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Racial/ethnic And Sociodemographic Disparities In Lipid Screening And Risk Factor Awareness Among Pregnant Women Receiving Prenatal Care

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ABSTRACT

BACKGROUND: Atherosclerotic cardiovascular disease (ASCVD) remains a leading cause of morbidity and mortality with younger women being disproportionately affected by traditional risk factors including dyslipidemia. Despite recommendations for lipid screening in early adulthood, many younger women currently do not undergo screening. Prenatal and early pregnancy care represent underutilized opportunities for lipid screening and ASCVD risk assessment. We aimed to assess the prevalence and variations in pregnant women reporting a prior lipid screening and an awareness of high cholesterol as a risk factor for ASCVD.

METHODS: We administered a survey to 234 pregnant women receiving prenatal care at one of the three clinics affiliated with the University of Pennsylvania Health System to assess self-reported demographic and clinical variables, prior lipid screening characteristics, and risk factor awareness. Participants' responses were augmented by screening data and previous lipid profile results from their electronic medical records (EMR).

RESULTS: A total of 200 pregnant women (86% response rate) completed the survey. Overall, 59% of pregnant women self-reported a previous lipid screening and 79% of women were aware of high cholesterol as an ASCVD risk factor. Stratified by racial/ethnic subgroups non-Hispanic (NH) Black women were less likely to report a prior screening (43% vs. 67%, $p=0.022$) and had lower levels of risk factor awareness (66% vs. 92%, $p<0.001$) compared with NH white women. While NH Black women were more likely to see an obstetrician/gynecologist (OB/GYN) for their usual source of non-pregnancy care compared with NH white women (18% vs. 5%, $p=0.043$), those seeking an OB/GYN were significantly less likely to receive a prior lipid

screening compared to those seeing a primary care physician (29% vs. 63%, p=0.007). Stepwise associations were observed between the presence of both a prior lipid screening and risk factor awareness with education and annual household income. After adjusting for covariates, NH Black women were more likely to lack prior screening (OR, 3.35; 95% CI, 1.29 – 8.67, p=0.013).

CONCLUSIONS: Significant racial/ethnic and sociodemographic disparities persist in both the presence of a prior lipid screening and awareness of high cholesterol as an ASCVD risk factor. Prenatal and early pregnancy care are underutilized opportunities to enhance lipid screening among younger women and reduce variations in access to preventive care.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

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 improvements has been observed among younger women (<55 years).[2-4] The increased prevalence of traditional ASCVD risk factors such as diabetes, obesity and overweight, hypertension, and dyslipidemia may contribute to the current trends.[3] Compared with all other known ASCVD risk factors, dyslipidemia represents a leading population-adjusted risk 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.[6] Despite recommendations for screening for lipid disorders in early adulthood, less than half of women have had a prior lipid screening, with considerable disparities existing for racial/ethnic minority and sociodemographic disadvantaged populations.[1,7-13] Therefore, novel strategies are needed to increase access to and utilization of lipid screening for young women to prevent early ASCVD and identify potential lipid disorders.

Considering that approximately 86% of women will have experienced at least 1 pregnancy by age 45 years,[14] prenatal and early pregnancy care represent a unique period during which a large proportion of women receive preventive care, though lipid screening has not routinely been performed during this period.[14,15] Marked changes in lipid levels – particularly in total cholesterol and triglycerides – occur by the second and third trimesters, however, the majority of women receive prenatal care beginning in the first trimester of pregnancy, prior to significant changes in lipid metabolism.[14,16-22] Pregnancy, often referred to as a cardiometabolic "stress test," along with the pre-pregnancy period represent a unique and currently underutilized

opportunity to not only screen for potential lipid disorders among younger women, but also to utilize OB/GYN history to inform ASCVD risk reduction strategies and/or referral patterns to a primary care physician or cardiovascular specialist during the postpartum period.[2,23]

Accordingly, the objective of this cross-sectional survey study was to assess the prevalence of prior lipid screening and awareness of high cholesterol as an ASCVD risk factor among pregnant women. Additionally, we aimed to better characterize differences in screening and awareness based on race/ethnicity and sociodemographic characteristics in our urban population of women receiving prenatal care.

METHODS

Study Design and Participants

This cross-sectional survey study sought to assess the prevalence and variations in lipid screening and risk factor awareness among pregnant women receiving prenatal care from one of three clinics affiliated with the University of Pennsylvania Health System (UPHS) between May – August 2019. Surveys were administered in-person to pregnant, English-speaking women 18 years of age or older prior to their prenatal care visit. After obtaining informed consent forms and completed surveys, clinical variables 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) and ethnicity (Hispanic or non-Hispanic). Due to limited sample size for Hispanic, Asian, and multiracial subgroups, analyses were conducted among non-Hispanic (NH) white and NH Black women. Pregnant women were excluded if they were younger than 18 years of age 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, gestational hypertension, and preeclampsia. The presence of a previous premature birth was defined as delivery <37 weeks' gestation. Participants' gestational age was categorized by trimester at the time of survey completion. We also assessed whether women had a usual source of non-pregnancy care and if so, with what type of healthcare provider (survey questions in supplemental materials).

Our main outcomes included a self-reported presence of prior lipid screening and an awareness of high cholesterol as an ASCVD risk factor. Among women reporting prior screening, we assessed the timing of screening (within past year, 2 years, or 5 years or longer) and the type of provider who ordered the screening test (primary care physician, OB/GYN, or other). Finally, we assessed participants' acceptability of lipid screening during early pregnancy on a 5-point Likert scale (strongly disagree to strongly agree) after providing a brief passage regarding the potential risk and benefits.

Electronic Medical Record (EMR) Data Collection

Upon survey completion, we reviewed each respondent's medical records to assess additional clinical characteristics and documentation of prior lipid screening results. Specifically, we abstracted prior levels of low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), total cholesterol, and triglycerides (in mg/dL). The timing of

prior EMR-documented screening was determined by the elapsed time between test date and 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 one woman with suspected undiagnosed FH, based on Dutch Lipid Clinic Network diagnostic criteria.[24-26]

Statistical Analyses

We analyzed continuous and categorical descriptive data using two-tailed *t* test and chi-square analysis or Fisher's 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 were dichotomized into "yes" and "no/unsure" due to the relatively small sample size. Odds ratios (OR) and 95% confidence intervals (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 was developed based on a backward elimination strategy, in which variables were removed individually from an originally full model to produce the most parsimonious final model.[27] A p-value < 0.05 was considered statistically significant. Analyses were conducted with SAS, version 9.4 (SAS Inc., Cary, North Carolina). The protocol was approved by the Institutional Review Board at the University of Pennsylvania.

RESULTS

We approached 234 pregnant women receiving prenatal care at UPHS and 200 women completed the surveys (85.5% response rate). Overall, 68% of participants were < 35 years of age (mean [±SD] age, 32.2 [±5.7] years) and approximately half (51%) were more than 28 weeks' 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% Hispanic, and 5% multiracial women. In our sample population, 59% of women had completed college or higher and 47% of participants indicated an annual household income of more than $100,000. We found that 88% of women had a usual source of non-pregnancy care, with 90% reporting 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 women and NH white women (Table 1). Notably, a greater proportion of NH white women were ≥ 35 years of age compared with NH Black women (41% vs. 18%, p=0.004). Additionally, NH white women were more likely to have completed college or higher compared with NH Black women (82% vs. 27%, p<0.001) and more likely to report an annual household income more than $100,000 compared with NH Black women (74% vs. 10%, p<0.001). Our results also showed that NH white women were less likely to indicate that an OB/GYN was their usual source of non-pregnancy care compared with NH Black women (5% vs. 18%, p=0.043).

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 with 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 a risk factor for ASCVD and 71% found lipid screening during early pregnancy acceptable. When stratified by race, we observed that NH white women were more likely to self-report a prior lipid screening (67% vs. 43%, p=0.022) and more likely to be aware of high cholesterol as an ASCVD risk factor (92% vs. 66%, p<0.001) compared with NH Black women. Acceptability of lipid screening during pregnancy was similar between NH white and NH Black women.

Figure 1 shows baseline characteristics associated with self-reported history of lipid screening, including age ≥ 35 compared to < 35 years (53% vs. 72%, p=0.011) and NH white race compared to NH Black race (67% vs. 43%, p=0.007). Highest completed level of education was associated with a stepwise increase in screening rates. Baseline characteristics associated with awareness of high cholesterol as an ASCVD risk factor included age ≥ 35 compared to < 35 years (88% vs. 75%, p=0.041), NH white compared to NH Black race (92% vs. 66%, p<0.001) and having a usual source of non-pregnancy care compared to not having usual care (82% vs 63%, p=0.003). Both highest completed level of education (p=0.006) and household income (p=0.003) were associated with a stepwise increase in screening rates. Family history of high cholesterol or cardiovascular disease were not associated with prior screening or awareness of high cholesterol as an ASCVD risk factor.

The results of the unadjusted and adjusted analyses are presented in Table 3. 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), NH Black race/ethnicity (OR, 2.73; 95% CI, 1.43 – 5.24), lower education level (OR, 3.76; 95% CI, 1.77 – 8.00), and lower household income (OR, 2.23; 95% CI, 1.16 – 4.30). 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). Similarly, we found significant unadjusted associations between lack of risk factor awareness and younger age (OR, 2.35; 95% CI, 1.02 – 5.44), NH Black race/ethnicity (OR, 6.13; 95% CI, 2.44 – 15.39), lower education level (OR, 3.43; 95% CI, 1.49 – 7.92), lower household income (OR, 4.19; 95% CI, 1.61 – 10.95), and no usual source of care (OR, 2.66; 95% CI, 1.07 – 6.62). After adjusting for these covariates, NH Black race/ethnicity (OR, 8.92; 95% CI, 2.07 – 38.42) and no usual source of care (OR, 8.60; 95% CI, 1.73 – 42.69) remained statistically significant.

Upon our abstraction of EMR data, only 62 (32%) women had evidence of prior lipid screening (Table 4). NH white women had higher rates of lipid screening compared with NH Black women (39% vs. 19%, p=0.016). We identified one NH Black participant with suspected FH who had not yet been formally diagnosed. Excluding this participant, the mean (SD) values were: total cholesterol of 174.4 (28.5) mg/dL, LDL-C of 96.7 (25.8) mg/dL, HDL-C of 60.9 (13.4) mg/dL, and triglycerides of 84.2 (40.8) mg/dL. NH white women had significantly higher HDL-C levels compared with NH Black women (63 vs. 52 mg/dL, p=0.048).

DISCUSSION

In a population 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 less likely to report prior screening (43% vs. 67%, p=0.022) and had lower rates of risk factor awareness (66%

vs. 92%, p<0.001) compared with NH white women. After adjusting for covariates, NH Black women were significantly more likely to lack a prior lipid screening. NH Black women and those without a usual source of care also had greater odds of being unaware of high cholesterol as a cardiovascular risk factor upon adjusting for covariates.

Though prior studies have provided evidence for racial/ethnic and sociodemographic differences in lipid screening practices,[9,11,12,28-30] 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 lipid screening prevalence of 59% corresponded to those previously observed. For instance, one study conducted by Kuklina and colleagues reported a lipid screening rate of approximately 50%, with minimal variations depending on the number of relative 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 Surveys (NHANES) that found that NH white individuals were more likely to be screened for high blood cholesterol levels compared with NH Black individuals (65% vs. 58%).[31]

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 more than one thousand women, Mosca *et al*. found that an awareness of increased ASCVD burden over time was higher in white women than Black women (62% vs. 38%) and was independently correlated with increased physical activity

and weight loss.[32] 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 ($p<0.05$).[32] Lastly, 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 to those who were unaware,[33] findings similar to the stepwise associations currently presented.

For inherited conditions of lipid metabolism such as FH, novel approaches are urgently needed for identifying proband patients and initiating cascade screening in family members when applicable. With approximately 90% of those with FH remaining undiagnosed and significant racial/ethnic disparities observed based on LDL-C achievement among those with FH,[24,25,34] interdisciplinary strategies for integrating screening and cardiovascular risk assessment during a period of greater healthcare utilization 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 utilize 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 primary care provider were less likely to undergo lipid screening compared to those seeing an internal medicine or family medicine practitioner (63% vs. 29%, $p=0.007$). 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 skills 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 screening were also observed upon review of participants' EMR data. Overall, fewer patients had EMR-documented lipid screening compared to self-report. This may be a result of patients undergoing lipid screening 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 one probable FH case that had not been previously evaluated by a lipid 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 monoclonal antibodies to proprotein convertase subtilisin/kexin type 9 (PCSK9) 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 a key partner in ASCVD prevention, management,

and counseling represents a unique opportunity to screen for potential lipid disorders, assess future cardiovascular risk, and leverage specialists for postpartum follow-up care.[2,38-40]

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 residual confounding cannot be discounted. Second, the retrospective review of the EMR did not capture all relevant clinical characteristics 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. Fourth, the presence of confounding after adjustment may have contributed to the larger effect estimates than those observed in unadjusted associations and the relatively small sample size may have contributed to the presence of several wider confidence intervals. Fifth, our study utilized an investigator-developed survey instrument, thereby strengthening the case for implementing future validation studies in larger, nationally representative cohorts. 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.

CONCLUSION

Despite current guidelines recommending focused screening for lipid disorders in childhood, adolescence, and early adulthood, we found that 2 in 5 pregnant women did not report a prior lipid screening and 1 in 3 were unaware of high cholesterol as an ASCVD risk factor.

Significant racial/ethnic and sociodemographic disparities were associated with both a prior screening as well as risk factor awareness. Leveraging prenatal and early pregnancy care is currently an underutilized opportunity to enhance lipid screening among younger women, identify potential lipid disorders, and reduce current variations in access to preventive cardiovascular care.

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FIGURES

Figure 1. 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

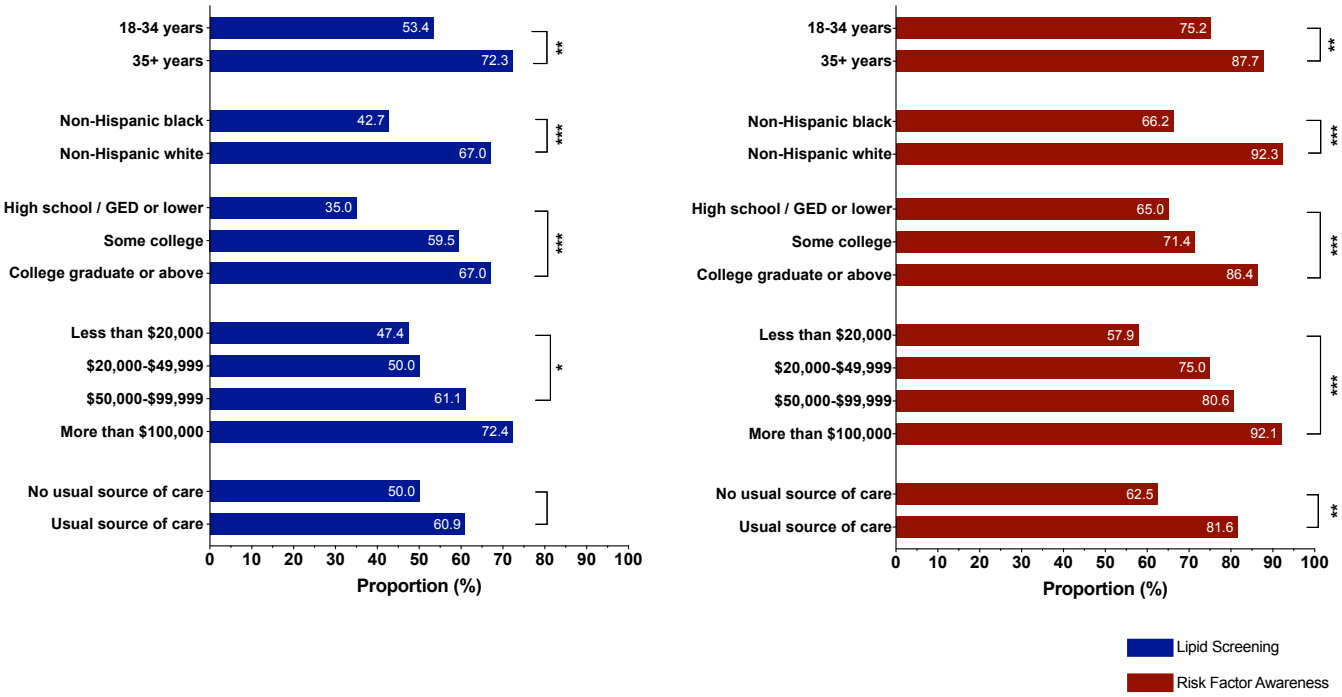

Figure Legend

* $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$

Abbreviations: GED, general education diploma

TABLES

Table 1. Overall demographic and clinical characteristics among pregnant women and differences stratified by all racial/ethnic subgroups

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, years				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 (weeks) 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
Less than $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)	
More than $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	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 weeks' gestation)	17 (8.6)	5 (5.5)	10 (14.7)	0.078

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

Abbreviations: GED, general education diploma; NH, non-Hispanic; OB/GYN, obstetrician/gynecologist

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 year	68 (57.1)	29 (48.3)	22 (73.3)	
Within past 2 years	23 (19.3)	11 (18.3)	6 (20.0)	
Within past 5 years 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)	

***** P-value represents statistical comparison between NH white and NH Black subgroups
Abbreviations: OB/GYN, obstetrician/gynecologist

Table 3. Unadjusted and adjusted associations between sociodemographic characteristics and lack of prior cholesterol screening and a lack of awareness of high cholesterol as a cardiovascular risk factor

Study Variables	Lack of Prior Lipid Screening				Lack of Risk Factor Awareness			
	Unadjusted	*P* Value	Adjusted*	*P* Value	Unadjusted	*P* Value	Adjusted*	*P* Value
Age, y		0.012		0.407		0.046		0.517
18 – 34	2.28 (1.20 – 4.33)		1.44 (0.61 – 3.42)		2.35 (1.02 – 5.44)		1.56 (0.41 – 6.00)	
≥ 35	*reference*		*reference*		*reference*		*reference*	
Race/Ethnicity		0.002		0.013		< 0.001		0.003
NH Black	2.73 (1.43 – 5.24)		3.35 (1.29 – 8.67)		6.13 (2.44 – 15.39)		8.92 (2.07 – 38.42)	
NH white	*reference*		*reference*		*reference*		*reference*	
Education		0.001		0.196		0.004		0.406
≤ Some college	3.76 (1.77 – 8.00)		1.96 (0.71 – 5.43)		3.43 (1.49 – 7.92)		1.66 (0.50 – 5.50)	
≥ College graduate	*reference*		*reference*		*reference*		*reference*	
Household Income		0.017		---		0.003		---
< $100,000 / y	2.23 (1.16 – 4.30)		---		4.19 (1.61 – 10.95)		---	
≥ $100,000 / y	*reference*		*reference*		*reference*		*reference*	
Usual Source of Care		0.310		0.100		0.035		0.009
No	1.56 (0.66 – 3.67)		2.78 (0.82 – 9.37)		2.66 (1.07 – 6.62)		8.60 (1.73 – 42.69)	
Yes	*reference*		*reference*		*reference*		*reference*	

Values are presented as odds ratios (OR) and 95% confidence intervals (CI)

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

Abbreviations: GED, general education diploma; NH, non-Hispanic

Table 4. 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 year	16 (25.8)	10 (28.6)	3 (25.0)	
Within past 2 years	8 (12.9)	5 (14.3)	2 (16.7)	
Within past 5 years	25 (40.3)	13 (37.1)	4 (33.3)	
Longer than past 5 years	13 (21.0)	7 (20.0)	3 (25.0)	

* Six participants with absence of electronic medical records

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

Abbreviations: EMR, electronic medical records; SD, standard deviation; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol

SUPPLEMENTAL TABLES

Supplemental Table 1. 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

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

Supplemental Table 2. 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

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

Supplemental Table 3. 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)	
Hispanic	10 (83.3)	2 (16.7)		9 (75.0)	3 (25.0)	
Asian	12 (66.7)	6 (33.3)		13 (72.2)	5 (27.8)	
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

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

APPENDIX

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)
□ Bile Acid Sequestrants (Colestid)
□ Niacin
□Ezetimibe (Zetia)
□ PSCK9 inhibitors (Repatha, Praluent)
□ 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
□ Cardiologist
□ Other, please describe: _____
□ OBGYN
□ Pediatrician
□ 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.