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ORIGINAL RESEARCH

Racial/Ethnic Disparities in Screening for and Awareness of High Cholesterol Among Pregnant Women Receiving Prenatal Care

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BACKGROUND: Atherosclerotic cardiovascular disease remains a leading cause of morbidity and mortality among women, with younger women being disproportionately affected by traditional cardiovascular risk factors such as dyslipidemia. Despite recommendations for lipid screening in early adulthood and the risks associated with maternal dyslipidemia during pregnancy, many younger women lack access to and utilization of early screening. Accordingly, our objective was to assess the prevalence of and disparities in lipid screening and awareness of high cholesterol as an atherosclerotic cardiovascular disease risk factor among pregnant women receiving prenatal care.

METHODS AND RESULTS: We invited 234 pregnant women receiving prenatal care at 1 of 3 clinics affiliated with the University of Pennsylvania Health System to complete our survey. A total of 200 pregnant women (86% response rate) completed the survey. Overall, 59% of pregnant women (mean age 32.2 [±5.7] years) self-reported a previous lipid screening and 79% of women were aware of high cholesterol as an atherosclerotic cardiovascular disease risk factor. Stratified by racial/ethnic subgroups, non-Hispanic Black women were less likely to report a prior screening (43% versus 67%, P=0.022) and had lower levels of awareness (66% versus 92%, P<0.001) compared with non-Hispanic White women. Non-Hispanic Black women were more likely to see an obstetrician/gynecologist for their usual source of non-pregnancy care compared with non-Hispanic White women (18% versus 5%, P=0.043). Those seeing an obstetrician/gynecologist for usual care were less likely to report a prior lipid screening compared with those seeing a primary care physician (29% versus 63%, P=0.007).

CONCLUSIONS: Significant racial/ethnic disparities persist in lipid screening and risk factor awareness among pregnant women. Prenatal care may represent an opportunity to enhance access to and uptake of screening among younger women and reduce variations in accessing preventive care services.

Key Words: atherosclerotic cardiovascular disease ■ disparities ■ lipid screening ■ pregnancy ■ prevention ■ risk factors

Atherosclerotic cardiovascular disease (ASCVD) is a leading cause of morbidity and mortality among women in the United States.[1] Though recent data show an overall decline in ASCVD incidence and mortality, a stagnation in population-level trends has been observed among younger women (aged <55 years).[2–4] The increased prevalence of traditional ASCVD risk factors such as diabetes mellitus, obesity and overweight, hypertension, and dyslipidemia may contribute, in part, to current trends.[3] Compared with all other known ASCVD risk factors, dyslipidemia is a leading population-adjusted risk factor among women.[5] Moreover, younger women with undiagnosed and undertreated lipid disorders, including familial hypercholesterolemia (FH), are known to be at greater risk for developing early ASCVD (aged <65 years).[6] Despite recommendations for the screening of lipid disorders in early

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CLINICAL PERSPECTIVE

What Is New?

- Our cross-sectional study of 200 pregnant women receiving prenatal care showed that 3 in 5 non-Hispanic Black women (2 in 5 women overall) lacked a prior self-reported lipid screening with significant disparities existing across socioeconomic characteristics.
- We found that 1 in 3 non-Hispanic Black women (1 in 5 women overall) were not aware of high cholesterol as a risk factor for atherosclerotic cardiovascular disease.
- Disparities in the presence of any prior lipid screening persisted upon review of participants' electronic medical records.

What Are the Clinical Implications?

- Leveraging prenatal and early pregnancy care may be a key opportunity to enhance lipid screening before normal changes in lipid metabolism occur during pregnancy, particularly considering the proportion of women who see their obstetrician/gynecologist for preventive care.
- Future studies should assess variations in lipid screening and risk factor awareness in a larger and more diverse population of pregnant women.
- Multidisciplinary collaborations between obstetrics/gynecology, primary care, and cardiology practitioners, as well as focused public health interventions, are needed to address current gaps in awareness and preventive care services.

Nonstandard Abbreviations and Acronyms

EMR	electronic medical records
FH	familial hypercholesterolemia
OB/GYN	obstetrician/gynecologist
UPHS	University of Pennsylvania Health System

adulthood, less than half of women have had a prior lipid screening, with considerable disparities existing for non-White women and socioeconomically disadvantaged populations.[7–13] Therefore, novel strategies are needed to increase access to and use of lipid screening for younger women to prevent early ASCVD and identify potential lipid disorders.

Considering that nearly 86% of women will have experienced at least 1 pregnancy by age 45 years,[14] pre-pregnancy and early prenatal care are periods during which a large proportion of women receive a range of health care services. However, lipid screening has not been shown to be performed widely among reproductive-aged women.[14,15] While marked changes in lipid levels occur by the second and third trimesters, the majority of women receive prenatal care beginning in the first trimester of pregnancy before significant changes in lipid metabolism.[14,16–22] Pregnancy, often referred to as a cardiometabolic "stress test," represents a unique opportunity to not only screen for potential lipid disorders, but also to leverage obstetric/gynecologic history to assess ASCVD risk and enhance risk factor awareness in women. While general knowledge, awareness, and perceived susceptibility to disease have been shown to increase prevention-seeking behaviors, public understanding of risk factors for ASCVD has also been deemed essential for primary and secondary prevention.[23,24] Integrating these strategies for screening during pregnancy and throughout early prenatal care may help inform close follow-up and referral transitions to a primary care physician or cardiovascular specialist during the postpartum period.[2,25]

Accordingly, the objective of this study was to survey pregnant women receiving prenatal care to assess the prevalence of prior lipid screenings and an awareness of high cholesterol as an ASCVD risk factor. Our goal was to assess the presence of lipid screening at any time before survey administration. Additionally, we aimed to characterize disparities in screening and awareness based on race/ethnicity and other sociodemographic characteristics in our urban population of pregnant women.

METHODS

The authors declare that all supporting data are available within the article (and its online supplementary files).

Study Design and Participants

This cross-sectional survey study sought to assess and compare the prevalence of screening for and awareness of high cholesterol as an ASCVD risk factor among pregnant women receiving prenatal care from 1 of 3 clinics affiliated with the University of Pennsylvania Health System (UPHS) between May 31, 2019 and August 1, 2019. Surveys were administered in-person to pregnant, English-speaking women aged ≥18 years at the time of any prenatal care visit occurring during the study period. As a result, our study population resembled a "convenience sample" in which pregnant women were not selected by means of a simple or stratified random sampling

scheme, rather roughly the majority of women attending their prenatal care visit at UPHS were invited to participate in our study during the specified study duration. After obtaining informed consent forms and completed surveys, clinical measures and lipid screening characteristics were abstracted from participants' electronic medical records (EMR). Racial/ethnic differences were assessed upon stratifying participants based on race (White, Black, Asian, or multiracial [defined as identifying with more than one racial group]) and ethnicity (Hispanic or non-Hispanic [NH]). Because of a limited sample size for Hispanic, Asian, and multiracial women, analyses were primarily conducted among NH White and NH Black women. Pregnant women were excluded if they were aged <18 years or if they were not proficient in English.

Survey Development and Administration

We developed a survey that assessed pregnant women's demographic and clinical characteristics including race/ethnicity, highest level of completed education, annual household income, family history of high cholesterol and ASCVD, and current and/or former health conditions during pregnancy such as gestational diabetes mellitus, gestational hypertension, and preeclampsia. The presence of a previous premature birth was defined as delivery <37 weeks of gestation. Participants' gestational age was categorized by trimester at the time of survey completion. We also assessed whether women had a usual source of nonpregnancy care and if so, with what type of healthcare provider (survey questions in Data S1).

Our main outcomes included a self-reported presence of any prior lipid screening and an awareness of high cholesterol as an ASCVD risk factor. The presence of any prior lipid screening was assessed based on participants' response to the question, "Have you ever had your cholesterol levels checked with a blood test?". Among women reporting a prior screening, we assessed the timing of screening (within the past year, 2 years, or 5 years or longer) and the type of provider who ordered the screening test (primary care physician, obstetrician/gynecologist [OB/GYN], or other). Additionally, participants' relative awareness of high cholesterol as an ASCVD risk factor was evaluated based on the survey question, "Have you ever heard that high cholesterol is a risk factor for developing heart disease?". Finally, we assessed participants' acceptability of lipid screening during early pregnancy by posing the following statement: "I would like my OB/GYN to check my cholesterol levels during early pregnancy, at the same time that I am getting my blood drawn for other necessary tests" and classifying responses based on a 5-point Likert scale (strongly disagree to strongly agree) after providing a brief passage about the potential risks and benefits of early screening (Data S1). The survey was validated among a small group of pregnant and recently postpartum women receiving care at UPHS, and the survey was accordingly updated based on their feedback.

EMR Data Collection

Upon survey completion, we reviewed each respondent's medical records to ascertain additional clinical characteristics and documentation of prior lipid screening results. Specifically, we abstracted prior levels of low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, total cholesterol, and triglycerides (in mg/dL). The timing of prior EMR-documented screening was determined by the elapsed time between test date and the date of survey completion. Six participants had missing EMR data and were excluded from EMR aspects of subsequent statistical analyses yielding an overall sample of 194 women with complete data. Analyses based on racial/ethnic differences in EMR-documented lipid levels were conducted to include all documented lipid profile results as well as a subsequent sensitivity analysis excluding results from 1 woman with suspected undiagnosed FH, based on the Dutch Lipid Clinic Network diagnostic criteria.[6,26,27]

Statistical Analysis

We analyzed continuous and categorical descriptive data using 2-tailed t test and Chi-square analysis or Fisher exact test, respectively. We conducted logistic regression analysis to ascertain the association between participants' characteristics and absence of prior lipid screening and lack of awareness of high cholesterol as an ASCVD risk factor. Self-reported screening and risk factor awareness responses were dichotomized into "yes" and "no/unsure" because of the relatively small sample size. Odds ratios (OR) and 95% CI were produced for unadjusted and adjusted associations. Our final model for logistic regression analyses adjusting for age, race/ethnicity, education level, and usual source of care status was developed based on a backward elimination strategy, in which variables were removed individually from an originally full model if not statistically significant to produce the most parsimonious final model.[28] A $P<0.05$ was considered statistically significant. Analyses were conducted with SAS, version 9.4 (SAS Inc., Cary, NC). The protocol and survey instrument were approved by the Institutional Review Board at the University of Pennsylvania.

RESULTS

We invited 234 pregnant women receiving prenatal care at UPHS to take our survey, in which 200 surveys were

completed (85.5% response rate). Overall, 68% of participants were aged <35 years (mean [±SD] age, 32.2 [±5.7] years) and approximately half (51%) were >28 weeks of gestation at the time of survey completion (Table 1). We observed the following racial/ethnic distribution in our sample: 46% NH White, 34% NH Black, 9% Asian, 6%

Table 1. Overall Demographic and Clinical Characteristics Among Pregnant Women and Differences Stratified by Non-Hispanic White and Non-Hispanic Black Women

Study Variables	Overall Population (n=200)*	NH White (n=91)	NH Black (n=68)	*P* Value
Age, mean (SD)	32.2 (5.7)	34.1 (5.0)	29.6 (5.8)	<0.001
Age categories, y				0.004
18–34	133 (67.9)	53 (58.9)	56 (82.4)	
≥35	63 (32.1)	37 (41.1)	12 (17.7)	
Race/Ethnicity				…
NH White	91 (45.5)	91 (100.0)	0 (0.0)	
NH Black	68 (34.0)	0 (0.0)	68 (100.0)	
Asian	18 (9.0)	0 (0.0)	0 (0.0)	
Hispanic	12 (6.0)	0 (0.0)	0 (0.0)	
Multiracial	9 (4.5)	0 (0.0)	0 (0.0)	
Missing	2 (1.0)	0 (0.0)	0 (0.0)	
Gestational age (wk) at time of survey				0.214
1–13	18 (9.3)	10 (11.2)	6 (9.0)	
14–27	78 (40.2)	42 (47.2)	22 (32.8)	
28+	98 (50.5)	37 (41.6)	39 (58.2)	
Education				<0.001
High school/GED or lower	40 (20.2)	6 (6.6)	28 (41.2)	
Some college or associate degree	42 (21.2)	10 (11.0)	22 (32.4)	
College graduate or above	116 (58.6)	75 (82.4)	18 (26.5)	
Annual household income				<0.001
<$20 000	19 (11.7)	3 (3.7)	11 (21.6)	
$20 000–$49 999	32 (19.8)	3 (3.7)	23 (45.1)	
$50 000–$99 999	35 (21.6)	15 (18.5)	12 (23.5)	
≥$100 000	76 (46.9)	60 (74.1)	5 (9.8)	
Usual source of non-pregnancy care				0.330
Yes	172 (87.8)	77 (85.6)	63 (92.7)	
No	24 (12.2)	13 (14.4)	5 (7.4)	
Non-pregnancy care provider type				0.043
Primary care, family medicine	153 (90.0)	71 (94.7)	52 (82.5)	
OB/GYN	17 (10.0)	4 (5.3)	11 (17.5)	
Family history of high cholesterol				0.002
Yes	67 (34.5)	43 (47.8)	11 (16.4)	
No	95 (49.0)	36 (40.0)	40 (59.7)	
Unsure	32 (16.5)	11 (12.2)	16 (23.9)	
Family history of cardiovascular disease				0.548
Yes	32 (16.2)	13 (14.3)	11 (16.4)	
No	156 (83.8)	78 (85.7)	56 (83.6)	
Past OB history				
Gestational diabetes mellitus	17 (8.6)	6 (6.6)	6 (8.8)	0.562
Gestational hypertension	13 (6.6)	7 (7.7)	6 (8.8)	0.160
Preeclampsia	18 (9.1)	6 (6.6)	10 (14.7)	0.123
Premature birth (<37 wks of gestation)	17 (8.6)	5 (5.5)	10 (14.7)	0.078

NH indicates non-Hispanic; OB, obstetric; and OB/GYN, obstetrician/gynecologist.
**P* value represents statistical comparison between NH White and NH Black subgroups.

Hispanic, and 5% multiracial (Table 1). In our sample, 59% of women had completed college or higher and 47% of participants indicated an annual household income of >$100 000. We found that 88% of women had a usual source of non-pregnancy care, with 90% receiving care from a primary care physician or family medicine practitioner and only 10% from an OB/GYN. Additionally, 35% and 16% of women reported having a family history of high cholesterol and ASCVD, respectively.

We found significant differences in demographic and clinical characteristics between NH Black and NH White women (Table 1). Notably, a smaller proportion of NH Black women were aged ≥35 years compared with NH White women (18% versus 41%, *P*=0.004). Additionally, NH Black women were less likely to have completed college or higher compared with NH White women (27% versus 82%, *P*<0.001) and less likely to report an annual household income ≥$100 000 compared with NH White women (10% versus 74%, *P*<0.001). Our results also showed that NH Black women were more likely to indicate that an OB/GYN was their usual source of non-pregnancy care compared with NH White women (18% versus 5%, *P*=0.043).

Asian, Hispanic, and multiracial women were not included in our primary statistical analyses because of smaller sample sizes (Table S1). Among our participants, 78% of Asian, 33% of Hispanic, and 56% of multiracial women had completed college or higher. Among these racial/ethnic subgroups, 47%, 30%, and 20% reported an annual household income of ≥$100 000, respectively.

Overall, 118 (59%) pregnant women reported a previous lipid screening, with the majority of participants (57%) indicating that they received this screening within the past year (Table 2). Among women reporting prior screening, 63% and 19% of women received screening from a primary care physician and OB/GYN, respectively. We found that 79% of participants were aware of high cholesterol as an ASCVD risk factor and 71% found lipid screening during early pregnancy care acceptable. Among women with a prior lipid screening, 91% reported normal levels while 4% and 3% reported borderline and abnormal levels, respectively.

When stratified by race/ethnicity, we observed that NH Black women were less likely to self-report a prior lipid screening (43% versus 67%, *P*=0.022) and were less likely to be aware of high cholesterol as an ASCVD risk factor (66% versus 92%, *P*<0.001) compared with NH White women. Acceptability of lipid screening

Table 2. Self-Reported Lipid Screening Characteristics and Risk Factor Awareness Stratified by Non-Hispanic White and Non-Hispanic Black Racial/Ethnic Subgroups

Screening Characteristics	Overall (n=200)	NH White (n=91)	NH Black (n=68)	*P* Value*
Prior lipid screening				0.022
Yes	118 (59.0)	61 (67.0)	29 (42.7)	
No	30 (15.0)	11 (12.1)	14 (20.6)	
Unsure	52 (26.0)	19 (20.9)	25 (36.8)	
Timing of prior lipid screening				0.077
Within past y	68 (57.1)	29 (48.3)	22 (73.3)	
Within past 2 y	23 (19.3)	11 (18.3)	6 (20.0)	
Within past 5 y or longer	28 (23.5)	20 (33.3)	2 (6.7)	
Type of provider ordering screening				0.355
Primary care or family medicine	79 (63.2)	38 (61.3)	25 (75.8)	
OB/GYN	24 (19.2)	11 (17.7)	5 (15.2)	
Other	22 (17.6)	13 (21.0)	3 (9.1)	
Awareness of high cholesterol as risk factor				<0.001
Yes	158 (79.0)	84 (92.3)	45 (66.2)	
No	35 (17.5)	7 (7.7)	16 (23.5)	
Unsure	7 (3.5)	0 (0.0)	7 (10.3)	
Acceptability of screening during pregnancy				0.610
Agree	141 (71.2)	63 (69.2)	46 (68.7)	
Neutral	44 (22.2)	22 (24.2)	15 (22.4)	
Disagree	13 (6.6)	6 (6.6)	6 (9.0)	

NH indicates non-Hispanic; and OB/GYN, obstetrician/gynecologist.
**P* value represents statistical comparison between NH White and NH Black subgroups.

during pregnancy was similar between NH White and NH Black women. Additionally, the prevalence of lipid screening among Asian, Hispanic, and multiracial women was 67%, 83%, and 44%, respectively, while an awareness of high cholesterol as an ASCVD risk was present in 72%, 75%, and 56% of women in each respective subgroup.

Figure and Table S2 show baseline characteristics associated with a self-reported history of lipid screening, including age ≥35 years compared with <35 years (53% versus 72%, *P*=0.011) and NH Black compared with NH White race/ethnicity (43% versus 67%, *P*=0.007). Highest completed level of education was associated with a stepwise increase in screening rates (*P*=0.002). Baseline characteristics associated with risk factor awareness included age ≥35 compared with <35 years (88% versus 75%, *P*=0.041), NH Black compared with NH White race/ethnicity (66% versus 92%, *P*<0.001) and having a usual source of non-pregnancy care compared with not having usual care (82% versus 63%, *P*=0.030). Highest completed level of education (*P*=0.006) and household income (*P*=0.003) were associated with a stepwise increase in awareness rates. Family history of high cholesterol or cardiovascular disease were not associated with the presence of prior lipid screening.

The results of the unadjusted and adjusted analyses are presented in Tables 3 and 4. Based on our unadjusted analysis of factors associated with greater odds of lacking prior lipid screening, we found significant associations based on younger age (OR, 2.28; 95% CI, 1.20–4.33; *P*=0.012), NH Black race/ethnicity (OR, 2.73; 95% CI, 1.43–5.24; *P*=0.002), lower education level (OR, 3.76; 95% CI, 1.77–8.00; *P*=0.001), and lower household income (OR, 2.23; 95% CI, 1.16–4.30; *P*=0.017). After adjusting for age, race/ethnicity, education, and usual source of non-pregnancy care, we found that NH Black race/ethnicity remained statistically significant (OR, 3.35; 1.29–8.67; *P*=0.013). Similarly, we found significant unadjusted associations between lack of risk factor awareness and younger age (OR, 2.35; 95% CI, 1.02–5.44; *P*=0.046), NH Black race/ethnicity (OR, 6.13; 95% CI, 2.44–15.39; *P*<0.001), lower education level (OR, 3.43; 95% CI, 1.49–7.92; *P*=0.004), lower household income (OR, 4.19; 95% CI, 1.61–10.95; *P*=0.003), and no usual source of care (OR, 2.66; 95% CI, 1.07–6.62; *P*=0.035). After adjusting for these covariates, NH Black race/ethnicity (OR, 8.92; 95% CI, 2.07–38.42; *P*=0.003) and no usual source of care (OR, 8.60; 95% CI, 1.73–42.69; *P*=0.009) remained statistically significant.

Upon our abstraction of EMR data, only 62 (32%) women had evidence of a prior lipid screening (Table 5). NH White women had higher rates of lipid screening compared with NH Black women (39% versus 19%, *P*=0.016). We identified 1 NH Black participant with suspected FH who had not yet been formally diagnosed. Excluding this participant for sensitivity analyses, the mean (SD) lipid levels included the following: total cholesterol of 174.4 (28.5) mg/dL, low-density lipoprotein cholesterol of 96.7

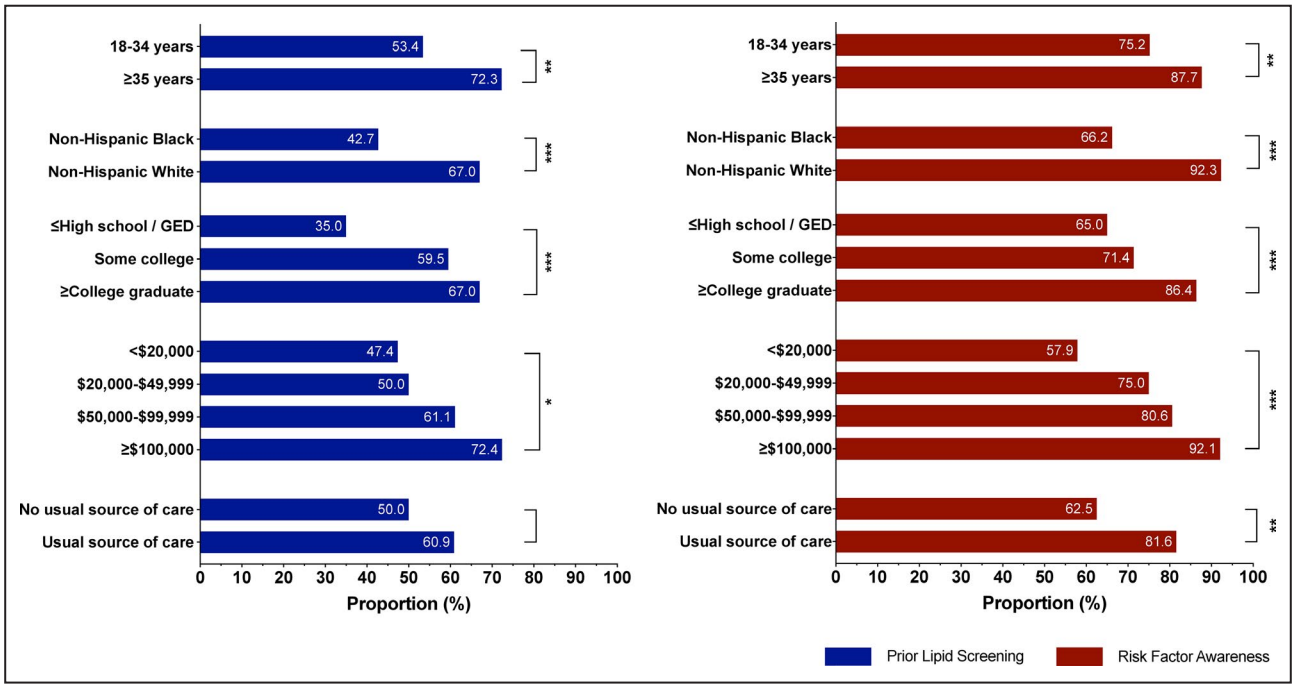

Figure. Self-reported lipid screening and risk factor awareness stratified by sociodemographic characteristics including age, race/ethnicity, highest level of completed education, household income, and usual source of care status.
GED indicates general education diploma. *P<0.10, **P<0.05, ***P<0.01.

Table 3. Unadjusted and Adjusted Associations Between Sociodemographic Characteristics and Lack of Prior Lipid Screening

Study Variables	Lack of Prior Lipid Screening			
	Unadjusted	*P* Value	Adjusted*	*P* Value
Age, y		0.012		0.407
18–34	2.28 (1.20–4.33)		1.44 (0.61–3.42)	
≥35	Reference		Reference	
Race/Ethnicity		0.002		0.013
NH Black	2.73 (1.43–5.24)		3.35 (1.29–8.67)	
NH White	Reference		Reference	
Education		0.001		0.196
≤ Some college	3.76 (1.77–8.00)		1.96 (0.71–5.43)	
≥ College graduate	Reference		Reference	
Household income		0.017		…
<$100 000/y	2.23 (1.16–4.30)		…	
≥$100 000/y	Reference		Reference	
Usual source of care		0.310		0.100
No	1.56 (0.66–3.67)		2.78 (0.82–9.37)	
Yes	Reference		Reference	

Values are presented as odds ratios (OR) and 95% CI. Unadjusted estimates derived from distinct logistic regression models for each study variable, adjusted estimates derived from single model with "…" representing variables not retained in the final model through backward elimination as they were not statistically significant in original full model. NH indicates non-Hispanic.

*Adjusted for age, race/ethnicity, education, and usual source of non-pregnancy care.

(25.8) mg/dL, high-density lipoprotein cholesterol of 60.9 (13.4) mg/dL, and triglycerides of 84.2 (40.8) mg/dL (Table S3). NH White women had significantly higher high-density lipoprotein cholesterol levels compared with NH Black women (63 versus 52 mg/dL, *P*=0.048).

Table 4. Unadjusted and Adjusted Associations Between Sociodemographic Characteristics and a Lack of Awareness of High Cholesterol as a Cardiovascular Risk Factor

Study Variables	Lack of Risk Factor Awareness			
	Unadjusted	*P* Value	Adjusted*	*P* Value
Age, y		0.046		0.517
18–34	2.35 (1.02–5.44)		1.56 (0.41–6.00)	
≥35	Reference		Reference	
Race/Ethnicity		<0.001		0.003
NH Black	6.13 (2.44–15.39)		8.92 (2.07–38.42)	
NH White	Reference		Reference	
Education		0.004		0.406
≤ Some college	3.43 (1.49–7.92)		1.66 (0.50–5.50)	
≥ College graduate	Reference		Reference	
Household income		0.003		…
<$100 000/y	4.19 (1.61–10.95)		…	
≥$100 000/y	Reference		Reference	
Usual source of care		0.035		0.009
No	2.66 (1.07–6.62)		8.60 (1.73–42.69)	
Yes	Reference		Reference	

Values are presented as odds ratios (OR) and 95% CI. Unadjusted estimates derived from distinct logistic regression models for each study variable, adjusted estimates derived from single model with "…" representing variables not retained in the final model through backward elimination as they were not statistically significant in original full model. NH indicates non-Hispanic.

*Adjusted for age, race/ethnicity, education, and usual source of non-pregnancy care.

Table 5. Lipid Screening Characteristics Among Pregnant Women From Data Abstraction of Electronic Medical Records Stratified by Non-Hispanic White and Non-Hispanic Black Racial/Ethnic Subgroups

EMR Screening Characteristics	Overall (n=194)*	NH White (n=89)	NH Black (n=65)	*P* Value†
Prior lipid screening				0.016
Yes	62 (32.0)	35 (39.3)	12 (18.5)	
No	132 (68.0)	54 (60.7)	53 (81.5)	
Timing of prior lipid screening (n=62)				0.927
Within past y	16 (25.8)	10 (28.6)	3 (25.0)	
Within past 2 y	8 (12.9)	5 (14.3)	2 (16.7)	
Within past 5 y	25 (40.3)	13 (37.1)	4 (33.3)	
Longer than past 5 y	13 (21.0)	7 (20.0)	3 (25.0)	

EMR indicates electronic medical records; NH, non-Hispanic.
*Six participants with absence of electronic medical records.
†*P* value represents statistical comparison between NH White and NH Black subgroups.

DISCUSSION

In our sample of pregnant women receiving prenatal care in a large, racially diverse urban area, we found that 59% of participants reported a prior lipid screening. Our findings demonstrated significant disparities in lipid screening by age, race/ethnicity, and education along with differences in risk factor awareness by these characteristics along with household income and usual source of care status. Notably, we found that NH Black women were significantly less likely to report a prior screening and had lower rates of risk factor awareness compared with NH White women. After adjusting for covariates, NH Black women had significantly higher odds of lacking a prior lipid screening. Moreover, NH Black women and those without a usual source of care also had greater adjusted odds of being unaware of high cholesterol as a cardiovascular risk factor.

Though prior studies have provided evidence for racial/ethnic and sociodemographic differences in lipid screening practices,[9,11,12,29–31] our cross-sectional survey represents one of the first studies demonstrating disparities in lipid screening and risk factor awareness among pregnant women receiving prenatal care. Our overall prevalence of lipid screening corresponded to those previously observed outside of pregnancy. For instance, Kuklina and colleagues showed a lipid screening rate of ≈50%, with minimal variations depending on the number of ASCVD risk factors present.[8] Lower socioeconomic status, lack of healthcare access, immigration status, and language barriers have also been shown to be significant predictors of racial and ethnic disparities in lipid screening.[9,11] Notably, our results align with population-level data from the National Health and Nutrition Examination Survey (NHANES) that found that NH White individuals were more likely to be screened for high blood cholesterol levels compared with NH Black individuals (65% versus 58%).[32]

In addition to observing differences in lipid screening rates by self-report and through assessment of participants' medical records, significant racial/ethnic differences were identified in awareness of high cholesterol as a risk factor for ASCVD. Our work can be interpreted alongside other studies that have assessed awareness of high cholesterol as a key modifiable risk factor. In a nationally representative sample of women, Mosca et al found that an awareness of increased ASCVD burden over time was higher in White women than Black women (62% versus 38%) and was independently correlated with increased physical activity and weight loss.[23] The authors found that only 46% of women could recall their lipid levels and that White women were significantly more knowledgeable of healthy lipid levels than either Black or Hispanic women ($P<0.05$).[23] Additionally, Huang and colleagues found that, among nearly 40 000 women without ASCVD in the Women's Health Study, women who were aware of their lipid levels had higher incomes and were more educated when compared with those who were unaware,[33] findings similar to the stepwise associations presented.

For inherited conditions of lipid metabolism such as FH, novel approaches are urgently needed for identifying probands and initiating cascade screening in close family members when applicable. With ≈90% of those with FH remaining undiagnosed and significant racial/ethnic disparities observed based on low-density lipoprotein cholesterol achievement among those with FH,[6,26,34] interdisciplinary strategies for integrating screening and cardiovascular risk assessment during a period of greater healthcare use may translate into a higher yield of case identification and subsequent cascade screening.[35] Since preventive health visits to an OB/GYN provider are often focused on reproductive health-related services, women of reproductive age who use OB/GYN services primarily for preventive care may not be receiving

a comprehensive spectrum of preventive screenings, counseling, and follow-up care.[15] Our results show that women who identify their OB/GYN as their usual source of non-pregnancy care were significantly less likely to undergo lipid screening compared with those seeing a primary care or family medicine practitioner. Leveraging the perinatal period is currently an underutilized opportunity to screen for potential lipid disorders, promote primary prevention of ASCVD, and inform necessary follow-up care and counseling, if needed.[36–38]

Engaging OB/GYN practitioners has been identified as a potential strategy for enhancing ASCVD prevention considering the high frequency in which women receive healthcare services from OB/GYNs during reproductive years, though barriers to effective screening, management, and referrals have been reported.[39–41] One national survey of OB/GYNs found that, while 61% of practitioners provided more than reproductive care when providing well-woman care, they were unlikely to manage elevated lipid levels.[42] Moreover, in a focus group of OB/GYNs, knowledge gaps and skill deficits along with liability concerns and barriers to prevention were identified as practice barriers.[40] Increased awareness initiatives, educational interventions, and multidisciplinary partnerships are needed to effectively communicate the reliability of lipid screening tests during early pregnancy, particularly during the first trimester before significant changes in lipid metabolism occur.

Racial differences in prior lipid screenings were also observed upon review of participants' EMR data. Overall, fewer patients had EMR-documented lipid screening compared with self-report. This may be a result of patients undergoing lipid screenings at other testing sites or through workplace wellness programs as well as being attributable to participant recall bias. Among the 194 women without missing EMR data, we identified at least 1 probable FH case that had not been previously evaluated by a clinical lipidology or cardiovascular specialist. While plasma cholesterol and triglyceride levels have been shown to increase by 25% to 50% and 150% to 300%, respectively, during pregnancy, women with FH experience a higher absolute increase in lipid levels, thus potentially putting them at greater risk for accelerated atherosclerosis.[43,44] Though statins and other lipid-lowering medications such as ezetimibe and PCSK9 (proprotein convertase subtilisin/kexin type 9) inhibitors are contraindicated and therefore not recommended during pregnancy and lactation, identifying FH earlier in life is critical for initiating appropriate postpartum follow-up care including lipid-lowering agents.[36] Engaging OB/GYNs as key partners in ASCVD prevention, management, and counseling represents a unique opportunity to screen for potential lipid disorders, assess future cardiovascular risk, and leverage specialized postpartum follow-up care.[2,38–40] Future studies will need to evaluate effective strategies for operationalizing lipid screening and follow-up for those with abnormal lipid results, especially among vulnerable populations.

Limitations

Our findings should be interpreted considering several limitations. First, responses to our survey may have been subject to response and/or recall bias. Despite aiming to survey all eligible women present in the waiting room during survey administration visits and an overall high response and completion rate, the risk of selection bias cannot be discounted. Second, the retrospective review of the EMR did not capture all relevant clinical characteristics, such as prior diagnosis of hypertension or diabetes mellitus and was subject to missing data. Third, our sample size limited our ability to further evaluate associations between lipid screening and risk factor awareness with sociodemographic characteristics in other subgroups. The relatively small sample size may have also reduced precision in the reported effect estimates. Fourth, our study used an investigator-developed survey instrument, thereby strengthening the case for implementing future validation studies in larger, nationally representative cohorts. Additionally, carrying out focus groups and/or cognitive interviews would help reduce bias and ensure a more equitable understanding of survey contents and questions, particularly given differences in educational attainment by race/ethnicity. Lastly, the external validity of our findings was limited to English-speaking, pregnant women receiving prenatal care in an urban setting and may not be generalizable to other populations.

CONCLUSIONS

Despite current guidelines recommending focused screening for lipid disorders in early adulthood along with the health risks associated with maternal dyslipidemia, we found that 2 in 5 pregnant women did not report a prior lipid screening and 1 in 5 were unaware of high cholesterol as an ASCVD risk factor. Significant racial/ethnic and sociodemographic disparities were associated with both lack of screening and risk factor awareness. Leveraging prenatal and early pregnancy care may represent an opportunity to enhance lipid screening among younger women, identify potential lipid disorders, and reduce current variations in accessing preventive cardiovascular services.

ARTICLE INFORMATION

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Supplementary Material

Data S1
Tables S1–S3

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SUPPLEMENTAL MATERIAL

Data S1.

Participant Survey

Thank you for filling out this survey. Please answer all questions. When you are finished, please return the survey to the research assistant.

First, we will ask you some questions about cholesterol testing and your use of health care service *before* pregnancy.

1. What is your date of birth? _____ / _____ / _____ (MM / DD / YYYY)
2. Are you currently pregnant?
   □ Yes □ No

   If you answered "Yes" to the above question, please answer the following:
   3. How many **weeks** pregnant are you? _____
4. Have you ever heard that high cholesterol is a risk factor for developing heart disease?
   □ Yes □ No □ I don't know
5. Have you ever been told that you have high cholesterol?
   □ Yes □ No □ I don't know
6. Have you ever had your cholesterol levels checked with a blood test?
   □ Yes □ No □ I don't know

   If you answered "Yes" to the above question, please answer the following:
   7. When did you last have them checked (approximately)?
   □ Within past year □ Within past 2 years
   □ Within past 5 years □ Within past 10 years
   □ Longer than 10 years ago

   8. Who ordered the test?
   □ Primary care or family medicine provider □ OBGYN
   □ Cardiologist □ Pediatrician
   □ Other, please describe: _____ □ I don't know

   9. What were you told about the results?
   Cholesterol levels were:
   □ normal □ not normal
   □ borderline □ wasn't told or I don't remember
10. Does high cholesterol run in the family?
    □ Yes □ No □ I don't know

    If you answered "Yes" to the above question, please answer the following:
    11. Who in the family has high cholesterol?
    □ Mother □ Father □ Brother □ Sister □ Grandparent
12. Have you ever been on cholesterol lowering medication?

□ Yes □ No □ I don't know

If you answered "Yes" to the above question, please answer the following:

13. Which cholesterol lowering medications have you taken?

□ Statins (Lipitor, Crestor) □Ezetimibe (Zetia)
□ Bile Acid Sequestrants (Colestid) □ PSCK9 inhibitors (Repatha, Praluent)
□ Niacin □ Other, please describe: _____

Next, we will ask you some questions about your personal medical history and your family history.

14. Is there a doctor or other health care provider that you see regularly for check-ups or health maintenance when you are **not** pregnant?
□ Yes □ No

If you answered "Yes" to the above question, please answer the following:

15. What kind of health care provider do you see?
□ Primary care, internal medicine, or family medicine provider □ OBGYN
□ Cardiologist □ Pediatrician
□ Other, please describe: _____ □ I don't know

16. Is this health care provider in the PENN system?
□ Yes □ No □ I don't know

If you answered "No" to the above question, please answer the following:

17. When is the last time you saw a health care provider for a routine check-up or health maintenance visit?
□ More than 1 year ago □ More than 3 years ago
□ More than 5 years ago □ I don't remember

18. Do you have any male first degree relatives (father, brother or son) who had a heart attack, stroke, or coronary artery disease that occurred before the age of 50 years?
□ Yes □ No □ I don't know

19. Do you have any female first degree relatives (mother, sister, daughter) who had a heart attack, stroke, or coronary artery disease that occurred before the age of 60 years?
□ Yes □ No □ I don't know

20. Have you ever had any of the following conditions during this pregnancy or a prior pregnancy?
□ Gestational diabetes □ Gestational hypertension
□ Preeclampsia

21. Have you ever delivered a baby prematurely (before 37 weeks gestation)?
□ Yes □ No

If yes to above question:
How many **weeks** pregnant were you when you delivered? _____

22. Do you *currently* smoke cigarettes or use tobacco most days of the week?
□ Yes □ No

If you answered "No" to the above question, please answer the following:
Did you smoke or use tobacco most days of the week before pregnancy?
□ Yes □ No

23. What was your weight prior to pregnancy? _____ (in pounds)

Next, we want to know your opinion about cholesterol screening in pregnancy.

Cholesterol levels are measured with a blood test. High cholesterol is a risk factor for developing heart disease. Unfortunately, many women do not receive the recommended screening for cholesterol during their reproductive years. We would like to know how you would feel about your OBGYN checking your cholesterol levels during early pregnancy to see if you are at risk. These results would not impact your pregnancy but might change your care after you deliver. For example, if you had high cholesterol, your OBGYN might be more likely to refer you to a primary care doctor to learn about ways to lower your cholesterol through healthy diet and exercise. In rare cases, the cholesterol level might be high enough for a referral to see a doctor specializing in cholesterol disorders.

Given this information, please respond to the following statement. Your answer is confidential and will not impact the care you receive from your doctors.

24. I would like my OBGYN to check my cholesterol levels during early pregnancy, at the same time that I am getting my blood drawn for other necessary tests.
□ Strongly agree □ Agree □ Neutral □ Disagree □ Strongly disagree

Finally, we want to ask you a few questions about your background.

25. What is your race?
□ White □ Black □ Asian □ Native American □ Multiracial □ Prefer not to answer

26. What is your ethnicity?
□ Hispanic □ Non-Hispanic □ Prefer not to answer

27. What is your highest level of education completed?
□ Less than 12th grade □ High school or GED □ Some college or associate degree
□ College graduate or above □ Prefer not to answer

28. What is your annual household income?
□ Less than $20,000 □ $20,000 - $49,999 □ $50,000 - $99,999 □ More than $100,000
□ Prefer not to answer

Thank you for completing the survey.
If you have any feedback for us, please provide write your comments below.

Table S1. Overall demographic and clinical characteristics among pregnant women and differences stratified by all racial/ethnic subgroups.

Study Variables	Overall Population (N=200)*	NH White	NH Black	Asian	Hispanic	Multiracial
Sample, n (%)	---	91 (45.5)	68 (34.0)	18 (9.0)	12 (6.0)	8 (4.5)
Age, mean (SD)	32.2 (5.7)	34.1 (5.0)	29.6 (5.8)	33.6 (4.5)	30.3 (6.0)	31.3 (6.5)
Age Categories, y						
18 – 34	133 (67.9)	53 (58.9)	56 (82.4)	9 (50.0)	10 (83.3)	5 (62.5)
35+	63 (32.1)	37 (41.1)	12 (17.7)	9 (50.0)	2 (16.7)	3 (37.5)
Gestational age (weeks) at time of survey						
1 – 13	18 (9.3)	10 (11.2)	6 (9.0)	1 (5.9)	1 (8.3)	0 (0.0)
14 – 27	78 (40.2)	42 (47.2)	22 (32.8)	6 (35.3)	5 (41.7)	3 (33.3)
28+	98 (50.5)	37 (41.6)	39 (58.2)	10 (58.8)	6 (50.0)	6 (66.7)
Education						
High school / GED or lower	40 (20.2)	6 (6.6)	28 (41.2)	1 (5.6)	3 (25.0)	2 (22.2)
Some college or associate degree	42 (21.2)	10 (11.0)	22 (32.4)	3 (16.7)	5 (41.7)	2 (22.2)
College graduate or above	116 (58.6)	75 (82.4)	18 (26.5)	14 (77.8)	4 (33.3)	5 (55.6)
Annual Household Income						
Less than $20,000	19 (11.7)	3 (3.7)	11 (21.6)	1 (6.7)	3 (30.0)	1 (20.0)
$20,000 – $49,999	32 (19.8)	3 (3.7)	23 (45.1)	3 (20.0)	2 (20.0)	1 (20.0)
$50,000 – $99,999	35 (21.6)	15 (18.5)	12 (23.5)	4 (26.7)	2 (20.0)	2 (40.0)
More than $100,000	76 (46.9)	60 (74.1)	5 (9.8)	7 (46.7)	3 (30.0)	1 (20.0)
Usual Source of Non-Pregnancy Care						
Yes	172 (87.8)	77 (85.6)	63 (92.7)	12 (66.7)	11 (100.0)	9 (100.0)
No	24 (12.2)	13 (14.4)	5 (7.4)	6 (33.3)	0 (0.0)	0 (0.0)
Non-Pregnancy Usual Care Provider Type						
Primary care, family medicine	153 (90.0)	71 (94.7)	52 (82.5)	10 (83.3)	11 (100.0)	9 (100.0)
OB/GYN	17 (10.0)	4 (5.3)	11 (17.5)	2 (16.7)	0 (0.0)	0 (0.0)
Family History of High Cholesterol						
Yes	67 (34.5)	43 (47.8)	11 (16.4)	9 (52.9)	2 (18.2)	2 (22.2)
No	95 (49.0)	36 (40.0)	40 (59.7)	6 (35.3)	8 (72.7)	5 (55.6)
Unsure	32 (16.5)	11 (12.2)	16 (23.9)	2 (11.8)	1 (9.1)	2 (22.2)
Family History of Cardiovascular Disease						
Yes	32 (16.2)	13 (14.3)	11 (16.4)	3 (16.7)	2 (16.7)	3 (33.3)
No	156 (83.8)	78 (85.7)	56 (83.6)	15 (83.3)	10 (83.3)	6 (66.7)
Past OB History						
Gestational diabetes	17 (8.6)	6 (6.6)	6 (8.8)	3 (16.7)	1 (8.3)	1 (11.1)
Gestational hypertension	13 (6.6)	7 (7.7)	6 (8.8)	0 (0.0)	0 (0.0)	0 (0.0)
Preeclampsia	18 (9.1)	6 (6.6)	10 (14.7)	1 (5.6)	1 (8.3)	0 (0.0)
Premature birth (<37 weeks' gestation)	17 (8.6)	5 (5.5)	10 (14.7)	0 (0.0)	1 (8.3)	1 (11.1)

* Frequencies may not add up to entire sample population (N=200) due to missing data based on race/ethnicity

GED, general education diploma; OB/GYN, obstetrician/gynecologist

Table S2. Demographic and clinical characteristics associated with a prior lipid screening and an awareness of high cholesterol as a cardiovascular risk factor.

Study Variables	Prior Lipid Screening			Awareness of High Cholesterol as Risk Factor		
	Yes (N = 118)	No / Unsure (N = 82)	P Value	Yes (N = 158)	No / Unsure (N = 42)	P Value
Age, y			0.011			0.041
18 – 34	71 (53.4)	62 (46.6)		100 (75.2)	33 (24.8)	
35+	47 (72.3)	18 (27.7)		57 (87.7)	8 (12.3)	
Gestational age (weeks) at time of survey			0.341			0.702
1 – 13	9 (50.0)	9 (50.0)		13 (72.2)	5 (27.8)	
14 – 27	43 (54.4)	36 (45.6)		62 (78.5)	17 (21.5)	
28+	63 (63.6)	36 (36.4)		80 (80.8)	19 (19.2)	
Race/Ethnicity			0.007			<0.001
NH White	61 (67.0)	30 (33.0)		84 (92.3)	7 (7.7)	
NH Black	29 (42.7)	39 (57.4)		45 (66.2)	23 (33.8)	
Asian	12 (66.7)	6 (33.3)		13 (72.2)	5 (27.8)	
Hispanic	10 (83.3)	2 (16.7)		9 (75.0)	3 (25.0)	
Multiracial	4 (44.4)	5 (55.6)		5 (55.6)	4 (44.4)	
Education			0.002			0.006
High school / GED or lower	14 (35.0)	26 (65.0)		26 (65.0)	14 (35.0)	
Some college or higher	25 (59.5)	17 (40.5)		30 (71.4)	12 (28.6)	
College graduate or above	79 (67.0)	39 (33.1)		102 (86.4)	16 (13.6)	
Annual Household Income			0.066			0.003
Less than $20,000	9 (47.4)	10 (52.6)		11 (57.9)	8 (42.1)	
$20,000 – $49,999	16 (50.0)	16 (50.0)		24 (75.0)	8 (25.0)	
$50,000 – $99,999	22 (61.1)	14 (38.9)		29 (80.6)	7 (19.4)	
More than $100,000	55 (72.4)	21 (27.6)		70 (92.1)	6 (7.9)	
Usual Source of Care			0.307			0.030
Yes	106 (60.9)	68 (39.1)		142 (81.6)	32 (18.4)	
No	12 (50.0)	12 (50.0)		15 (62.5)	9 (37.5)	
Usual Care Provider Type			0.007			<0.001
Primary care, family medicine	97 (63.0)	57 (37.0)		128 (83.1)	26 (16.9)	
OB/GYN	5 (29.4)	12 (70.6)		8 (47.1)	9 (52.9)	
Family History of High Cholesterol			0.239			0.006
Yes	45 (66.2)	23 (33.8)		57 (83.8)	11 (16.2)	
No	52 (54.2)	44 (45.8)		81 (84.4)	15 (15.6)	
Unsure	21 (65.6)	11 (34.4)		19 (59.4)	13 (40.6)	
Family History of CVD			0.876			0.300
Yes	19 (57.6)	14 (42.4)		24 (72.7)	9 (27.3)	
No	98 (59.0)	68 (41.0)		134 (80.7)	32 (19.3)	
Past OB History						
Gestational diabetes	12 (70.6)	5 (29.4)	0.310	13 (76.5)	4 (23.5)	0.789
Gestational hypertension	11 (84.6)	2 (15.4)	0.052	10 (76.9)	3 (23.1)	0.849
Preeclampsia	7 (38.9)	11 (61.1)	0.069	13 (72.2)	5 (27.8)	0.459
Premature birth (<37 weeks' gestation)	5 (29.4)	12 (70.6)	0.010	10 (58.8)	7 (41.2)	0.033

CVD, cardiovascular disease; GED, general education diploma; OB/GYN, obstetrician/gynecologist

Table S3. Lipid screening characteristics among pregnant women from data abstraction of electronic medical records stratified by non-Hispanic White and non-Hispanic Black racial/ethnic subgroups.

Lipid Levels, mean (SD)†	Overall (N=194)*	NH White (N=35)	NH Black (N=12)	P-Value†
Total cholesterol, mg/dL‡	174.4 (28.5)	175.4 (26.4)	175.3 (34.5)	0.905
LDL-C, mg/dL	96.7 (25.8)	96.0 (20.7)	109.5 (33.2)	0.125
HDL-C, mg/dL	60.9 (13.4)	63.0 (13.7)	52.0 (9.7)	0.048
Triglycerides, mg/dL	84.2 (40.8)	82.5 (40.7)	67.7 (26.1)	0.124

* Six participants with absence of electronic medical records

† P-value represents statistical comparison between NH White and NH Black subgroups

‡ Cholesterol levels from outlier (n=1) with suspected untreated familial hypercholesterolemia excluded from statistical analysis

SD, standard deviation; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol