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Evaluation of AAP Guidelines for Cholesterol Screening in Youth Project HeartBeat!

Mona A. Eissa, MD, PhD¹, Eugene Wen, MD², Nicole L. Mihalopoulos, MD, MPH³, Jo Anne Grunbaum, EdD⁴, and Darwin R. Labarthe, PhD⁴

¹ University of Texas Medical School, Houston, Texas

² Canadian Institute for Health Information, Ottawa, Canada

³ University of Utah, Salt Lake City, Utah

⁴ CDC, Atlanta, Georgia

Abstract

Background—The American Academy of Pediatrics (AAP) criterion for screening for hypercholesterolemia in children is family history of hypercholesterolemia or cardiovascular disease or BMI ≥ 85 th percentile. This paper aims to determine the sensitivity, specificity, and positive predictive value (PPV) of dyslipidemia screening using AAP criteria along with either family history or BMI.

Methods—Height, weight, plasma total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides, and family history were obtained for 678 children aged 8, 11, and 14 years, enrolled from 1991 to 1993 in Project HeartBeat!. Sensitivity, specificity, and PPV screening of each lipid component using family history alone, BMI ≥ 85 th percentile alone, or family history and/or BMI ≥ 85 th percentile, were calculated using 2008 AAP criteria (total cholesterol, LDL-C, and triglycerides ≥ 90 th percentile; HDL-C < 10 th percentile).

Results—Sensitivity of detecting abnormal total cholesterol, LDL-C, HDL-C, and triglycerides using family history alone ranged from 38% to 43% and significantly increased to 54%–66% using family history and/or BMI. Specificity significantly decreased from approximately 65% to 52%, and there were no notable changes in PPV. In black children, cholesterol screening using the BMI ≥ 85 th percentile criterion had higher sensitivity than when using the family history criterion. In nonblacks, family history and/or BMI ≥ 85 th percentile had greater sensitivity than family history alone.

Conclusions—When the BMI screening criterion was used along with the family history criterion, sensitivity increased, specificity decreased, and PPV changed trivially for detection of dyslipidemia. Despite increased screening sensitivity by adding the BMI criterion, a clinically significant number of children still may be misclassified.

Introduction

Dyslipidemia is an established risk factor for cardiovascular disease (CVD) among adults.^{1–}

³ During adolescence, abnormal cholesterol concentrations are associated with arterial fatty

Address correspondence and reprint requests to: Mona A.H. Eissa, MD, PhD, Department of Pediatrics, Medical School, University of Texas Health Science Center at Houston, 6431 Fannin, MSB #3.146A, Houston TX 77030. Mona.A.Eissa@uth.tmc.edu.

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streaks and later progression to dyslipidemia and atherosclerosis in adulthood.^{4–7} Early identification of children with dyslipidemia is important for implementing early interventions to prevent or delay the progress of atherosclerosis.

The American Academy of Pediatrics (AAP) recently revised their guidelines for cholesterol screening. The new recommendations are that children and adolescents should be screened for abnormal lipid and lipoprotein concentrations if they have one or more parents or grandparents with premature (aged ≤ 55 years) CVD or high blood cholesterol (≥ 240 mg/dL); unknown family history; or are overweight (BMI ≥ 85 th percentile) or obese (BMI ≥ 95 th percentile).⁸

Dyslipidemia is associated with obesity in children, and several studies indicate that obesity is a risk factor for hypercholesterolemia.^{9–13} Studying patterns of cholesterol in relation to adiposity may determine if clinical measures of adiposity, such as BMI, are indicative of abnormal lipid concentrations.

Body mass index is widely used to identify individuals who are overweight or obese.¹⁴ Other measures of adiposity, such as fat free–mass index, fat-mass index, and percent body fat (PBF), may be more predictive of dyslipidemia during puberty because PBF increases in girls and decreases in boys.¹⁵ However, among these measures, only BMI is commonly and easily used in a clinical setting. The purpose of this study is to determine the effectiveness (sensitivity, specificity, and positive predictive value [PPV]) of the AAP screening criteria for identifying dyslipidemia in children who participated in Project HeartBeat!.

Methods

Study Design and Population

Project HeartBeat! was a longitudinal study designed to assess patterns of change in CVD risk factors, including blood pressure, blood lipids, cardiac structure and function, and smoking among children and adolescents. Three cohorts of children, aged 8, 11, and 14 years at baseline, from The Woodlands and Conroe TX, were enrolled between October 1991 and July 1993. The IRB of the University of Texas Health Science Center at Houston and of Baylor College of Medicine approved the protocol. For each participant, informed consent or assent and parental consent were obtained.

A probability sample of 678 participants was assessed at baseline: 314 were aged 8 years, 197 were aged 11 years, and 167 were aged 14 years. Of the total, 49.1% percent were female; 79.9% were nonblack (74.6% white and 5.3% of other race/ethnicity [3.7% Hispanic, 1% Asian, and 0.6% American Indian]) and 20.1% were black. CVD medical history about parents was available for 588 mothers and 567 fathers. Details of the study design, population, and data collection procedures have been described elsewhere.¹⁶

Data Collection

Blood lipids—Plasma lipid concentrations were determined in the Lipid Research Laboratory of Baylor College of Medicine. Each participant's blood was drawn, after an overnight fast, into powdered EDTA-containing tubes by trained and certified phlebotomists at the participant's home. The blood was kept on ice at 4°C and was separated within 1 hour of collection. Aliquots were kept in -70°C freezers until laboratory testing. For a total of 677 samples drawn at baseline, plasma total cholesterol, HDL cholesterol (HDL-C), and triglycerides were determined using standard enzymatic methods.¹⁷ One blood lipid sample for a participant in the cohort of those aged 8 years did not have matching ID for family history data and was excluded from analyses. A Cobas Fara II analyzer was used, and standards for inter- and intra-assay required that coefficients of variation not exceed 3%. Plasma LDL-C was calculated using the equation¹⁸

$$\text{LDL} - \text{C} = [\text{TC} - (\text{TG}/5 + \text{HDL} - \text{C})],$$

where TC is total cholesterol, and TG is triglycerides. For this study, plasma concentration values were multiplied by 1.03 to convert them to serum values. Serum lipids and lipoproteins levels were classified as abnormal if they were >90th percentile for age and gender for total cholesterol, LDL-C, and triglycerides; and <10th percentile for HDL-C. These are the definitions used in the new AAP guidelines.⁸

Anthropometric measures—Height and weight were obtained by trained and certified technicians working in pairs. Participants were barefoot and wore surgical scrub suits over underwear during measurement. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. Weight was measured to the nearest 0.1 kg using a beam-balance scale. For each measurement, one observer operated the equipment and took the measurement and the second observer recorded the measurement on a paper form. The stadiometer and scale were assessed daily and calibrated as needed. BMI was calculated by standard formula (kg/m^2). BMI percentile was calculated using CDC age- and gender-specific percentiles.¹⁴ BMI percentile was selected as the measure of weight status for this analysis because of the ease and prevalence of its use in a clinical setting.

Family history—A questionnaire was sent to each child's parent along with a cover letter from the project director. Parents returned the questionnaire in a self-addressed envelope. Family history questions were taken from the National Health and Nutrition Examination Survey.¹⁹ Data collected included demographic information on the child, and the age and health history of the child's biological parents. The following question was asked separately for the biological mother and the biological father: *Has a doctor ever told your child's biological mother (father) that she (he) has or has had any of the following conditions?* The conditions included high blood pressure, high cholesterol, heart attack, stroke, and diabetes (no differentiation between types 1 and 2). For each condition, the response options were yes, no, and don't know. If any of the child's biological parents or biological grandparents were deceased, the age at death and cause of death were asked. Children with missing family history were included in analyses with negative family history.

Statistical Analysis

Prevalence of dyslipidemia that included abnormal serum total cholesterol, LDL-C, HDL-C, and triglyceride levels; overweight; and family history for CVD were calculated. Age-specific cut-points were used for total cholesterol, LDL-C, HDL-C, and triglycerides as defined in the AAP guidelines.⁸ Family history was defined as either biological parent having been diagnosed with high blood pressure, high cholesterol, heart attack, or stroke when aged <55 years, or any biological parent or grandparent having died from CVD or cerebrovascular diseases when aged <55 years. BMI $\geq$ 85th percentile for specific age and gender was defined as overweight.¹⁴

Sensitivity was calculated as the proportion of adverse serum lipid and lipoprotein cases who met the screening criteria; specificity was calculated as the proportion of nonadverse serum lipid and lipoprotein cases who did not meet the screening criteria; and PPV was calculated as the proportion of screening positive cases who actually had adverse serum lipid and lipoprotein levels. Effects of adding screening criteria when computing sensitivity, specificity, and PPV were assessed by testing the difference between the paired proportions with and without the criteria using McNemar's test. The chi-square test was used for comparisons between gender and race/ethnic groups. SAS version 9.1 was used for the analysis. Statistical significance was set at $p=0.05$.

Results

The prevalence of adverse serum lipid and lipoprotein levels, family history, and overweight status (BMI $\geq$ 85th percentile for specific age and gender) among the study population and for each cohort is presented in Table 1. The prevalence of family history was high among all three age cohorts, and nearly 39% of the cohort for those aged 14 years had family history. The average parental ages were 37.9 ± 4.9 years for biological mothers and 40.5 ± 5.6 years for biological fathers. The prevalence of abnormal lipid and lipoprotein concentrations varied among age cohorts; the prevalence of abnormal total cholesterol (11.4%) and LDL-C (9.0%) was lowest among the cohort of those aged 14 years, and the prevalence of abnormal HDL-C (12.7%) and triglycerides (25.4%) was lowest among the cohort of those aged 11 years. Approximately 24% of the children in all age cohorts had BMI $\geq$ 85th percentile. Forty-two percent of children had family history and/or BMI $\geq$ 85th percentile.

Sensitivity, specificity, and PPV for adverse levels of total cholesterol, LDL-C, HDL-C, and triglycerides using family history alone, BMI alone, or one or both of those as the criterion for identifying children with dyslipidemia are shown in Table 2. Sensitivity in identifying subjects with abnormal lipid and lipoprotein concentrations was not different for family history alone (38%–43%) vs BMI alone (34%–43%). Sensitivity using family history and/or BMI was significantly higher (total cholesterol, 54%; LDL-C, 61%; HDL-C, 66%; triglycerides, 62%). On the other hand, specificity for all four lipid components was significantly higher when BMI alone than when family history alone was used (approximately 80% vs 65%, respectively), and it was significantly lower when family history and/or BMI were used (approximately 52%). PPV was significantly different for HDL-C and triglycerides only when comparing family history alone (16% vs 24%, respectively) and BMI alone (31% vs 41%, respectively).

Sensitivity, specificity, and PPV for identifying adverse total cholesterol, LDL-C, HDL-C, and triglycerides by gender groups are presented in Table 3. Boys and girls had similar differences in sensitivity, specificity, and PPV for identifying dyslipidemia. In boys, the sensitivity for identifying abnormal lipids and lipoproteins was similar for family history only (35%–45%) and BMI only (36%–47%) and increased significantly when using family history and/or BMI (51%–68%) as a screening criterion. Compared to family history alone, specificity was significantly greater for BMI alone (78%–82% vs 63%–71%, respectively) and significantly lower for family history and/or BMI (50%–56%). PPV, which ranged from 18% for LDL-C to 41% for triglycerides, did not differ for any of the lipids and lipoproteins using any of the criteria. Similarly, in girls, sensitivity to detect dyslipidemia was lower for BMI alone (30%–37%) compared to family history alone (40%–49%), but the difference did not achieve significance. Sensitivity was significantly greater for all lipids and lipoproteins using family history and/or BMI criteria (59%–69%). Specificity using family history alone (62%–63%) was significantly lower than that using BMI alone (78%–80%) and was significantly higher than that using family history and/or BMI criteria (49%–50%). There were no significant differences in PPV when screening criteria were compared.

Sensitivity, specificity, and PPV for adverse levels of total cholesterol, LDL-C, HDL-C, and triglycerides by race groups are presented in Table 4. In nonblack children, sensitivity using family history alone (40%–51%) was greater than that using BMI alone (31%–39%), but the difference did not achieve significance. Sensitivity increased significantly for all lipids and lipoproteins using family history and/or BMI (54%–68%). Specificity was significantly greater for BMI alone (80%–83%) than for family history alone (61%–63%) and significantly lower when using family history and/or BMI criteria (48%–51%). PPV was significantly different for HDL-C only when comparing family history alone (16.5%) and BMI alone (22.3%). In black children, sensitivity was greater using BMI alone (47%–64%), or family history and/or BMI (53%–75%), compared to family history alone (18%–35%), but these differences were

significant only for HDL-C (55% and 59% vs 18%, respectively). Specificity for all lipids and lipoproteins was similar for both family history alone (77%–80%) and BMI alone (73%–75%) and decreased significantly using family history and/or BMI (58%–62%). PPV did not differ among the criteria for any lipids or lipoproteins.

Discussion

A cross-sectional analysis of data from Project HeartBeat! was performed to determine the effect of using family history alone compared with using either BMI alone, or family history and/or BMI together, on the sensitivity, specificity, and PPV of blood cholesterol screening in children and adolescents. A cross-sectional rather than a longitudinal analysis of the data was performed to furnish healthcare providers with a tool for determining if a child should be screened for dyslipidemia at a given clinical visit. The intent was not to predict which children would develop dyslipidemia.

The main finding of the current study is that using family history screening criteria had a low yield for identifying children and adolescents with abnormal lipids and lipoproteins. Using family history and/or BMI as a criterion instead of family history only for blood lipid and lipoprotein screening among children and adolescents significantly increased the sensitivity, by almost 42% for total cholesterol, 47% for LDL-C, 54% for HDL-C, and 44% for triglycerides. This increase was accompanied by a significant decrease in the specificity (by about 20%–22% for total cholesterol, LDL-C, HDL-C, and triglycerides) and no notable change in PPV. However, using only BMI increased specificity by 21% for all lipids and lipoproteins. Results of dyslipidemia screening measurements using either family history alone or BMI alone were similar between gender groups, but varied among race/ethnic groups. In black children, use of BMI only, or family history or BMI is superior for identifying children with dyslipidemia. In nonblack children, family history and/or BMI together appear to be better screening criteria than family history alone or BMI alone for identifying dyslipidemia.

In the current study, sensitivity of dyslipidemia screening using the AAP criteria ranged from 54% to 66%; specificity ranged from 50% to 53%; and PPV ranged from 16% to 32%. Other studies^{3,20–22} that examined the effectiveness of family history as a screening criterion reported a range from 33.1% to 80% for sensitivity, 21% to 79.9% for specificity, and 11.6% to 45% for PPV. The variation in these studies' results may be attributable to the wide age range of parents and grandparents and the differences in the definition of family history used. These studies concluded that the family history screening criterion offers little improvement over random population screening. The current analysis showed that using the family history criterion alone was even less effective in black children and that using the BMI criterion alone had a higher screening sensitivity for detecting dyslipidemia, especially abnormal HDL-C levels.

Screening programs for dyslipidemia in children are intended to identify **at-risk** individuals who may develop early atherosclerotic heart disease. This analysis and other studies showed that the family history criterion may fail to identify a substantial portion of at-risk individuals. It appears that early identification of dyslipidemia among children and adolescents who have family history or BMI $\geq$ 85th percentile would enable more children with dyslipidemia to be diagnosed and treated early. However, a considerable number of children with dyslipidemia will still be missed. Further, the ability to identify "normals" using BMI or family history is poor, and thus a substantial number of normal children and adolescents would be screened for dyslipidemia unnecessarily.

This analysis had several limitations. It included mostly nonblack subjects; therefore, generalizing these results to other ethnic and racial groups should be considered with caution.

The small sample size of black children may explain the occasional lack of significance when the race difference in screening criteria was examined. Classifying family history as having high blood pressure or as early death resulting from heart disease may confound the association between dyslipidemia and family history and is a limitation of the study. The AAP guidelines recommend that children with a family history of premature CVD or dyslipidemia receive a higher level of intervention than those with a family history of hypertension or obesity.⁸

Several methodologic issues may need to be considered when interpreting the results. First, family history data did not include grandparent history of CVD unless it was the cause of death, and the criterion used may have resulted in a lower prevalence of positive family history if the cause of death was not CVD. Second, BMI, a measure of weight status, may not accurately reflect the degree of adiposity. Other indicators of adiposity, such as fat-mass index, may better predict hypercholesterolemia; however, these predictors are not practical for use in screening.²³ Identifying children and adolescents with dyslipidemia may not be the optimum or the only factor in identifying children and adolescents at highest risk for CVD. There may well be other known (e.g., inflammatory) and unknown factors that could be important.

Conclusion

Using the criterion of family history and/or BMI ≥ 85 th percentile (either family history or BMI, or both) improved the sensitivity of dyslipidemia screening and decreased its specificity. Despite the increase in the screening sensitivity, a clinically significant number of children may still be misclassified.

In view of the current childhood obesity epidemic in the U.S., our findings support the use of overweight and obesity as screening criteria for dyslipidemia in certain populations. Further, universal screening criteria may need to be revised to take population-specific criteria into account. Important challenges to be addressed include not only educating primary care pediatric providers about risk factors for CVD (i.e., obesity, dyslipidemia), but also advocating for insurance benefits to screen for these important risk factors among high-risk children. Further studies are needed to examine the effectiveness of using other criteria for dyslipidemia screening in ethnically diverse youth populations within a broad age range.

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Table 1
Demographic characteristics of study population and prevalence of family history, adverse blood lipids, and overweight, *n* (%)

	All participants (<i>n</i> =677) ^a	Aged 8 years (<i>n</i> =313)	Aged 11 years (<i>n</i> =197)	Aged 14 years (<i>n</i> =167)
Gender				
Boys	345 (51)	159 (50.8)	104 (52.8)	82 (49.1)
Girls	332 (49)	154 (49.2)	93 (47.2)	85 (50.9)
Race				
Nonblacks	542 (80.1)	235 (75.1)	159 (80.7)	148 (88.6)
Blacks	135 (19.9)	78 (24.9)	38 (19.3)	19 (13.4)
Family history^b				
TC ≥90th percentile AAP	242 (35.7)	103 (32.9)	74 (37.6)	65 (38.9)
TC ≥75th percentile PHB	121 (17.9)	71 (22.7)	31 (15.7)	19 (11.4)
LDL-C ≥90th percentile	140 (20.7)	44 (14.1)	52 (26.4)	44 (26.3)
HDL-C <10th percentile	92 (13.6)	55 (17.6)	22 (11.2)	15 (9)
TGs >90th percentile	91 (13.4)	40 (12.8)	25 (12.7)	26 (15.6)
BMI ≥85th percentile	175 (25.8)	80 (25.6)	50 (25.4)	45 (26.9)
BMI ≥85th percentile or family history	161 (23.8)	76 (24.3)	46 (23.4)	39 (23.4)
	344 (50.8)	153 (48.9)	103 (52.3)	88 (52.7)

^a Study population was 678 participants; one blood lipid sample for a participant in the cohort of those aged 8 years did not have matching ID for family history data and was excluded from analyses.

^b Family history=family history of cardiovascular disease (parental history of high blood pressure, high cholesterol, heart attack, and stroke; and parent or grandparent who died from cardiovascular or cerebrovascular diseases when aged <55 years)

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PHB, Project HeartBeat; TC ≥90th percentile AAP, total cholesterol ≥90th percentile for age and gender in 2008 AAP guidelines; TGs, triglycerides

Table 2
Sensitivity, specificity, and PPV of TC, LDL-C, HDL-C and TGs screening^a

Lipid test	Screening criterion	Sensitivity (CI)	Specificity (CI)	PPV (CI)
TC ≥90th percentile	Family history	0.380 (0.294, 0.467)	0.647 (0.608, 0.687)	0.190 (0.141, 0.240)
LDL-C ≥90th percentile	Family history	0.413 (0.312, 0.514)	0.651 (0.613, 0.690)	0.157 (0.111, 0.203)
HDL-C <10th percentile	Family history	0.429 (0.327, 0.530)	0.654 (0.615, 0.692)	0.161 (0.115, 0.207)
TGs ≥90th percentile	Family history	0.434 (0.361, 0.508)	0.669 (0.628, 0.710)	0.314 (0.256, 0.373)
TC ≥90th percentile	BMI ≥85th percentile	0.339 (0.255, 0.423)	0.784* (0.750, 0.818)	0.255 (0.187, 0.322)
LDL-C ≥90th percentile	BMI ≥85th percentile	0.380 (0.281, 0.480)	0.785* (0.751, 0.818)	0.217 (0.154, 0.281)
HDL-C <10th percentile	BMI ≥85th percentile	0.429 (0.327, 0.530)	0.792* (0.759, 0.825)	0.242* (0.176, 0.308)
TGs ≥90th percentile	BMI ≥85th percentile	0.377 (0.305, 0.449)	0.811* (0.776, 0.845)	0.410* (0.334, 0.486)
TC ≥90th percentile	BMI ≥85th percentile or family history	0.537* (0.448, 0.626)	0.498* (0.457, 0.540)	0.189 (0.148, 0.230)
LDL-C ≥90th percentile	BMI ≥85th percentile or family history	0.609* (0.509, 0.708)	0.508* (0.467, 0.548)	0.163 (0.124, 0.202)
HDL-C <10th percentile	BMI ≥85th percentile or family history	0.659* (0.561, 0.757)	0.515* (0.475, 0.556)	0.174 (0.134, 0.215)
TGs ≥90th percentile	BMI ≥85th percentile or family history	0.623* (0.551, 0.695)	0.532* (0.488, 0.576)	0.317 (0.268, 0.366)

* Significant at $p < 0.05$; differences in sensitivity, specificity, and PPV between using family history as a screening criterion and using BMI ≥85th percentile alone or family history or BMI ≥85th percentile were examined.

^a Family history=family history of cardiovascular disease (parental history of high blood pressure, high cholesterol, heart attack, and stroke; or parent or grandparent who died from cardiovascular or cerebrovascular diseases when aged <55 years)

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PPV, positive predictive value; TC, total cholesterol; TGs, triglycerides

Table 3
Sensitivity, specificity, and PPV of TC, LDL-C, HDL-C, and TGs screening by gender groups^a

Lipid test	Screening criterion	Sensitivity (CI)	Specificity (CI)	PPV (CI)
Boys				
TC ≥90th percentile	Family history	0.351 (0.244, 0.457)	0.672 (0.615, 0.728)	0.235 (0.157, 0.312)
LDL-C ≥90th percentile	Family history	0.368 (0.243, 0.494)	0.634 (0.619, 0.728)	0.183 (0.112, 0.253)
HDL-C <10th percentile	Family history	0.453 (0.319, 0.587)	0.688 (0.635, 0.741)	0.209 (0.134, 0.283)
TGs ≥90th percentile	Family history	0.439 (0.345, 0.533)	0.714 (0.657, 0.772)	0.409 (0.319, 0.499)
TC ≥90th percentile	BMI ≥85th percentile	0.364 (0.256, 0.471)	0.787* (0.738, 0.836)	0.329 (0.229, 0.429)
LDL-C ≥90th percentile	BMI ≥85th percentile	0.386 (0.260, 0.512)	0.781* (0.734, 0.829)	0.259 (0.166, 0.352)
HDL-C <10th percentile	BMI ≥85th percentile	0.472 (0.337, 0.606)	0.795* (0.748, 0.841)	0.294 (0.197, 0.391)
TGs ≥90th percentile	BMI ≥85th percentile	0.393 (0.300, 0.485)	0.819* (0.770, 0.868)	0.494 (0.387, 0.600)
TC ≥90th percentile	BMI ≥85th percentile or family history	0.506* (0.395, 0.618)	0.504* (0.444, 0.564)	0.227 (0.164, 0.289)
LDL-C ≥90th percentile	BMI ≥85th percentile or family history	0.561* (0.433, 0.690)	0.514* (0.456, 0.572)	0.186 (0.128, 0.244)
HDL-C <10th percentile	BMI ≥85th percentile or family history	0.679* (0.554, 0.805)	0.534* (0.477, 0.591)	0.209 (0.149, 0.270)
TGs ≥90th percentile	BMI ≥85th percentile or family history	0.636* (0.544, 0.727)	0.563* (0.500, 0.626)	0.395 (0.322, 0.468)
Girls				
TC ≥90th percentile	Family history	0.432 (0.285, 0.578)	0.625 (0.569, 0.681)	0.150 (0.088, 0.212)
LDL-C ≥90th percentile	Family history	0.486 (0.320, 0.651)	0.630 (0.575, 0.685)	0.134 (0.075, 0.193)
HDL-C <10th percentile	Family history	0.395 (0.239, 0.550)	0.619 (0.564, 0.675)	0.118 (0.062, 0.174)
TGs ≥90th percentile	Family history	0.426 (0.309, 0.544)	0.629 (0.571, 0.687)	0.228 (0.155, 0.301)
TC ≥90th percentile	BMI ≥85th percentile	0.295 (0.161, 0.430)	0.781* (0.734, 0.829)	0.171 (0.086, 0.256)
LDL-C ≥90th percentile	BMI ≥85th percentile	0.371 (0.211, 0.532)	0.788* (0.741, 0.834)	0.171 (0.086, 0.256)
HDL-C <10th percentile	BMI ≥85th percentile	0.368 (0.215, 0.522)	0.789* (0.742, 0.836)	0.184 (0.097, 0.271)
TGs ≥90th percentile	BMI ≥85th percentile	0.353 (0.239, 0.467)	0.803* (0.755, 0.851)	0.316 (0.211, 0.420)
TC ≥90th percentile	BMI ≥85th percentile or family history	0.591* (0.446, 0.736)	0.493* (0.435, 0.551)	0.151 (0.098, 0.205)
LDL-C ≥90th percentile	BMI ≥85th percentile or family history	0.686* (0.532, 0.840)	0.502* (0.445, 0.559)	0.140 (0.088, 0.191)
HDL-C <10th percentile	BMI ≥85th percentile or family history	0.632* (0.478, 0.785)	0.497* (0.439, 0.554)	0.140 (0.088, 0.191)
TGs ≥90th percentile	BMI ≥85th percentile or family history	0.603* (0.487, 0.719)	0.504* (0.443, 0.564)	0.238 (0.175, 0.302)

* Significant at $p < 0.05$; differences of sensitivity, specificity, and PPV between using family history as a screening criterion and using (BMI ≥85th percentile) or (family history or BMI ≥85th percentile) were examined.

^aFamily history=family history of cardiovascular disease (parental history of high blood pressure, high cholesterol, heart attack, and stroke; or parent or grandparent who died from cardiovascular or cerebrovascular diseases when aged <55 years)

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PPV, positive predictive value; TC, total cholesterol; TGs, triglycerides

Table 4
Sensitivity, specificity, and PPV of TC, LDL-C, HDL-C, and TGs screening, by race/ethnic group^a

Lipid test	Screening criterion	Sensitivity (CI)	Specificity (CI)	PPV (CI)
Nonblacks				
TC ≥90th percentile	Family history	0.402 (0.307, 0.497)	0.611 (0.566, 0.657)	0.193 (0.140, 0.247)
LDL-C ≥90th percentile	Family history	0.436 (0.326, 0.546)	0.616 (0.572, 0.661)	0.160 (0.111, 0.210)
HDL-C <10th percentile	Family history	0.507 (0.389, 0.625)	0.626 (0.582, 0.667)	0.165 (0.115, 0.215)
TGs ≥90th percentile	Family history	0.445 (0.367, 0.523)	0.630 (0.582, 0.679)	0.325 (0.262, 0.389)
TC ≥90th percentile	BMI ≥85th percentile	0.314 (0.224, 0.404)	0.798* (0.760, 0.835)	0.264 (0.186, 0.343)
LDL-C ≥90th percentile	BMI ≥85th percentile	0.333 (0.229, 0.438)	0.795* (0.759, 0.832)	0.215 (0.142, 0.288)
HDL-C <10th percentile	BMI ≥85th percentile	0.391 (0.276, 0.506)	0.801* (0.765, 0.837)	0.223 ^d (0.149, 0.297)
TGs ≥90th percentile	BMI ≥85th percentile	0.355 (0.280, 0.430)	0.829* (0.792, 0.867)	0.455 (0.366, 0.543)
TC ≥90th percentile	BMI ≥85th percentile or family history	0.539* (0.442, 0.636)	0.477* (0.431, 0.524)	0.193 (0.147, 0.239)
LDL-C ≥90th percentile	BMI ≥85th percentile or family history	0.603* (0.494, 0.711)	0.487* (0.442, 0.533)	0.165 (0.122, 0.208)
HDL-C <10th percentile	BMI ≥85th percentile or family history	0.681* (0.571, 0.791)	0.497* (0.452, 0.542)	0.165 (0.122, 0.208)
TGs ≥90th percentile	BMI ≥85th percentile or family history	0.606* (0.530, 0.683)	0.506* (0.457, 0.556)	0.330 (0.275, 0.384)
Blacks				
TC ≥90th percentile	Family history	0.263 (0.065, 0.461)	0.784 (0.710, 0.859)	0.167 (0.033, 0.300)
LDL-C ≥90th percentile	Family history	0.286 (0.049, 0.522)	0.785 (0.712, 0.858)	0.133 (0.012, 0.255)
HDL-C <10th percentile	Family history	0.182 (0.021, 0.343)	0.770 (0.692, 0.848)	0.133 (0.012, 0.255)
TGs ≥90th percentile	Family history	0.350 (0.141, 0.559)	0.800 (0.727, 0.873)	0.233 (0.082, 0.385)
TC ≥90th percentile	BMI ≥85th percentile	0.474 (0.249, 0.698)	0.733 (0.652, 0.813)	0.225 (0.096, 0.354)
LDL-C ≥90th percentile	BMI ≥85th percentile	0.643 (0.392, 0.894)	0.744 (0.666, 0.822)	0.225 (0.096, 0.354)
HDL-C <10th percentile	BMI ≥85th percentile	0.545* (0.337, 0.754)	0.752 (0.673, 0.832)	0.300 (0.158, 0.442)
TGs ≥90th percentile	BMI ≥85th percentile	0.550 (0.332, 0.768)	0.748 (0.668, 0.827)	0.275 (0.137, 0.413)
TC ≥90th percentile	BMI ≥85th percentile or family history	0.526 (0.302, 0.751)	0.578* (0.488, 0.667)	0.169 (0.074, 0.265)
LDL-C ≥90th percentile	BMI ≥85th percentile or family history	0.643 (0.392, 0.894)	0.587* (0.499, 0.675)	0.153 (0.061, 0.244)
HDL-C <10th percentile	BMI ≥85th percentile or family history	0.591* (0.385, 0.796)	0.593* (0.502, 0.684)	0.220 (0.115, 0.326)
TGs ≥90th percentile	BMI ≥85th percentile or family history	0.750* (0.560, 0.940)	0.617* (0.529, 0.706)	0.254 (0.143, 0.365)

* Significant at $p < 0.05$; differences in sensitivity, specificity, and PPV between using family as a screening criterion and using BMI ≥85th percentile alone or family history and BMI ≥85th percentile together were examined.

^aFamily history=family history of cardiovascular disease (parental history of high blood pressure, high cholesterol, heart attack, and stroke; or parent or grandparent who died from cardiovascular or cerebrovascular diseases when aged <55 years)

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PPV, positive predictive value; TC, total cholesterol; TGs, triglycerides