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Ethnic differences in maternal total cholesterol and triglyceride levels during pregnancy: the contribution of demographics, behavioural factors and clinical characteristics.

Ysbrand J Schreuder ¹, Barbara A Hutten ², Manon van Eijsden ³, Eugene H Jansen ⁴, Maud N. Vissers ⁵, Marcel Th Twickler ⁵, Tanja G.M. Vrijkotte ¹

¹ Department of Public Health, Academic Medical Centre, University of Amsterdam, Amsterdam, the Netherlands

² Department of Clinical Epidemiology, Biostatistics and Bioinformatics, Academic Medical Centre, University of Amsterdam, Amsterdam, The Netherlands

³ Public Health Service of Amsterdam, Department of Epidemiology, Documentation and Health Promotion, Amsterdam, the Netherlands

⁴ Laboratory for Health Protection Research, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands

⁵ Department of Vascular Medicine, Academic Medical Centre, University of Amsterdam, Amsterdam, the Netherlands

Correspondence: TGM Vrijkotte
Department of Public Health
Academic Medical Centre
University of Amsterdam
PO box 22660
1100 DD Amsterdam
The Netherlands
Tel: 00 31 20 5664523
Fax : 00 31 20 6972316
Email: T.Vrijkotte@amc.uva.nl

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Short title: Ethnic differences in maternal lipid profile.

Abstract

Background/Objectives: Lipid disturbances during pregnancy may lead to early onset of metabolic diseases in the offspring. However, there is little knowledge on ethnic differences in lipid levels during pregnancy. We evaluated ethnic differences in non-fasting total cholesterol (TC) and triglyceride (TG) levels during early gestation and the role of demographics, behavioural factors and clinical characteristics.

Subjects/Methods: Non-diabetic pregnant women (N=3025) from the Amsterdam Born Children and their Development (ABCD) study. The studied ethnic groups were: Dutch, Surinam-Hindustani, African-Caribbean, Turkish, Moroccan and Ghanaian. A multilingual questionnaire was used to gather information on maternal demographics, behavioural factors and clinical characteristics. Non-fasting TC, TG, % saturated-fatty-acid (%SFA) and % linoleic acid status (%LA) were assessed in blood samples collected at the first antenatal visit.

Results: Ghanaian (-0.51 mmol/l), African-Caribbean (-0.19 mmol/l), and Moroccan (-0.15 mmol/l) women had significant lower TC levels compared to Dutch women. TG levels were lower in Ghanaian (log-transformed -0.12 mmol/l) but significantly higher in Surinam-Hindustani (0.10 mmol/l) and Turkish women (0.07 mmol/l). Age, physical activity, pre-pregnancy BMI, smoking, %SFA and %LA were independently related to TC and/or TG. However, only pre-pregnancy BMI could partly explain observed disparities. Furthermore, pre-pregnancy BMI had a relatively large effect on TG levels in Surinam-Hindustani and Turkish women.

Conclusion: TC and TG levels differed between ethnic groups during early gestation. Only pre-pregnancy BMI partly explained the ethnic differences to a relevant degree. Reduction in BMI before pregnancy may improve lipid profile, especially in Surinam-Hindustani and Turkish women.

Keywords Lipid profile, pregnancy, ethnicity, behavioural factors, ABCD study, pre-pregnancy BMI.

Introduction

Availability of maternal cholesterol and triglycerides (TG) is an essential factor in early pregnancy for an optimal development of both foetus and placenta.(Herrera, 2002; Woollett, 2005) When pregnancy progresses, specific changes in total cholesterol (TC), fractionated cholesterol and TG occur which leads to physiologically increased lipid levels towards the end of pregnancy.(Sattar et al., 1997; Brizzi et al., 1999) It is thought that progressive increase in oestrogen levels during gestation induces most of these alterations in lipoprotein metabolism (Desoye et al., 1987) which suggests the necessity of these metabolic changes for pregnancy maintenance and foetal growth. Indeed, reduced maternal TC levels are associated with intrauterine growth restriction and preterm delivery.(Sattar et al., 1999; Edison et al., 2007) Conversely, marked elevated maternal TC and TG levels are associated with an increased risk on preeclampsia and other pregnancy related complications.(vandenElzen et al., 1996; Enquobahrie et al., 2004) In addition, increased cholesterol deposition in foetal aortas could give rise to exaggerated lipid-rich lesions in both aortic arch and abdominal aorta in children.(Napoli et al., 1997; Napoli et al., 1999) These observations correspond to the 'foetal origins hypothesis' which states that an unfavourable intra-uterine metabolic environment predisposes for premature cardiovascular disease.(Koklu et al., 2006; Skilton, 2008)

Ethnic differences in lipid profile are well studied with in general a more favourable profile in the African populations, and a less favourable profile in the Indian-populations, compared to Western-populations in terms of cardiovascular risk.(Bhalodkar et al., 2005; Cappuccio, 1997; Godsland et al., 2007) However, ethnic differences in lipid-profile during pregnancy is less frequently studied and results are inconclusive.(Koukkou et al., 1994))

The underlying mechanisms that may explain possible ethnic differences in lipid profile are unknown. Genetic factors or structural variances in oestrogen levels could play a role in addition to behavioural factors. Behavioural factors related to lipid profile include smoking (Willett et al., 1983), low physical activity (Kelley et al., 2004), high fat diet (Millen et al., 1996; Sonnenberg et al., 1996) and alcohol use.(Razay et al., 1992) Large ethnic

differences in these behavioural factors have also been noted (Zoratti, 1998; Daryani et al., 2005b; Daryani et al., 2006; Gentles et al., 2007) but up till now, it is unclear to what extent these factors contribute to ethnic differences in lipid profile during pregnancy. Knowledge about these ethnic differences in TC and TG and the explanatory role of behavioural factors is essential for initiating appropriate intervention strategies to prevent adverse pregnancy outcome and early predisposition of cardiovascular and related metabolic diseases.

We aimed to evaluate ethnic differences in TC and TG levels during pregnancy, and to explore to what extent maternal demographics, behavioural factors and clinical characteristics could explain possible differences.

Methods

This study is part of the Amsterdam Born Children and their Development study (www.abcd-study.nl). The ABCD study is a prospective community-based cohort study, which examines the relationship between maternal lifestyle and psychosocial conditions during pregnancy and the child's health at birth and later in life, with specific interest in ethnic differences. (van Eijsden et al., 2008; Goedhart et al., 2008a)

Study population

Between January 2003 and March 2004, all pregnant women living in Amsterdam (n = 12.373) were invited to enrol in the ABCD study at their first prenatal visit to an obstetric caregiver (median: 12.9 weeks, interquartile range 11.9 – 14.3 weeks). From these women, 8266 (response 67%) filled out an extensive pregnancy questionnaire including questions about socio-demographic characteristics, lifestyle, dietary habits and ethnic background. The questionnaire was in Dutch, accompanied by an English, Turkish or Arabic copy depending on the women's country of birth. These women were also asked to participate in the ABCD biomarker study. For this study, additional blood sampling took place after routine blood collection for screening purposes. The response rate for the ABCD biomarker study was 53% (n = 4389). TC and TG analyses were available for 95% (n = 4185). The study protocol was

approved by the medical ethics committees of all Amsterdam hospitals and the Registration Committee of Amsterdam, and participants gave their written informed consent.

In this study, data of the six largest ethnic groups living in Amsterdam (Dutch, Surinam-Hindustani, African-Caribbean, Turkish, Moroccan and Ghanaian women) were used (N = 3073). Our analyses were based on data from the first and second trimester only. Women using lipid altering medication (N = 39) and women with self reported pre-pregnancy diabetes (N = 9) were excluded due to influence on TC and TG levels, leaving 3025 women in the study population.

Laboratory Methods

Blood sampling was performed non-fasting. One blood sample was taken in a 10-mL EDTA (K) Vacutainer (Beckton Dickinson BV, Alphen aan de Rijn, the Netherlands) for the preparation of plasma and one blood sample was taken in a 9-mL Vacuette (Greiner BV, Alphen aan de Rijn, the Netherlands) for the preparation of serum. Aliquots were prepared by centrifugation (1600 x g for 10 min at room temperature) and stored at -80°C until analysis.(van Eijdsden et al., 2008)

TC and TG levels in the serum samples were determined at the Laboratory for Health Protection Research of the Dutch National Institute for Public Health and the Environment (RIVM). TC assay was performed using the CHOD-PAP method on a Hitachi 912 analyzer (Roche Diagnostics, Mannheim, Germany). TG was assayed with the GPO-PAP method (Roche Diagnostics, Mannheim, Germany). The interassay coefficient of variation (CV) was 1.0% for cholesterol and 2.3% for triglycerides.

The plasma samples were sent to the Analytical Biochemical Laboratory (ABL, Assen, the Netherlands) to perform fatty acid analysis using high performance capillary gas chromatography.(van Eijdsden et al., 2008) The absolute amounts of SFA and LA (18:2-n6) (in mg/L plasma) were quantified on the basis of recovery from an internal standard and calculated in a relative value (percentage of total fatty acids).

Measurements

Ethnicity was based on the country of birth of the pregnant woman and her mother to include first and second generation women.(Stronks et al., 2009) We distinguished three groups of covariables: 1) demographic variables: maternal age, parity (0, 1, ≥ 2), cohabitant status (living together with partner vs. single) and maternal education (years of education after primary school: ≤ 5 , 6-10, >10 year), 2) behavioural factors: self-reported physical activity (no exercise, low, moderate, vigorous), total %SFA (in quintiles), total %LA (in quintiles), smoking (no, yes and quit smoking because of pregnancy) and alcohol consumption (no vs. yes) and 3) clinical characteristics: maternal pre-pregnancy body mass index (BMI, based on self-reported height and weight, kg/m^2), pre-existent hypertension (no vs. yes) and depressive symptoms (CES-D scale (Radloff, 1977): lower vs. higher than the 90th percentile). Physical activity during the previous week was scored by calculating a Metabolic equivalent (MET) score for the various reported activities using the compendium of physical activities.(Ainsworth et al., 2000) Percentage SFA was used as an indicator for saturated fatty acid consumption and %LA as an indicator for poly-unsaturated fatty acid consumption.

Statistical analysis

Differences in demographic variables, behavioural factors and clinical characteristics between the ethnic groups were tested with the Chi-square test for categorical variables and ANOVA for continuous variables. General linear models were built to study the relationship between ethnicity and TC or TG in more detail. First, univariate analyses were performed to explore the individual associations of ethnicity, maternal demographics, behavioural factors and clinical characteristics with TC and TG levels. As our results showed that TC and TG levels increased with gestational age (data not shown), we corrected for gestational age in further analyses.

We constructed three different extended models for multivariate analysis in a hierarchical approach. We used backward stepwise selection of variables to identify

independent predictors of TC and TG. In model 1, demographics were added to ethnicity, model 2 subsequently added all behavioural factors to the model and in model 3, all clinical characteristics were added.

All potential first order interactions with ethnicity were tested. TG levels were log transformed to improve the normality of the residuals in the various models. $P < 0.05$ was considered significant. All statistical analyses were performed with the SPSS package version 15.0 (SPSS Inc, Chicago, USA).

Results

Study population

Compared to the non-response group (women of the same ethnicity as study population, but with no available blood samples, $N = 2720$), the study population ($N = 3025$) was significantly older ($P = .004$), more often nulliparous ($P < .001$), more often from Dutch origin ($P < .001$), were higher educated ($P < .001$) and had a lower pre-pregnancy BMI ($P < .001$).

Table 1 presents the characteristics of the 3025 study participants according to ethnicity. Of the pregnant women, 74.8% were Dutch, 2.0% were Surinam-Hindustani, 7.8% African-Caribbean, 5.6% Turkish, 8.1% Moroccan, and 1.8% Ghanaian. Compared to the ethnic minority women, Dutch women were older, higher educated, more physically active, less often depressed, had a lower pre-pregnancy BMI and were more often nulliparous. There were large differences in cohabitant status, the mean %SFA and mean %LA. Smoking during pregnancy was most common in Turkish women, while Dutch women were more likely to consume alcohol. Pre-pregnancy hypertension was most common among African-Caribbean women. The mean time at blood withdrawal did not differ between the ethnic groups ($P = 0.61$).

Total cholesterol

Mean levels of TC were highest in Surinam-Hindustani women (5.21 mmol/L) and lowest in Ghanaian women (4.65 mmol/L) (Table 1). Univariate analysis showed significantly

lower TC levels for African-Caribbean (β : -0.19 ± 0.06 (SE)), Moroccan (-0.15 ± 0.06) and Ghanaian (-0.51 ± 0.12) women compared to the Dutch women (Table 2).

Univariate analyses showed that maternal age was positively and parity was negatively associated with TC (Table 2). The relation between behavioural factors, clinical characteristics and TC was more pronounced. %SFA, smoking and pre-pregnancy BMI were univariately significantly associated with higher TC levels, while physical activity and %LA were negatively associated with TC (Table 2). Multivariate analysis adjusted for demographics (Table 2, model 1) showed that ethnic differences mostly remained the same. Further adjustment for behavioural factors (Table 2, model 2) and clinical characteristics (Table 2, model 3) resulted in loss of significance in TC levels for Moroccan women compared to Dutch women ($P = 0.077$). In addition to ethnicity, maternal age, parity, physical activity, %SFA, %LA and pre-pregnancy BMI were all independently associated with TC in the final model.

Triglycerides

Median TG levels were highest in Surinam-Hindustani (1.56 mmol/L) women and lowest in Ghanaian women (1.11 mmol/L) (Table 1). Univariate analysis showed significantly higher TG levels (log transformed) for Surinam-Hindustani (β : 0.1 ± 0.03 (SE)) and Turkish (0.07 ± 0.02) women compared to Dutch women, while Ghanaian women had significant lower TG levels (-0.12 ± 0.03) (Table 3).

Further univariate analysis showed that maternal age, parity and maternal education were significantly associated with TG levels (Table 3). Behavioural factors %SFA and smoking were positively associated with TG levels, whereas physical activity, %LA and alcohol consumption were negatively associated. Pre-pregnancy BMI was also positively associated with TG levels, however, to a different degree within the ethnic groups (see below). Multivariate analysis adjusted for demographics (Table 3, model 1) showed that ethnic differences mostly remained the same. Further adjustment for behavioural factors (Table 3, model 2) slightly reduced the differences for Surinam-Hindustani, African-

Caribbean and Turkish women compared to Dutch women, yet the differences remained significant. After adjustment for clinical characteristics and the interaction between ethnicity and pre-pregnancy BMI (Table 3, model 3), the difference in TG levels for Turkish women compared to Dutch women was slightly reduced. The African-Caribbean and Ghanaian women had significant lower TG levels compared to Dutch women in this final model. Furthermore, maternal age, education, physical activity, %SFA, %LA, smoking, alcohol consumption and pre-pregnancy BMI were all independently associated with TG levels.

Interaction pre-pregnancy BMI and ethnicity

The interaction between pre-pregnancy BMI and ethnicity was not significant for TC ($P=0.09$; Fig 1a), which means that the association between pre-pregnancy BMI and TC was the same for all ethnic groups. However, Figure 1b shows that the effect of increasing pre-pregnancy BMI has a larger effect on TG levels in Surinam-Hindustani and Turkish women compared to Dutch, African-Caribbean and Moroccan women. In Ghanaian women, pre-pregnancy BMI was not related to TG levels (P for interaction = 0.03).

Discussion

In this study, we evaluated ethnic differences in TC and TG levels during early pregnancy and the explanatory role of demographics, behavioural factors and clinical characteristics.

Compared to Dutch women, African-Caribbean, Moroccan and Ghanaian women displayed significant lower TC levels. Furthermore, Surinam-Hindustani and Turkish women had significantly higher TG levels, whereas Ghanaian women had significantly lower TG levels. Demographics and behavioural factors, except for cohabitant status, all contribute to gestational lipid profile independently. However, pre-pregnancy BMI was the only factor that could – partly – explain the ethnic differences in gestational lipid profile.

The ethnic differences found in both TC and TG levels confirm results from previous studies in both non-pregnant (Zoratti, 1998; Despres et al., 2000; Lamon-Fava et al., 2005) and pregnant women (Koukkou et al., 1994), reporting more favourable TC and TG levels in African/Afro-Caribbean women as compared to Caucasian women. Taylor et al. (1987) found a significant difference in TG levels between postpartum African-Caribbean and Indian-Caribbean women which is similar to our observations for African-Caribbean and Surinam-Hindustani women. In contrast to their study, however, we also observed a significant difference in TC levels. The results of our comparison between Turkish and Dutch pregnant women, i.e. no difference in TC levels but significant higher TG levels, is in line with another study that compared Turkish to Swedish non-pregnant women. (Daryani et al., 2005b) However, no studies evaluated TC and TG levels as a result from early pregnancy between various ethnic populations in one living area.

Interestingly, previous results derived from the ABCD cohort showed that Ghanaian women have the highest risk for adverse birth outcomes, also after adjustments. (Goedhart et al., 2008a; Goedhart et al., 2008b) Since the Ghanaian women had the lowest TC and TG levels, this observation may confirm that reduced lipid levels during gestation may contribute to a reduced pregnancy outcome.

In our study, maternal behavioural factors and clinical characteristics were closely related to changes in TC or TG levels in early pregnancy. In men and non-pregnant women, %SFA, BMI and smoking have been demonstrated to be positively related with TC and/or TG levels whereas physical activity, %LA and alcohol intake were inversely related. (Millen et al., 1996; Sonnenberg et al., 1996; Howard et al., 2003; Willett et al., 1983; Kelley et al., 2004; Daryani et al., 2005a; Razay et al., 1992)

Despite marked ethnic differences in various behavioural factors and clinical characteristics, only pre-pregnancy BMI explained ethnic disparities in gestational lipid profile. Indeed, pre-pregnancy BMI was significantly related to TG levels, especially in Surinam-Hindustani and Turkish women, and, to some extent, TC levels (Figure 1). In

contrast to waist circumference, BMI does not specify the fat location. Numerous studies have shown that the accumulation of central fat is more associated with abnormal lipid/lipoprotein profile compared to a general fat distribution.(Snijder et al., 2004b; Seidell et al., 2001; Canoy et al., 2006) The ethnic differences might be explained by the variability in fat deposition, i.e. visceral vs. subcutaneous accumulation.(Despres et al., 2000; Snijder et al., 2004b; Snijder et al., 2004a) For instance, Ghanaian women have more subcutaneous fat deposits compared with Caucasian women and also the lowest TC and TG levels (Table 2 and 3). This indicates that there could be modulators of lipoprotein metabolism involved that are related to visceral fat, which may result in a different expression of lipid phenotype. Indeed, Després et al.(Despres et al., 2000) found higher lipoprotein lipase and lower hepatic lipase activities in African-American than in white women and Bower et al.(Bower et al., 2002) showed that African-American women have an increased capacity to synthesize locally TG in omental adipose tissue compared to Caucasian women. In African Americans, the relationship between BMI and waist circumference/visceral fat with assessment of CT scanning (L4 protocol) is less than in white American women.(Carroll et al., 2008) In addition, a different metabolic activity of abdominal fat and other environmental factors are closely related to differences in insulin resistance comparing African women with Caucasian women with subsequent effects on lipid levels.(Reimann et al., 2007) These intrinsic metabolic properties of local fat tissue, dependent on membership of an ethnic group, may explain the observed lipid differences despite a similar pre-pregnancy BMI among ethnic groups.

Some limitations and strengths of our study should be acknowledged. Our study population consisted of a large, unselected cohort of pregnant women, who represented the main ethnic groups in the region of Amsterdam City, the Netherlands. Despite the large sample size, there was selective participation and our results apply to a relatively healthy sample. This could have made our estimates too conservative. Furthermore, blood sampling was non-fasting and performed just on one occasion, but this is expected to only dilute our results. We did not have data of other lipid fractions, such as high density lipoprotein

cholesterol (HDL-c) or low density lipoprotein cholesterol (LDL-C). However, the aim of our analysis was not to perform a cardiovascular risk profile but to assess TG and TC levels. Finally, although we adjusted for several factors, we cannot exclude some residual confounding, either resulting from unmeasured or inaccurately measured covariates. We did not have diet questionnaires although it is known that there are differences in dietary patterns between ethnic groups.(Daryani et al., 2005a; Daryani et al., 2006; Diaz et al., 2005). However we did include %SFA and %LA in our analysis to reflect in average dietary composition. Behavioural and clinical characteristics were self-reported, which may have introduced some bias for measures, such as pre-pregnancy BMI, as women could misreport height and weight. However, in large epidemiological studies self report found to accurately measure BMI for the purpose of associational analysis.(McAdams et al., 2007)

Whereas too low TC levels have been associated with adverse outcome at short term, too high levels may be predictive for atherosclerosis in the newborn at long term. Facing the epidemic of overweight, lipid levels will rather be too high than too low at the population level. When the foetus is exposed to an atherogenic environment in utero, the vulnerability for enhanced risk for atherosclerosis-related disease may be higher already in early life. Based on the current data, this vulnerability may be more prominent in specific ethnic groups. However, the minimally required level of lipids that protect against adverse outcomes is also unknown. Altogether, more data is needed to define the optimal lipid ranges for both mother and child.

To decrease ethnic differences in cardiovascular health, prevention should start in the preconception phase and focus on weight reduction which can be achieved by dietary advises and physical activity programs. Although physical activity, %SFA and %LA did not explain the ethnic disparities in TC and TG levels, they remain important means to reduce pre-pregnancy BMI. In addition, smoking also contributed to adverse TG levels. This is particularly important for the Turkish women as 23.8% continued to smoke during pregnancy.

In conclusion, early gestational TC and TG levels differ between ethnic groups. Among all ethnic groups, this change in TG and TC levels is mostly explained by pre-pregnancy BMI. Another distribution of fat or intrinsic metabolic properties of both fat tissue and glucose/insulin homeostasis are all factors that characterize each ethnic group. In this background, preventive measures (eg. weight reduction) to lower TG and TC levels during pregnancy should be offered to especially Surinam-Hindustani and Turkish women already in the preconception phase. Before such preconception prevention strategy should be considered, more results are needed to acknowledge that an adverse gestational lipid profile is associated with pregnancy outcome and the occurrence of late onset disease in the newborn.

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Details of Ethics Approval

Approval for the ABCD study was obtained from the Central Committee on Research involving Human Subjects (CCMO; number P02.0335L, 2002), the Medical Ethical Committees of participating hospitals and the Registration Committee of Amsterdam.

Conflicts of interest

None declared.

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Figure 1 Interaction between ethnicity and pre-pregnancy BMI on total cholesterol levels (a)* and triglyceride levels (b) ‡.

*Model 2: adjusted for maternal age, parity, physical activity and %SFA and gestational age at blood sampling

‡Model 2: adjusted for: maternal age, education, physical activity, %SFA, smoking, alcohol consumption and gestational age at blood sampling.

Table 1 Characteristics of study participants according to ethnicity.

	N	Dutch	Surinam – Hindustani	African - Caribbean	Turkish	Moroccan	Ghanaian	P value
N	3025	2262	61	235	168	245	54	
Demographics								
Maternal age (years)		32.0 (3.95)	29.6 (5.19)	28.9 (6.53)	25.8 (4.91)	27.4 (5.31)	31.0 (5.43)	P < 0.001
Parity (%)								
0	1751	61.2	45.9	54.9	47.0	46.5	31.5	P < 0.001
1	924	31.7	31.1	23.8	33.3	25.3	25.9	
≥ 2	350	7.1	23.0	21.3	19.6	28.2	42.6	
Cohabitant status (% living alone)	364	7.8	31.1	48.5	4.2	7.8	56.6	P < 0.001
Education (years)								
0 – 5 years	494	7.4	34.4	28.6	53.0	51.2	53.8	P < 0.001
6 – 10 years	1153	36.3	42.6	50.6	39.9	43.0	38.5	
> 10 years	1365	56.4	23.0	20.8	7.1	5.8	7.7	
Behavioural factors								
Physical activity (%)								
No physical activity	411	6.8	32.8	36.2	38.7	30.6	22.2	P < 0.001
Low	1060	30.1	52.5	41.7	47.6	54.7	66.7	
Moderate	1245	50.1	14.8	19.1	11.9	13.5	7.4	
Vigorous	309	13.0	0.0	3.0	1.8	1.2	3.7	
%SFA ¹ (%)		46.9 (1.13)	47.0 (1.16)	46.8 (1.19)	46.8 (1.23)	46.3 (1.31)	46.7 (1.25)	P < 0.001
Q1	601	18.7	16.4	19.6	19.2	32.8	22.6	P < 0.001
Q2	602	18.7	19.7	23.0	22.8	25.4	30.2	
Q3	601	21.1	18.0	17.0	21.6	14.3	9.4	
Q4	601	20.6	19.7	21.7	16.8	14.8	20.8	
Q5	601	20.8	26.2	18.7	19.8	12.7	17.0	
% LA ² (%)		18.7(2.38)	19.6(2.05)	19.0(2.25)	20.7(2.68)	19.9(2.53)	17.8(2.72)	P < 0.001
Q1	601	22.0	9.8	16.6	7.2	12.3	37.7	P < 0.001
Q2	601	21.3	19.7	20.0	13.2	13.1	18.9	
Q3	602	20.4	18.0	22.1	13.8	19.7	18.9	
Q4	601	19.6	24.6	20.9	20.4	22.5	15.1	
Q5	601	16.7	27.9	20.4	45.5	32.4	9.4	
Smoking while pregnant (%)								
No	2201	71.0	77.0	65.5	66.1	95.5	94.3	P < 0.001
Quit smoking	522	19.5	14.8	21.3	10.1	1.6	3.8	
Yes	301	9.6	8.2	13.2	23.8	2.9	1.9	
Alcohol use while pregnant (%)	742	31.1	6.6	12.3	0.6	0.4	7.4	P < 0.001
Clinical characteristics								
Pre-pregnancy BMI (kg/m ²)	3025	22.5 (3.4)	23.0 (4.1)	24.0 (4.6)	23.7 (4.1)	24.9 (4.3)	26.5 (4.6)	P < 0.001
BMI ≥25 kg/m ² (%)	654	16.5	19.7	33.2	27.9	45.7	59.3	P < 0.001
Pre-existent hypertension (%)	102	3.0	3.3	7.7	2.4	3.3	5.6	
Depressed (%)	339	7.3	21.7	23.5	28.7	22.1	12.0	
TC (mmol/L) ³	3025	5.15 (0.85)	5.21 (0.86)	4.96 (0.86)	5.12 (0.85)	5.00 (0.86)	4.65 (0.85)	P < 0.001
TC > 6.5 mmol/l ⁴ (%)	95	4.6	0.0	3.7	5.2	3.4	0.0	NS
TG (mmol/L) ³	3006	1.25 (0.64)	1.56 (0.9)	1.30 (0.68)	1.55 (0.79)	1.37 (0.75)	1.11 (0.58)	P < 0.001
TG > 2.3 mmol/l ⁴ (%)	84	3.6	10.3	2.2	10.4	2.5	0.0	P = 0.002
Ethnic differences in maternal lipids								

Time of blood collection (hours:minutes)	12:26(02:16)	12.46(02:18)	12:24(02:15)	12:42(01:57)	12:20(01:58)	12:54(02:22)	NS
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Continuous variables were expressed as mean (standard deviation), except for triglycerides, which was expressed as median (interquartile range).

BMI, body mass index; SFA, saturated fatty acids; TC, total cholesterol; TG, triglycerides.

¹ Saturated fatty acids: quintile distribution.

² Linoleic acid: quintile distribution.

³ Adjusted for gestational age at blood sampling.

⁴ Dutch reference values for TC and TG in fasting blood samples. Only women with gestational age ≤ 14 weeks were included.

Table 2 Univariate and multivariate associations between total cholesterol and ethnicity.

	Univariate analysis ¹	Multivariate analysis Model 1 ²	Multivariate analysis Model 2 ³	Multivariate analysis Model 3 ⁴
	β (SE)	β (SE)	β (SE)	B (SE)
Ethnicity				
Dutch	Reference	Reference	Reference	Reference
Surinam-Hindustani	0.06 (0.11)	0.08 (0.11)	0.08 (0.11)	0.07 (0.11)
African-Caribbean	-0.19 (0.06)***	-0.15 (0.06)*	-0.18 (0.06)**	-0.21 (0.06)***
Turkish	-0.03 (0.07)	0.04 (0.08)	0.10 (0.08)	0.07 (0.08)
Moroccan	-0.15 (0.06)**	-0.14 (0.07)*	-0.04 (0.06)	-0.09 (0.06)
Ghanaian	-0.51 (0.12)***	-0.47 (0.12)***	-0.52 (0.12)***	-0.59 (0.12)***
Demographics				
Maternal age (years)	0.01 (0.003)***	0.02 (0.004)***	0.02 (0.004)***	0.02 (0.004)***
Parity				
0	Reference	Reference	Reference	Reference
1	-0.05 (0.04)	-0.09 (0.04)*	-0.09 (0.04)**	-0.11 (0.04)**
≥2	-0.11 (0.05)*	-0.17 (0.06)**	-0.14 (0.06)*	-0.17 (0.06)**
Cohabitant status				
Living together	Reference	-	-	-
Living apart	-0.06 (0.05)			
Education (years)				
0 – 5	-0.02 (0.05)	0.14 (0.05)**	-	-
6 – 10	0.05 (0.03)	0.12 (0.04)***		
> 10	Reference	Reference		
Behavioural factors				
Physical activity				
No exercise	Reference		Reference	Reference
Low	-0.08 (0.05)		-0.12 (0.05)*	-0.11 (0.05)*
Moderate	-0.05 (0.05)		-0.15 (0.05)**	-0.14 (0.05)**
Vigorous	-0.16 (0.07)*		-0.25 (0.07)***	-0.23 (0.07)***
%SFA ⁵				
Q1	Reference		Reference	Reference
Q2	0.12 (0.05)*		0.11 (0.05)*	0.11 (0.05)*
Q3	0.20 (0.05)***		0.14 (0.05)**	0.14 (0.05)**
Q4	0.23 (0.05)***		0.16 (0.05)***	0.16 (0.05)***
Q5	0.43 (0.05)***		0.32 (0.05)***	0.32 (0.05)***
%LA ⁶				
Q1	0.40 (0.05)***		0.29 (0.05)***	0.26 (0.05)***
Q2	0.28 (0.05)***		0.20 (0.05)***	0.19 (0.05)***
Q3	0.27 (0.05)***		0.21 (0.05)***	0.19 (0.05)***
Q4	0.15 (0.05)**		0.12 (0.05)*	0.11 (0.05)*
Q5	Reference		Reference	Reference
Smoking while pregnant				
No	Reference		-	-
Quit smoking	0.04 (0.04)			
Yes	0.10 (0.05)*			
Alcohol while pregnant				
	-0.02 (0.04)		-	-
Clinical characteristics				
BMI (kg/m ²)	0.02 (0.004)***			0.02 (0.004)***
Pre-existent hypertension	0.01 (0.09)			-
Depressed	-0.02 (0.05)			-

*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001

¹ Univariate analysis: adjusted for gestational age at blood sampling.

² Model 1, adjusted for: maternal age, parity, maternal education and gestational age at blood sampling.

³ Model 2, adjusted for: maternal age, parity, physical activity, %SFA, %LA and gestational age at blood sampling.

⁴ Model 3, adjusted for: maternal age, parity, physical activity, %SFA, %LA, BMI and gestational age at blood sampling.

⁵ Saturated fatty acids: quintile distribution.

⁶ Linoleic acid: quintile distribution.

Table 3 Univariate and multivariate associations between triglycerides (log transformed) and ethnicity.

	Univariate analysis ¹	Multivariate analysis Model 1 ²	Multivariate analysis Model 2 ³	Multivariate analysis Model 3 ⁴
	β (SE)	β (SE)	β (SE)	β (SE) ⁵
Ethnicity				
Dutch	Reference	Reference	Reference	Reference
Surinam-Hindustani	0.10 (0.03)***	0.09 (0.03)***	0.08 (0.03)**	0.08 (0.03)**
African Caribbean	-0.02 (0.01)	-0.03 (0.01)*	-0.04 (0.02)**	-0.05 (0.02)***
Turkish	0.07 (0.02)***	0.06 (0.02)***	0.06 (0.02)**	0.04 (0.02)*
Moroccan	0.02 (0.01)	-0.02 (0.02)	-0.01 (0.02)	-0.02 (0.02)
Ghanaian	-0.12 (0.03)***	-0.16 (0.03)***	-0.16 (0.03)***	-0.15 (0.04)***
Demographics				
Maternal age (years)	0.002 (0.001)*	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***
Parity				
0	Reference	-	-	-
1	0.02 (0.01)*			
≥2	0.03 (0.01)*			
Cohabitant status				
Living together	Reference	-	-	-
Living apart	-0.01 (0.01)			
Maternal education				
0 – 5 years	0.06 (0.01)***	0.08 (0.01)***	0.05 (0.01)***	0.04 (0.01)**
6 – 10 years	0.04 (0.01)***	0.05 (0.01)***	0.03 (0.01)***	0.03 (0.01)***
> 10 years	Reference	Reference	Reference	Reference
Behavioural factors				
Physical activity				
No exercise	Reference		Reference	Reference
Low	-0.02 (0.01)		-0.004 (0.01)	-0.004 (0.01)
Moderate	-0.04 (0.01)***		-0.03 (0.01)*	-0.03 (0.01)*
Vigorous	-0.07 (0.02)***		-0.05 (0.02)**	-0.05 (0.02)**
% SFA ⁶				
Q1	Reference		Reference	Reference
Q2	0.03 (0.01)*		0.02 (0.01)	0.02 (0.01)
Q3	0.04 (0.01)***		0.03 (0.01)*	0.02 (0.01)*
Q4	0.06 (0.01)***		0.04 (0.01)***	0.04 (0.01)***
Q5	0.09 (0.01)***		0.06 (0.01)***	0.06 (0.01)***
% LA ⁷				
Q1	0.07 (0.01)***		0.06 (0.01)***	0.05 (0.01)***
Q2	0.05 (0.01)***		0.05 (0.01)***	0.04 (0.01)***
Q3	0.03 (0.01)**		0.03 (0.01)**	0.03 (0.01)*
Q4	0.02 (0.01)		0.02 (0.01)	0.01 (0.01)
Q5	Reference		Reference	Reference
Smoking while pregnant				
No	Reference		Reference	Reference
Quit smoking	-0.004 (0.01)		0.003 (0.01)	0.004 (0.01)
Yes	0.07 (0.01)***		0.05 (0.01)***	0.06 (0.01)***
Alcohol while pregnant				
	-0.04 (0.01)***		-0.04 (0.01)***	-0.03 (0.01)***
Clinical characteristics				
BMI (kg/m ²)	0.01 (0.01)***			
Interaction BMI/ethnicity				
Dutch				Reference
Surinam-Hindustani				0.003 (0.01)
Africa-Caribbean				-0.001(0.003)
Turkish				0.01 (0.004)*
Moroccan				-0.004 (0.003)
Ghanaian				-0.01 (0.01)
Pre-existent hypertension	0.03 (0.02)			-
Depressed	0.02 (0.01)			-

*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001

¹ Univariate analysis: adjusted for gestational age at blood sampling.

² Model 1, adjusted for: maternal age, maternal education and gestational age at blood sampling.

³ Model 2, adjusted for: maternal age, maternal education, physical activity, %SFA, %LA, smoking, alcohol consumption and gestational age at blood sampling.

⁴ Model 3, adjusted for: maternal age, maternal education, physical activity, %SFA, %LA, smoking, alcohol consumption, BMI, interaction ethnicity by BMI and gestational age at blood sampling.

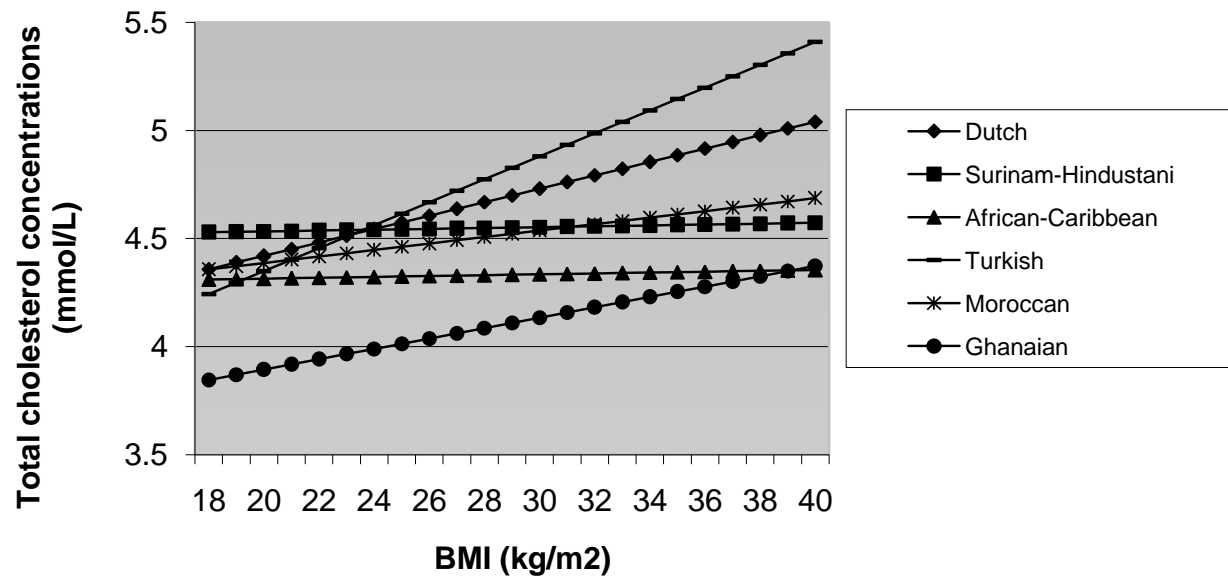
⁵ β (SE) for ethnicity are calculated with mean BMI of the population (22.97 kg/m²).

⁶ Saturated fatty acids: quintile distribution.

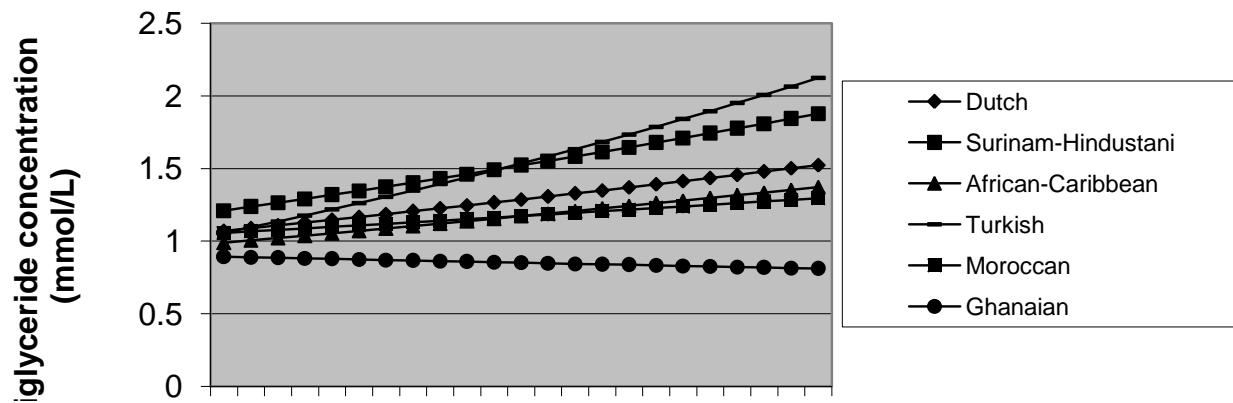
⁷ Linoleic acid: quintile distribution.

s: quintile distribution.

1 a



1 b



Tri

18 20 22 24 26 28 30 32 34 36 38 40

BMI (kg/m²)