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Lipid Screening in Children and Adolescents in Community Practice 2007-2010

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Abstract

Background—Integrated guidelines on cardiovascular health and risk reduction in children issued in 2011 newly recommended universal screening for dyslipidemia in children at 9-11 years and 17-21 years.

Methods and Results—We determined the frequency and results of lipid testing in 301,080 children and adolescents aged 3-19 enrolled in three large U.S. health systems in 2007-2010 before the 2011 guidelines were issued. Overall, 9.8% of the study population was tested for lipids. The proportion tested varied by BMI percentile (5.9% of normal weight, 10.8% of overweight and 26.9% of obese children) and age (8.9% of 9-11 year olds and 24.3% of 17-19 year olds). In normal weight individuals, 2.8% of 9-11 year olds and 22.0% of 17-19 year olds were tested. In multivariable models, age and BMI category remained strongly associated with lipid testing. Sex, race, ethnicity, and blood pressure were weakly associated with testing. Abnormal lipid levels were found in 8.6% for total cholesterol, 22.5% for HDL-C, 12.0% for non-HDL-C, 8.0% for LDL-C and 21% for triglycerides (age 10-19). There was a strong and graded association of abnormal lipid levels with BMI, particularly for HDL-C and triglycerides (2- to 6-fold higher odds ratio in obese compared with normal weight children).

Conclusions—Lipid screening was uncommon in 9-11 year olds and was performed in a minority of 17-19 year olds during 2007-2010. These data serve as a benchmark for assessing change in practice patterns after the new recommendations for pediatric lipid screening and management.

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Keywords

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Abnormal serum lipid levels in childhood are associated with dyslipidemia in adulthood and with the onset and severity of atherosclerosis in adolescence and young adulthood.[1-6] Concern about the adverse effects of dyslipidemia on cardiovascular risk in the U.S. population has been heightened by the increasing prevalence of overweight and obesity in children.[7, 8] In new guidelines sponsored by National Heart, Lung, and Blood Institute (NHLBI) and endorsed by the American Academy of Pediatrics in 2011, the Expert Panel on Integrated Pediatric Guideline for Cardiovascular Health and Risk Reduction in Children and Adolescents concluded that there is sufficient evidence to support early identification of dyslipidemia and recommended universal screening for dyslipidemia in children at age 9-11 and again at age 17-21.[9]

The expert panel recommendations contrast with the most recent recommendations of the U.S. Preventive Services Task Force on this topic in 2007, which rated the evidence as insufficient to recommend for or against routine screening for lipid disorders in children or young adults up to age 20.[10] Other groups have recommended selective screening based on family history of premature heart disease or hypercholesterolemia or the presence of other risk factors,[10, 11] but the expert panel pointed out that such screening has not been proven to be effective and misses large numbers of children with dyslipidemia.[12] However, critics of the expert panel recommendations have raised concerns regarding the low predictive value of childhood lipid screening, adverse psychological effects of labeling, the unknown safety of lifelong statin treatment, the long-term costs, and lack of outcome data.[13-16]

Given the controversy surrounding the varying expert recommendations, additional data on pre-guideline pediatric lipid screening practices are needed to inform assessment of the impact of the new recommendations on identification of clinically significant dyslipidemia in children and adolescents. The present study used electronic data from three major U.S. health systems to describe lipid screening from 2007-2010 in children and adolescents aged 3-19 and to describe the proportion of abnormal test results. These data can serve as a benchmark for future studies examining changes in community practice in screening for dyslipidemia during childhood.

METHODS

Study Setting and Population

This is an analysis of data from a retrospective cohort study conducted in three large integrated healthcare delivery systems: HealthPartners of Minnesota, Kaiser Permanente Colorado (KPCO), and Kaiser Permanente Northern California (KPNC). The three participating study sites use the EpiCare © electronic health record (EHR) system (Verona, WI). The EHR captures enrollment and demographic data, encounter data including ICD-9-CM diagnosis codes, prescribed medications, laboratory test results, and vital signs. The human subjects review board at HealthPartners approved the study protocol, and individual

written consent was not required. KPCO and KPNC ceded human subjects oversight to HealthPartners.

The cohort was established primarily to study pediatric hypertension and obesity.[17, 18] The study population included 363,318 children and adolescents 3-19 years of age with at least one visit during the study period from January 1, 2007 through December 31, 2010. Of these, 306,643 (84%) had an eligible blood pressure (BP) reading during the study period, defined as a BP measured in an outpatient setting with a corresponding height measurement taken within 90 days before or after the BP measurement. At HealthPartners and KPCO, all subjects from 2007 through 2010 were eligible for study inclusion. The study population at KPNC consisted of a 50% sample of subjects from 2007-2010 who were seen in 3 KPNC subregions with early EHR implementation. Follow-up within the cohort began on the date of their first eligible BP reading and ended when health plan enrollment ended or 12/31/2010, whichever occurred sooner.

Since these analyses were designed to examine patterns of lipid screening in the general pediatric population, we excluded 3474 patients with dyslipidemia or conditions associated with dyslipidemia for which testing is recommended. We used International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes to identify patients with the following exclusion diagnoses or procedures based on encounters occurring before the date of initial lipid testing: dyslipidemia (272.×),Type 1 or 2 diabetes (codes 250.×), chronic kidney disease (585.×), nephrotic syndrome (581.××), idiopathic hypercalcemia (275.42), acute intermittent porphyria (277.1), heart transplantation (E878.0, 37.5×), solid organ transplantation (V42), Kawasaki disease (446.1), systemic lupus erythematosus (710.0), rheumatoid arthritis (714.3×), HIV infection (042), hypothyroidism / hypopituitarism (243, 244.×, 253.2×, 253.3×, 253.4×), hepatitis (070.××, 573.1, 573.2, 573.3), obstructive liver disease / cholestatic conditions (576.×), biliary cirrhosis (571.6), polycystic ovary syndrome (256.4), cystine storage disease (270.4), glycogen storage disease (271.0), juvenile Tay-Sachs disease (330.1), anorexia (307.1, 307.5), progeria / Werner's syndrome (259.8), and Klinefelter syndrome (758.7). We also excluded 1920 children who were treated with isotretinoin (General Product Identifier [GPI] codes 90050013000110, 90050013000120, 90050013000130, 90050013000140, 96587846002900) at any time during the study period and 33 who were treated with lipid lowering medications (GPI codes starting with 39200025, 39300030, 39400010, 39400030, 39400050, 39400060, 39400065, 39400075, 39409902, 39450050, 395000, 39500050, 39500055, 39994002) before the date of lipid testing in this study. We further excluded 216 children whose initial lab testing did not include a total cholesterol measurement. The final analytic sample consisted of 301,080 children.

Analytic Methods

We calculated the proportion of children who had at least one measurement of total cholesterol, and within this subgroup the proportion of children who had at least one measurement of HDL-cholesterol (HDL-C). The proportion of children with a non-HDL-C measurement was calculated if the total cholesterol and HDL-C measurements occurred on the same day. The proportion of children with an LDL-cholesterol (LDL-C) was calculated

if total cholesterol, HDL-C and fasting triglycerides were measured on the same day or there was a direct measurement of LDL-C. At KPNC, we could not determine from EHR data whether triglyceride measurements were performed in the fasting state; therefore, in our primary analyses we excluded calculated LDL-C and triglyceride measurements from KPNC. In secondary analyses, we included non-fasting triglycerides measurements and calculated LDL-C measurements from all sites.

We examined the proportion of children with lipid testing stratified by age at initial testing (3-5, 6-8, 9-11, 12-16, 17-19), body mass index (BMI) percentile (<85th, 85 - <95th, ≥95th), and BP percentile (greater of systolic or diastolic BP, <90th, 90 - <95th, ≥95th) measured closest to the date of lipid testing or at the midpoint of follow up for children without lipid testing. We also stratified by sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian, other race, unknown race/ethnicity), insurance type (commercial, government, other [high-deductible, private pay or self-funded], or unknown), and whether the child had at least one well-child visit during the study period.

We calculated the mean value and standard deviation (SD) of lipid test results for the first recorded total cholesterol, HDL-C, non-HDL-C, fasting triglyceride and LDL-C (estimated using the Friedewald formula[19] or directly measured). Using the first lipid test(s) recorded (total cholesterol, total cholesterol/HDL-C, or fasting lipid panel/ direct LDL-C), we classified children as having normal, borderline and abnormal test results categorized according to the classification of the Expert Panel.[9] Using multivariable logistic regression, we assessed the association of the characteristics of the study participants as defined above with lipid testing (at least one test of total cholesterol vs. no testing) and with abnormal test results (odds of abnormal vs. normal results, borderline results excluded). Analyses were performed using SAS 9.1.3 (Cary, NC).

RESULTS

Of the 301,080 children who met the study eligibility criteria, 50.1% were boys and 49.9% were girls (Table 1). The mean follow-up of the children was 25 months, and 21.2% of children had less than 12 months of follow-up. About a quarter of the population had unknown race/ethnicity, 39.7% were non-Hispanic white, 9.1% non-Hispanic black, 15.6% Hispanic, and 8.4% Asian/Pacific Islander. The proportion with normal weight (BMI <85th percentile) was 69.9%, with 15.4% overweight (BMI 85th - <95th percentile) and 14.8% obese (BMI≥95th percentile).

Overall, 29,360 (9.8%) of the study population was tested for lipids with measurement of at least total cholesterol (Table 1). The proportion of children and adolescents tested increased markedly with age. The proportion tested varied by BMI percentile (5.9% of normal weight, 10.8% of overweight and 26.9% of obese children) and there was also a greater likelihood of lipid testing with higher BP percentile category. There was relatively little variation in lipid testing by insurance type, but the 16% of children who did not have a well-child visit were less likely to be tested. After multivariable adjustment, age and BMI category remained strongly associated with lipid testing, while female sex, race, Hispanic ethnicity, Asian race, and BP percentile category were more weakly associated with testing (Table 1). Although

children with commercial and government insurance were equally likely to be tested, children without well-child visits were much less likely to be tested even after adjustment for age and BMI (HR 0.33, 95% CI 0.31-0.34).

In normal weight children, testing rates were 0.5% of 3-5 year olds, 1.6% of 6-8 year olds, 2.8% of 9-11 years olds, 7.1% of 12-16 year olds, and 22.0% of 17-19 year olds (Table 2). Among all ages, both sexes, and all racial/ethnic groups the proportion tested was progressively higher in overweight and obese children. The highest screening rates were in obese Hispanic youth aged 12-16 (41.9%), followed by Asian/Pacific Islanders age 12-16 (37.9%). Obese non-Hispanic Whites age 17-19 were more likely to be screened than younger teens (34.4% vs 30.9% respectively). Females were more likely to be screened across all ethnic and BMI categories, with the highest overall screening rate in obese Hispanic females age 12-16 (45.6%).

Those tested for total cholesterol usually had an HDL-C done on the same day (86.7%), allowing calculation of non-HDL-C (Table 3). Fewer children had testing for fasting triglycerides (28.0%) or assessment of LDL-C (33.2%) as part of their initial evaluation, although when measurements with unknown duration of fasting were included most children were also tested for triglycerides (76.9%) and LDL-C (80.3%, data not shown). Abnormal lipid levels were found in 8.6% of the cohort for total cholesterol, 22.5% for HDL-C, 12.0% for non-HDL-C, 8.0% for LDL-C and 19% - 38% for triglycerides, depending on age and sex (Table 3). Thirty-two individuals (0.33%) had LDL-C ≥190 mg/dl, of whom 10 had normal weight, 12 were overweight and 10 were obese (data not shown).

Girls were less likely than boys to have low levels of HDL-C. Children age 9-11 had the highest proportion of abnormal non-HDL-C levels (14.4%) compared with other age groups, and more Black children had lower levels (9.7%) than children of other races/ethnicities. There was a strong and graded association of abnormal lipid levels with BMI in the overweight and obese range, particularly for HDL-C and triglycerides. In multivariable models, the odds of abnormal lipid results were 2- to 6-fold higher in obese children compared to those with normal weight (Table 4). Asian and Black children were less likely to have low HDL-C levels, while Black and Hispanic children were less likely to have elevated total cholesterol and non-HDL-C, and Black children were markedly less likely to have elevated triglyceride levels. Mean results of lipid measurements by age, race/ethnicity, and BMI are shown in Table 5.

DISCUSSION

Our findings from this study in community-based health care systems demonstrate that during the period from 2007-2010 lipid screening was uncommon in 9-11 year old children and was performed in less than one quarter of 17-19 year old adolescents, both of the age groups targeted by the recent integrated guidelines for screening. Lipid screening was even relatively low in obese children at all ages, despite the ongoing pediatric recommendation for screening in this group during the period of this study.[20-22]

Few data are available on contemporary lipid screening practices in children and adolescents and no studies have reported data following publication of the recommendation for universal screening. A recent study from the National Ambulatory Medical Care Survey using data from 10,159 health maintenance visits among patients aged 2-19 years from 1995 through 2010 reported that lipid screening was performed at only 347 visits (3.4%, 95% CI 3.1% - 3.8%) with little change over the period of observation.[23] However, that study lacked data on other risk factors that might have affected testing decisions and was thus unable to distinguish screening from indicated testing. Moreover, unlike our longitudinal study, that cross-sectional study was likely to have underestimated the proportion of youth being screened over time and at visits other than well-child visits.

Our study population had a similar prevalence of overweight and obesity as has been reported for a representative sample of U.S. children age 2-19 during 2007-2010 in the National Health and Nutrition Examination Surveys (NHANES).[7, 8] However, in contrast to NHANES which reported lipid tests for all children in their sample regardless of BMI, our study population was more likely to be differentially screened based on BMI. Mean total cholesterol levels for each age and sex subgroup were quite similar to the national population-based data reported in NHANES, but HDL-C levels were consistently 3 to 6 mg/dl lower than national data from 2007-2010.[24] Triglyceride levels were generally 10 to 20 mg/dl higher than national data (with considerable variability by age, sex and race/ethnicity). This pattern is expected given the observed higher rates of lipid testing in overweight and obese children, who have a greater likelihood of abnormal HDL-C and triglycerides. Consequently, non-HDL-C and LDL-C levels were also higher in our sample than in NHANES, except for adolescents 17-19 years old. We observed other patterns as expected based on national data: total cholesterol and non-HDL-C peaked at age 9-11, decreased in early adolescence, and increased thereafter; HDL-C fell progressively with age in boys, while in girls it reached a nadir at age 9-11 and increased in adolescence; black children had higher levels of HDL-C and markedly lower levels of triglycerides compared with white and Hispanic children.

We found abnormal lipid levels in 8.6% of the cohort for total cholesterol, 22.5% for HDL-C, 12.0% for non-HDL-C, 8.0% for LDL-C and 19% - 38% for triglycerides, depending on age and sex. While the proportion of children with total cholesterol ≥200 mg/dl (8.6% vs 8.1%) and LDLC ≥130 mg/dl (8.0% vs. 7.4%) did not differ substantially from the proportion in NHANES, we identified a higher proportion of children with HDL-C <40 mg/dl (22.5% vs. 14.8%), non-HDL-C ≥145 mg/dl (12.0% vs. 10.%), and triglycerides ≥130 mg/dl (20.7% vs. 12.4%).[24] Again, this is likely related to selective screening of overweight and obese children in our study settings during 2007-2010 as recommended by then-current guidelines. Therefore, as screening practices add universal screening in 9-11 year olds and 17-21 year olds to targeted screening of children in other age groups as recommended in new 2011 guidelines,[9] we anticipate that the proportion of children with abnormal levels of lipids will be lower than we observed in 2007-2010, but higher than in a random sample of the population like NHANES. However, the absolute numbers of children with abnormal test results requiring further evaluation and management is likely to increase.

The 2011 guidelines state that children with non-HDL-C ≥145 mg/dl or HDL-C <40 should be further evaluated with 2 subsequent fasting lipid panels, and subsequent management should be based on levels of LDL-C and triglycerides. Our data and NHANES data suggest that 11% to 14% of children will have non-HDL-C levels ≥145 mg/dl, and additional children will have HDL <40 mg/dl. Thus, many individuals will be newly identified as having dyslipidemia and be recommended to receive additional diagnostic testing.

Although abnormal lipid values were more likely to be found in children with elevated BMI percentile, we found some normal weight children with a low level of HDL-C (12.6%) and/or a high level of non-HDL-C (6.9%). Thus, targeted screening for children with BMI above the 85th or 95th percentile would clearly miss some normal weight children with lipid abnormalities, including a small number of children with LDL-C levels compatible with familial hypercholesterolemia. Our study lacked data on family history, but others have found that using family history of premature CVD or dyslipidemia also fails to detect a substantial proportion of children with abnormal lipids.[12]

These results should be interpreted in light of several limitations of the study. First, we required a blood pressure and height measurement, so this analysis does not include the 16% of enrolled children who received little or no care during the study period, as evidenced by not having at least one BP and height measurement. If these children had been included screening rates would likely have been somewhat lower. Second, we included children in the analysis regardless of their duration of enrollment in the health system, so this may partly explain why 16% of children did not have a well-child visit. These children were much less likely to be screened even though they were receiving some health care. Third, the screening rates reflect only completed lipid tests and do not include tests that were ordered but not completed. Fourth, some children may have had a lipid screen prior to the start of the study period in 2007 and were appropriately not re-tested. For this reason it is also possible that some test results we observed during 2007-2010 were follow-up tests for abnormal screening tests conducted before 2007. Finally, although we excluded children with clinical indications for lipid testing, family history of dyslipidemia and premature cardiovascular disease were not available in our electronic records. Therefore some children with normal BMI and no other apparent indication for testing may have been tested based on family history.

We conclude that in 2007-2010 lipid screening was uncommon in 9-11 year olds and was performed in a minority of 17-19 year olds. These data provide a useful benchmark for assessing change in practice patterns in large heath systems following the new recommendations for pediatric lipid screening and subsequent management. The costs of universal screening at age 9-11 and 17-21 and the effectiveness of this policy for identifying at-risk youth and lowering their risk of CVD later in life will require further research.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

BP	blood pressure
BMI	body mass index
ICD-9-CM	International Classification of Diseases, 9th Revision, Clinical Modification
EHR	electronic health record
CI	confidence interval
mm Hg	millimeters of mercury
OR	odds ratio

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Table 1

Characteristics of children and adolescents included in the analysis, the proportion that had lipid testing, and the adjusted odds of lipid testing, 2007-2010.

		Overall Sample		Lipid Testing*		Multivariable Model**	
		N	%	N	%	Odds Ratio (95% CI)	p-value
N		301080	100	29360	9.8		
Gender	Male	150805	50.1	13956	9.3	1.00 (ref)	--
	Female	150275	49.9	15404	10.3	1.15 (1.12-1.18)	<.0001
Age Group	3-5	70621	23.5	790	1.1	0.12 (0.11-0.13)	<.0001
	6-8	44774	14.9	2003	4.5	0.51 (0.49-0.54)	<.0001
	9-11	51108	17.0	4525	8.9	1.00 (ref)	--
	12-16	94156	31.3	12230	13.0	1.72 (1.65-1.78)	<.0001
	17-19	40421	13.4	9812	24.3	5.42 (5.20-5.65)	<.0001
Race/Ethnicity	White	119587	39.7	10938	9.2	1.00 (ref)	--
	Black	27297	9.1	2724	10.0	1.11 (1.05-1.17)	0.0001
	Hispanic	47123	15.6	5867	12.5	0.95 (0.91-1.00)	0.05
	Asian/PI	25162	8.4	2263	9.0	1.15 (1.11-1.20)	<.0001
	Other	3974	1.3	430	10.8	1.10 (0.98-1.23)	0.09
	Unknown	77937	25.9	7138	9.2	0.85 (0.82-0.88)	<.0001
BMI percentile	< 85	210369	69.9	12404	5.9	1.00 (ref)	--
	85 - <95	46313	15.4	5016	10.8	1.87 (1.81-1.94)	<.0001
	≥95	44398	14.8	11940	26.9	6.34 (6.15-6.55)	<.0001
BP percentile	< 90	266652	88.6	24675	9.3	1.00 (ref)	--
	90 - <95	18966	6.3	2307	11.6	1.07 (1.01-1.12)	0.01
	≥95	15462	5.1	2378	15.4	1.12 (1.06-1.18)	<.0001
Insurance Type	Commercial	235144	78.1	23890	10.2	1.00 (ref)	--
	Government	30949	10.3	2725	8.8	0.99 (0.94-1.04)	0.59
	Other	10393	3.5	664	6.4	0.89 (0.81-0.97)	0.006
	Missing	24594	8.2	2081	8.5	1.57 (1.48-1.67)	<.0001
Well Child Visit	Yes	253429	84.2	25614	10.1	1.00 (ref)	--
	No	47651	15.8	3746	7.9	0.33 (0.31-0.34)	<.0001

* Lipid testing denotes the proportion with at least one test of total cholesterol

** Logistic regression model adjusted for all listed variables and site.

Table 2

Proportion of children with at least one measurement of total cholesterol

		Children and Adolescents by Age Group					
		All	**3-5 yrs**	**6-8 yrs**	**9-11 yrs**	**12-16 yrs**	**17-19 yrs**
		N=301080	**N=70621**	**N=44774**	**N=51108**	**N=94156**	**N=40421**
BMI percentile	Total						Both Sexes
All racial/ethnic groups							
< 85	210369	12404 (5.9)	289 (0.5)	512 (1.6)	948 (2.8)	4451 (7.1)	6204 (22.0)
85 - <95	46313	5016 (10.8)	96 (1.0)	294 (4.7)	788 (9.4)	2287 (14.4)	1551 (24.8)
≥95	44398	11940 (26.9)	405 (5.4)	1197 (18.8)	2789 (30.6)	5492 (35.6)	2057 (34.6)
Non-Hispanic White							
< 85	89244	5839 (6.5)	111 (0.5)	198 (1.6)	405 (2.9)	1915 (6.9)	3210 (23.8)
85 - <95	16903	1792 (10.6)	18 (0.5)	82 (4.0)	225 (7.9)	785 (12.9)	682 (26.2)
≥95	13440	3307 (24.6)	75 (4.0)	252 (15.2)	634 (24.9)	1564 (30.9)	782 (34.4)
Non-Hispanic Black							
< 85	17165	992 (5.8)	18 (0.4)	62 (2.3)	75 (2.9)	427 (8.6)	410 (18.9)
85 - <95	4946	488 (9.9)	9 (0.8)	27 (3.9)	56 (7.2)	209 (12.7)	187 (25.0)
≥95	5186	1244 (24.0)	31 (3.2)	99 (14.1)	270 (26.7)	598 (33.4)	246 (34.6)
Hispanic							
< 85	28133	1618 (5.8)	60 (0.7)	78 (1.7)	126 (3.0)	598 (8.0)	756 (23.1)
85 - <95	8467	1018 (12.0)	30 (1.4)	59 (4.8)	183 (11.8)	454 (17.8)	292 (28.4)
≥95	10523	3231 (30.7)	170 (8.0)	390 (23.3)	814 (36.9)	1371 (41.9)	486 (39.3)
Asian/Pacific Islander							
< 85	18599	1036 (5.6)	47 (0.7)	56 (2.0)	82 (3.1)	374 (8.3)	477 (24.9)
85 - <95	3483	423 (12.1)	16 (1.6)	42 (8.6)	76 (12.2)	197 (19.5)	92 (26.1)
≥95	3080	804 (26.1)	47 (5.5)	129 (24.9)	220 (35.4)	321 (37.9)	87 (35.7)
Other/Unknown							
< 85	57228	2919 (5.1)	53 (0.4)	118 (1.3)	260 (2.6)	1137 (6.3)	1351 (18.3)
85 - <95	12514	1295 (10.3)	23 (1.1)	84 (4.7)	248 (9.8)	642 (14.1)	298 (19.6)
≥95	12169	3354 (27.6)	82 (4.9)	327 (18.1)	851 (31.2)	1638 (36.7)	456 (30.7)
							Males
All racial/ethnic groups		N=150805	N=36349	N=23355	N=26063	N=47274	N=17764
< 85	103355	5544 (5.4)	170 (0.6)	283 (1.7)	516 (3.2)	2051 (6.6)	2524 (20.7)
85 - <95	22455	2057 (9.2)	53 (1.1)	147 (4.4)	403 (9.2)	915 (12.2)	539 (21.3)
≥95	24995	6355 (25.4)	228 (5.4)	676 (18.7)	1598 (30.0)	2877 (32.7)	976 (31.9)
Non-Hispanic White							
< 85	44199	2565 (5.8)	70 (0.64)	122 (1.8)	237 (3.4)	873 (6.4)	1263 (21.9)
85 - <95	8347	701 (8.4)	11 (0.65)	40 (3.8)	125 (7.9)	315 (10.6)	210 (20.0)
≥95	7558	1698 (22.5)	45 (4.33)	132 (14.3)	344 (23.3)	803 (27.5)	374 (31.2)
Non-Hispanic Black							

		Children and Adolescents by Age Group					
		All	**3-5 yrs**	**6-8 yrs**	**9-11 yrs**	**12-16 yrs**	**17-19 yrs**
		N=301080	**N=70621**	**N=44774**	**N=51108**	**N=94156**	**N=40421**
< 85	8775	457 (5.2)	9 (0.36)	26 (1.8)	41 (3.0)	210 (8.1)	171 (18.6)
85 - <95	2235	197 (8.8)	4 (0.75)	12 (3.3)	24 (6.4)	79 (11.3)	78 (29.2)
≥95	2502	549 (21.9)	13 (2.5)	46 (13.0)	131 (26.4)	264 (30.5)	95 (35.2)
Hispanic							
< 85	13632	680 (5.0)	36 (0.8)	41 (1.8)	62 (3.0)	265 (7.4)	276 (22.0)
85 - <95	3994	401 (10.0)	20 (1.9)	29 (4.5)	88 (11.0)	176 (15.5)	88 (24.9)
≥95	5915	1742 (29.5)	95 (7.9)	232 (23.4)	485 (37.5)	721 (39.1)	209 (35.4)
Asian/Pacific Islander							
< 85	8955	475 (5.3)	31 (0.9)	24 (1.7)	36 (3.0)	178 (8.4)	206 (26.2)
85 - <95	1893	228 (12.0)	5 (1.0)	23 (8.2)	50 (13.4)	101 (18.7)	49 (28.0)
≥95	2060	552 (26.8)	27 (5.1)	96 (28.0)	169 (37.0)	209 (36.7)	51 (31.9)
Other/Unknown							
< 85	27794	1367 (4.9)	24 (0.4)	70 (1.5)	140 (3.0)	525 (5.8)	608 (17.6)
85 - <95	5986	530 (8.9)	13 (1.3)	43 (4.5)	116 (9.4)	244 (11.4)	114 (16.6)
≥95	6960	1814 (26.1)	48 (5.26)	170 (17.0)	469 (29.3)	880 (34.0)	247 (29.4)
							Females
All racial/ethnic groups		N=150275	N=34272	N=21419	N=25045	N=46882	N=22657
< 85	107014	6860 (6.4)	119 (0.5)	229 (1.5)	432 (2.5)	2400 (7.5)	3680 (22.9)
85 - <95	23858	2959 (12.4)	43 (0.9)	147 (5.1)	385 (9.6)	1372 (16.4)	1012 (27.2)
≥95	19403	5585 (28.8)	177 (5.3)	521 (18.9)	1191 (31.4)	2615 (39.4)	1081 (37.4)
Non-Hispanic White							
< 85	45045	3274 (7.3)	41 (0.4)	76 (1.3)	168 (2.4)	1042 (7.4)	1947 (25.2)
85 - <95	8556	1091 (12.8)	7 (0.4)	42 (4.3)	100 (7.8)	470 (15.0)	472 (30.5)
≥95	5882	1609 (27.4)	30 (3.5)	120 (16.3)	290 (27.1)	761 (35.6)	408 (37.9)
Non-Hispanic Black							
< 85	8390	535 (6.4)	9 (0.4)	36 (2.8)	34 (2.9)	217 (9.2)	239 (19.1)
85 - <95	2711	291 (10.7)	5 (0.9)	15 (4.8)	32 (7.9)	130 (13.7)	109 (22.7)
≥95	2684	695 (25.9)	18 (4.0)	53 (15.1)	139 (26.9)	334 (36.1)	151 (34.2)
Hispanic							
< 85	14501	938 (6.5)	24 (0.6)	37 (1.7)	64 (3.0)	333 (8.4)	480 (23.8)
85 - <95	4473	617 (13.8)	10 (1.0)	30 (5.3)	95 (12.5)	278 (19.5)	204 (30.2)
≥95	4608	1489 (32.3)	75 (8.0)	158 (23.1)	329 (36.1)	650 (45.6)	277 (42.9)
Asian/Pacific Islander							
< 85	9644	561 (5.8)	16 (0.5)	32 (2.3)	46 (3.1)	196 (8.3)	271 (24.0)
85 - <95	1590	195 (12.3)	11 (2.3)	19 (9.2)	26 (10.4)	96 (20.4)	43 (24.3)
≥95	1020	252 (24.7)	20 (6.3)	33 (18.9)	51 (31.1)	112 (40.3)	36 (42.9)
Other/Unknown							

		Children and Adolescents by Age Group					
		All	**3-5 yrs**	**6-8 yrs**	**9-11 yrs**	**12-16 yrs**	**17-19 yrs**
		N=301080	**N=70621**	**N=44774**	**N=51108**	**N=94156**	**N=40421**
< 85	29434	1552 (5.3)	29 (0.5)	48 (1.0)	120 (2.2)	612 (6.7)	743 (18.9)
85 - <95	6528	765 (11.7)	10 (0.9)	41 (4.9)	132 (10.1)	398 (16.5)	184 (22.0)
≥95	5209	1540 (29.6)	34 (4.5)	157 (19.5)	382 (33.8)	758 (40.3)	209 (32.4)

Table 3

Proportion of children and adolescents with abnormal lipid test results

		Total Cholesterol ≥200 (mg/dl) No (%)		HDL Cholesterol <40 (mg/dl) No (%)		Non-HDL Cholesterol ≥145 (mg/dl) No (%)		Triglycerides ≥100 (mg/dl), Age 3-9 No (%)		Triglycerides ≥130 (mg/dl), Age 10-19 No (%)		LDL Cholesterol ≥130 (mg/dl) No (%)	
All tests		29360 (100)		25443 (86.7)		25443 (86.7)		652 (2.2)		7560 (25.8)		9750 (33.2)	
All Abnormal		2539 (8.6)		5720 (22.5)		3056 (12.0)		211 (32.4)		1562 (20.7)		783 (8.0)	
		%	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**
Gender	Male	8.5	(8.0-8.9)	27.5	(26.7-28.3)	12.7	(12.1-13.3)	28.1	(23.5-32.7)	22.8	(21.4-24.2)	7.8	(7.0-8.6)
	Female	8.8	(8.4-9.3)	18.0	(17.3-18.6)	11.4	(10.9-11.9)	37.9	(32.3-43.6)	18.8	(17.6-20.0)	8.2	(7.5-9.0)
Age Group**	3-5	5.8	(4.2-7.5)	14.5	(11.6-17.5)	7.9	(5.6-10.2)	16.7	(8.1-25.3)	--	--	6.8	(1.6-12.1)
	6-8	8.6	(7.4-9.8)	15.2	(13.5-16.9)	10.7	(9.3-12.2)	31.5	(26.6-36.4)	--	--	7.4	(4.8-9.9)
	9-11	10.6	(9.7-11.5)	21.3	(20.0-22.5)	14.4	(13.3-15.5)	38.4	(32.2-44.6)	27.8	(24.7-31.0)	8.1	(6.6-9.7)
	12-16	7.2	(6.7-7.6)	25.8	(25.0-26.7)	11.2	(10.6-11.8)	--	--	22.4	(20.9-23.8)	7.6	(6.7-8.4)
	17-19	9.8	(9.2-10.4)	21.1	(20.2-21.9)	12.4	(11.7-13.1)	--	--	17.5	(16.2-18.7)	8.5	(7.7-9.3)
Race	White	9.1	(8.6-9.7)	22.6	(21.8-23.5)	12.2	(11.5-12.9)	26.4	(21.2-31.5)	19.8	(18.5-21.1)	8.4	(7.7-9.2)
	Asian	9.6	(8.4-10.8)	15.7	(14.1-17.3)	12.1	(10.7-13.6)	23.8	(5.6-42.0)	24.2	(18.8-29.6)	8.5	(5.7-11.3)
	Black	7.6	(6.6-8.6)	17.1	(15.5-18.6)	9.7	(8.5-11.0)	7.0	(0.4-13.6)	9.8	(7.4-12.2)	6.9	(5.2-8.6)
	Hispanic	8.2	(7.5-8.9)	26.3	(25.1-27.5)	12.4	(11.5-13.3)	50.9	(43.2-58.7)	24.5	(22.4-26.7)	6.8	(5.6-7.9)
	Other	9.3	(6.6-12.0)	26.2	(21.6-30.7)	15.6	(11.8-19.4)	25.0	(0.5-49.5)	21.1	(14.0-28.2)	10.3	(5.8-14.8)
	Unknown	8.3	(7.7-9.0)	22.8	(21.8-23.9)	11.9	(11.1-12.7)	35.5	(27.1-43.9)	22.9	(20.6-25.1)	8.5	(7.1-9.8)
BMI	< 85 pct	6.7	(6.2-7.1)	12.6	(11.9-13.2)	6.9	(6.4-7.4)	13.6	(8.5-18.6)	11.3	(10.3-12.4)	5.6	(5.0-6.3)
	85 - <95 pct	8.6	(7.8-9.4)	20.2	(19.0-21.4)	11.3	(10.4-12.3)	20.0	(10.9-29.1)	19.1	(16.9-21.3)	9.1	(7.7-10.6)
	≥95 pct	10.7	(10.2-11.3)	32.4	(31.5-33.3)	17.0	(16.3-17.7)	43.0	(38.1-47.9)	32.5	(30.8-34.2)	10.4	(9.4-11.4)
BP percentile	< 90	8.1	(7.8-8.5)	21.7	(21.1-22.2)	11.2	(10.8-11.6)	31.7	(27.9-35.5)	19.6	(18.6-20.5)	7.6	(7.0-8.2)
	90 - <95	9.4	(8.2-10.6)	26.1	(24.2-28.0)	13.2	(11.7-14.6)	44.9	(31-58.8)	26.1	(22.3-29.9)	10	(7.7-12.3)
	≥95	13.5	(12.1-14.8)	27.0	(25.1-28.9)	18.9	(17.2-20.6)	24.1	(8.6-39.7)	31.8	(27.2-36.4)	12.3	(9.5-15.1)
Insurance Type	Commercial	8.6	(8.3-9.0)	22.2	(21.7-22.8)	11.8	(11.4-12.3)	30.1	(25.8-34.3)	20.1	(19.1-21.1)	8.1	(7.5-8.7)
	Government	7.8	(6.8-8.8)	25.2	(23.4-27.1)	13.2	(11.8-14.7)	40.2	(31.5-48.9)	24.2	(21.0-27.4)	8.7	(7.0-10.5)
	Other	8.4	(6.3-10.5)	24.2	(20.9-27.5)	11.0	(8.6-13.4)	42.2	(27.8-56.7)	19.0	(15.4-22.6)	6.5	(4.4-8.7)
	None/Missing	10.0	(8.8-11.3)	21.4	(19.3-23.4)	13.0	(11.3-14.7)	22.2	(8.6-35.8)	24.8	(20.5-29.2)	7.6	(5.9-9.3)

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		Total Cholesterol ≥200 (mg/dl) No (%)		HDL Cholesterol <40 (mg/dl) No (%)		Non-HDL Cholesterol ≥145 (mg/dl) No (%)		Triglycerides ≥100 (mg/dl), Age 3-9 No (%)		Triglycerides ≥130 (mg/dl), Age 10-19 No (%)		LDL Cholesterol ≥130 (mg/dl) No (%)	
Well Child Visit	Yes	8.4	(8.1-8.7)	22.4	(21.9-23.0)	11.9	(11.5-12.3)	32.6	(28.8-36.3)	20.3	(19.4-21.3)	8.0	(7.4-8.6)
	No	10.4	(9.4-11.3)	22.8	(21.4-24.3)	13.0	(11.8-14.2)	30.0	(17.3-42.7)	23.3	(20.4-26.2)	8.1	(6.6-9.5)

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Table 4

Adjusted odds of abnormal lipid test results*

Model		Abnormal Total Cholesterol		Abnormal HDL Cholesterol		Abnormal non-HDL Cholesterol		Abnormal Triglyceride		Abnormal LDL Cholesterol	
		N=22529		N=20453		N=19774		N=7065		N=8220	
Variable		**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Gender	Male	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--
	Female	1.11(1.02-1.21)	0.02	0.51 (0.48-0.55)	<.0001	0.91 (0.84-0.98)	0.02	0.81 (0.70-0.94)	0.005	1.06 (0.91-1.24)	0.42
Age Group	3-5	0.51-0.37-0.70)	<0.0001	0.68 (0.52-0.89)	0.005	0.46 (0.33-0.64)	<0.0001	0.31 (0.11-0.89)	0.03	0.90 (0.38-2.15)	0.81
	6-8	0.83 (0.69-1.00)	0.05	0.67 (0.57-0.78)	<.0001	0.73 (0.61-0.88)	0.001	0.51 (0.34-0.77)	0.001	0.90 (0.58-1.39)	0.63
	9-11	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--
	12-16	0.62 (0.55-0.71)	<0.0001	1.86 (1.68-2.05)	<.0001	0.79 (0.71-0.89)	<0.0001	0.91 (0.74-1.12)	0.39	0.94 (0.73-1.20)	0.60
	17-19	1.05 (0.92-1.20)	0.44	2.02 (1.81-2.26)	<.0001	1.30 (1.14-1.47)	<0.0001	1.07 (0.85-1.35)	0.57	1.41 (1.09-1.83)	0.008
Race	White	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--
	Asian	1.16 (0.98-1.37)	0.08	0.67 (0.58-0.78)	<.0001	1.08 (0.92-1.27)	0.35	1.27 (0.85-1.90)	0.25	1.03 (0.70-1.51)	0.90
	Black	0.74 (0.62-0.87)	0.0002	0.55 (0.48-0.63)	<.0001	0.59 (0.50-0.69)	<0.0001	0.17 (0.11-0.26)	<0.0001	0.66 (0.49-0.88)	0.005
	Hispanic	0.79 (0.70-0.90)	0.0002	1.03 (0.94-1.13)	0.55	0.84 (0.75-0.95)	0.004	1.07 (0.89-1.29)	0.47	0.65 (0.52-0.81)	0.0002
	Other	0.89 (0.63-1.25)	0.50	0.97 (0.73-1.27)	0.81	1.02 (0.75-1.39)	0.92	0.80 (0.47-1.36)	0.41	1.01 (0.60-1.68)	0.98
	Unknown	0.89 (0.80-1.00)	0.06	0.97 (0.89-1.06)	0.53	0.91 (0.82-1.02)	0.09	1.05 (0.86-1.29)	0.61	0.91 (0.74-1.13)	0.40
BMI	< 85 pct	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--
	85 - <95 pct	1.51 (1.33-1.71)	<.0001	2.30 (2.08-2.55)	<.0001	2.19 (1.93-2.49)	<0.0001	2.34 (1.82-3.01)	<0.0001	2.01 (1.61-2.52)	<0.0001
	≥95 pct	2.13 (1.92-2.36)	<.0001	5.64 (5.17-6.15)	<.0001	4.19 (3.77-4.66)	<0.0001	6.26 (5.12-7.65)	<0.0001	2.70 (2.23-3.27)	<0.0001
BP	<90th pct	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--
	90-<95th pct	1.07 (0.92-1.24)	0.40	1.11 (0.98-1.25)	0.10	1.06 (0.92-1.22)	0.46	1.15 (0.89-1.49)	0.29	1.14 (0.87-1.5)	0.35
	≥95 pct	1.62 (1.42-1.85)	<.0001	1.07 (0.95-1.20)	0.26	1.57 (1.38-1.78)	<0.0001	1.40 (1.07-1.85)	0.02	1.37 (1.03-1.81)	0.03
Insurance Type	Commercial	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--
	Government	0.88 (0.75-1.04)	0.13	1.12 (0.99-1.26)	0.07	1.07 (0.93-1.24)	0.35	1.05 (0.83-1.33)	0.70	1.05 (0.81-1.35)	0.72
	Other	1.00 (0.75-1.34)	1.00	0.96 (0.77-1.18)	0.67	0.95 (0.73-1.24)	0.70	1.09 (0.81-1.48)	0.56	0.88 (0.61-1.27)	0.49
	Missing	1.09 (0.89-1.34)	0.41	1.00 (0.83-1.21)	0.98	1.06 (0.86-1.32)	0.58	0.95 (0.63-1.43)	0.79	0.83 (0.59-1.17)	0.28
Well Child Visit	Yes	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--	1.00 (ref)	--

Model		Abnormal Total Cholesterol		Abnormal HDL Cholesterol		Abnormal non-HDL Cholesterol		Abnormal Triglyceride		Abnormal LDL Cholesterol	
		N=22529		N=20453		N=19774		N=7065		N=8220	
Variable		OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
	No	1.18 (1.03-1.34)	0.01	1.11 (0.99-1.24)	0.07	1.08 (0.95-1.23)	0.26	1.33 (1.04-1.69)	0.02	0.90 (0.71-1.15)	0.40

* Each model contains all the variables listed in the first column, odds of abnormal vs. normal results, borderline results excluded.

Table 5

) by age, sex, race/ethnicity and BMI category among children and adolescents aged 3-19 years old

					Boys (N= 13956)					Girls (N= 15404)
Total terol g/dl) 3965	HDL-C (mg/dl) N=12090	non-HDL-C (mg/dl) N=12090	Triglycerides geometric mean (mg/dl) N=3820	LDL-C (mg/dl) N=4538	N (%)	Total Cholesterol (mg/dl) N=15404	HDL-C (mg/dl) N=13353	no n-HDL-C (mg/dl) N=13353	Triglycerides geometric mean (mg/dl) N=4392	LDL-C (mg/dl) N=5212
29.5)	51.8 (12.0)	102.1 (25.4)	57.9 (45.6)	88.1 (23.0)	339 (2.2)	156.4 (27.0)	49.7 (0.6)	108.3 (25.3)	72.7(34.6)	100.8 (27.3)
27.9)	51.4 (10.8)	110.9 (25.30	71.8 (50.2)	95.5 (22.3)	897 (5.82)	163.4 (33.4)	49.8 (11.3)	114.0 (32.9)	83.7 (54.0)	96.6 (23.3)
31.2)	49.2 (10.9)	115.9 (30.1)	87.4 (68.4)	96.3 (26.2)	2008 (13.04)	160.3 (29.9)	46.8 (10.3)	114.3 (29.8)	103.3 (66.9)	94.5 (23.8)
30.9)	44.4 (9.7)	111.2 (30.5)	90.2 (65.5)	92.4 (25.3)	6387 (41.46)	156.0 (28.8)	47.8 (10.2)	108.4 (28.2)	89.4 (62.3)	92.9 (25.1)
31.2)	44.5 (9.7)	109.4 (31.2)	87.0 (65.7)	91.4 (26.7)	5773 (37.48)	162.0 (31.4)	51.9 (11.7)	110.6 (29.6)	81.2 (45.2)	94.3 (26.6)
30.8)	45.2 (10.1)	109.7 (30.2)	85.4 (65.7)	91.8 (26.5)	5974 (38.8)	161.5 (31.2)	50.2 (11.3)	111.7 (29.7)	86.8 (49.1)	94.6 (26.3)
32.8)	48.8 (10.7)	112.6 (31.4)	91.4 (58.5)	93.9 (27.8)	1008 (6.5)	160.3 (28.7)	51.5 (10.7)	109.9 (28.5)	89.8 (49.6)	95.7 (27.5)
30.0)	48.1 (10.8)	110.2 (29.0)	73.7 (45.5)	96.2 (25.1)	1521 (9.9)	156.2 (29.1)	50.3 (10.8)	106.4 (28.0)	66.2 (33.1)	92.3 (25.0)
31.2)	45.4 (10.5)	113.2 (30.1)	94.9 (68.0)	93.6 (24.8)	3044 (19.8)	157.2 (28.9)	47.5 (10.7)	110.2 (28.2)	92.6 (62.8)	92.6 (24.0)
31.9)	45.4 (10.4)	112.7 (33.1)	97.7 (128.1)	89.2 (25.7)	237 (1.5)	159.5 (30.3)	48.1 (11.3)	112.2 (29.6)	91.6 (45.8)	97.1 (27.9)
30.7)	46.3 (10.3)	111.4 (30.1)	87.3 (59.4)	92.5 (25.3)	3620 (23.5)	158.7 (30.8)	49.1 (11.1)	110.0 (30.0)	88.4 (70.3)	93.6 (25.3)
28.8)	48.7 (10.7)	100.0 (25.8)	71.0 (43.4)	86.1 (24.2)	6860 (44.5)	158.8 (30.8)	53.8 (11.3)	105.8 (29.0)	77.1 (40.7)	91.2 (25.5)
31.2)	47.2 (10.9)	110.1 (30.1)	86.5 (65.5)	94.8 (26.8)	2959 (19.2)	159.3 (30.6)	49.1 (10.5)	110.7 (29.2)	84.9 (64.4)	96.1 (27.1)
31.3)	43.8 (9.5)	120.1 (30.6)	105.5 (74.8)	98.8 (25.8)	5585 (36.3)	160.1 (29.6)	44.9 (9.2)	115.3 (28.8)	101.1 (62.7)	96.5 (24.9)

DL-cholesterol (HDL-C), LDL-cholesterol (LDL-C), standard deviation (std dev)