delivery.  
*Journal of Perinatology*. 2007;27:672–80.  
Available from: [DOI:10.1038/sj.jp.7211806](https://doi.org/10.1038/sj.jp.7211806).
  37. Toleikyte I, I KR, Leren TP, Iversen PO.  
Pregnancy Outcomes in Familial Hypercholesterolemia Clinical Perspective: A Registry-Based Study.  
*Circulation*. 2011;124:1606–14.  
Available from: [Doi:10.1161/circulationaha.110.990929](https://doi.org/10.1161/circulationaha.110.990929).
  38. Edison RJ, Berg K, Remaley A, Kelley R, Rotimi C, Stevenson RE.  
Adverse birth outcome among mothers with low serum cholesterol.  
*Pediatrics*. 2007;120:723–33.  
Available from: [DOI:10.1542/peds.2006-1939](https://doi.org/10.1542/peds.2006-1939).
  39. Liu X, Du J, Wang G, Chen Z, Wang W, Xi Q.  
Effect of pre-pregnancy body mass index on adverse pregnancy outcome in north of China.  
*Archives of Gynecology and Obstetrics*. 2011;283:65–70.  
Available from: [DOI:10.1007/s00404-009-1288-5](https://doi.org/10.1007/s00404-009-1288-5).
  40. Baker AM, Haeri S.  
Estimating risk factors for spontaneous preterm delivery in teen pregnancies.  
*Archives of Gynecology and Obstetrics*. 2014;289:1203–6.  
Available from: [DOI:10.1007/s00404-014-3149-0](https://doi.org/10.1007/s00404-014-3149-0).
  41. Chatzi L, Plana E, Daraki V, Karakosta P, Alegkakis D, Tsatsanis C.  
Metabolic syndrome in early pregnancy and risk of preterm birth.  
*American Journal of Epidemiology*. 2009;170:829–36.  
Available from: [DOI:10.1093/aje/kwp211](https://doi.org/10.1093/aje/kwp211).
  42. Shoji H, Murano Y, Mori M, Matsunaga N, Ohkawa N, Suganuma H.  
Lipid profile and atherogenic indices soon after birth in Japanese preterm infants.  
*Acta Paediatrica (Oslo, Norway)*. 2014;103:22–6.  
Available from: [DOI:10.1111/apa.12436](https://doi.org/10.1111/apa.12436).
  43. Jin WY, Lin SL, Hou RL, Chen XY, Han T, Jin Y.  
Associations between maternal lipid profile and pregnancy complications and perinatal outcomes: a population-based study from China.  
*BMC Pregnancy and Childbirth*. 2016;16:60.  
Available from: [DOI:10.1186/s12884-016-0852-9](https://doi.org/10.1186/s12884-016-0852-9).
  44. Emet T, Ustüner I, Güven SG, Balık G, Ural Ü, Tekin YB.  
Plasma lipids and lipoproteins during pregnancy and related pregnancy outcomes.  
*Archives of Gynecology and Obstetrics*. 2013;288:49–55.  
Available from: [DOI:10.1007/s00404-013-2750-y](https://doi.org/10.1007/s00404-013-2750-y).
  45. Kelishadi R, Badiie Z, Adeli K.  
Cord blood lipid profile and associated factors: baseline data of a birth cohort study.  
*Paediatric and Perinatal Epidemiology*. 2007;21:518–24.  
Available from: [DOI:10.1111/j.1365-3016.2007.00870.x](https://doi.org/10.1111/j.1365-3016.2007.00870.x).

46. Mudd LM, Holzman CB, Catov JM, Senagore PK, Evans RW.  
Maternal lipids at mid-pregnancy and the risk of preterm delivery.  
Acta Obstetrica et Gynecologica Scandinavica. 2012;91:726–35.  
Available from: [DOI:10.1111/j.1600-0412.2012.01391.x](https://doi.org/10.1111/j.1600-0412.2012.01391.x).

2609

Biomed. Res. Ther. 2018, 5(8): 2590-2609  
.....