ABSTRACT: This document provides a pediatric-focused companion to “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond,” focused on cardiovascular health promotion and disease reduction in adults and children. The principles detailed in the document reflect the American Heart Association’s new dynamic and proactive goal to promote cardiovascular health throughout the life course. The primary focus is on adult cardiovascular health and disease prevention, but critical to achievement of this goal is maintenance of ideal cardiovascular health from birth through childhood to young adulthood and beyond. Emphasis is placed on the fundamental principles and metrics that define cardiovascular health in children for the clinical or research setting, and a balanced and critical appraisal of the strengths and weaknesses of the cardiovascular health construct in children and adolescents is provided. Specifically, this document discusses 2 important factors: the promotion of ideal cardiovascular health in all children and the improvement of cardiovascular health metric scores in children currently classified as having poor or intermediate cardiovascular health. Other topics include the current status of cardiovascular health in US children, opportunities for the refinement of health metrics, improvement of health metric scores, and possibilities for promoting ideal cardiovascular health. Importantly, concerns about the suitability of using single thresholds to identify elevated cardiovascular risk throughout the childhood years and the limits of our current knowledge are noted, and suggestions for future directions and research are provided.

Key Words: AHA Scientific Statements ◼ blood pressure ◼ body mass index ◼ cholesterol ◼ diet ◼ glucose ◼ pediatrics ◼ physical activity ◼ smoking

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The "Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association's Strategic Impact Goal Through 2020 and Beyond" statement, published in 2010, provides guidance on cardiovascular health promotion and disease reduction in adults and children. It also offers a novel definition of cardiovascular health and identifies metrics to enable cardiovascular health monitoring in the pediatric and adult populations over time. The principles detailed in the document reflect the American Heart Association's (AHA's) new dynamic and proactive goal to promote cardiovascular health throughout the life course. The primary focus is on adult cardiovascular health and disease prevention, but critical to achievement of this goal is maintenance of ideal cardiovascular health from birth through childhood to young adulthood and beyond.

This document provides a pediatric-focused companion document emphasizing the fundamental principles and metrics that define cardiovascular health in children for the clinical or research setting. The authors offer a balanced and critical appraisal of the strengths and weaknesses of the cardiovascular health construct in children and adolescents and discuss 2 important factors: the promotion of ideal cardiovascular health in all children and the improvement in cardiovascular health metric scores in children currently classified as having poor or intermediate cardiovascular health. Other topics include the current status of cardiovascular health in US children, opportunities for the refinement of health metrics, improvement in health metric scores, and possibilities for promoting ideal cardiovascular health. Concerns about the suitability of using single thresholds to identify elevated cardiovascular risk throughout the childhood years and the limits of our current knowledge are noted, and suggestions for future directions and research are provided.

Despite a comprehensive definition of cardiovascular health, it is now widely recognized that the development of childhood cardiovascular and metabolic disease risk factors and the consequent loss of cardiovascular health are accelerated in childhood primarily in conjunction with weight gain and obesity. The number of overweight children (defined as a body mass index [BMI] ≥85th percentile using the Centers for Disease Control and Prevention [CDC] Growth Charts) and the prevalence of obesity (defined as a BMI ≥95th percentile using the CDC Growth Charts) have risen dramatically over the past 4 decades for youth 2 to 19 years of age, with a recognized epidemic occurring between the mid-1980s and mid-1990s in the United States. US data from 2009 to 2010 indicate that 17% of 2- to 19-year-olds are obese and an additional 15% are overweight. Youth with obesity have significantly worse circulating lipid profiles (higher total and low-density lipoprotein cholesterol, higher triglycerides, and lower high-density lipoprotein cholesterol) and higher blood pressure (BP), glucose, and insulin concentrations than their nonobese peers. Obesity in youth is also linked to increased left ventricular mass in childhood and adulthood, as well as increased carotid intima-media thickness measured in adulthood. Although obesity prevalence has plateaued in the past decade, the rates in minority, low-income, and rural populations remain high.

Moreover, rates of pediatric severe obesity are increasing; the prevalence is ≈6% in the United States. Youth with severe obesity are at much higher risk of developing cardiovascular disease even compared with their overweight or obese peers.

There is also evidence that childhood levels of cardiovascular risk factors predict early subclinical atherosclerosis and cardiac pathology and adult morbidity and mortality. The Bogalusa Heart Study demonstrated that in youth who died at an average age of 19.6 years, there was a direct association between degree of atherosclerosis in the coronary arteries and levels of antemortem cardiovascular risk factors, including BMI, lipids, and BP. The PDAY Study (Pathobiologic Determinants of Atherosclerosis in Youth), which included autopsies of nearly 3000 individuals 15 to 34 years of age, provided results in postmortem examination similar to the Bogalusa Heart Study findings.

The stages of cardiovascular disease prevention include primordial (the prevention of risk factor development), primary (the prevention of cardiovascular disease and stroke among individuals at risk), and secondary (the prevention of recurrent disease and complications). Most children are born with ideal cardiovascular health, which the AHA defines as the simultaneous presence of 4 favorable health behaviors (related to smoking, BMI, physical activity, and healthy diet status) and 3 favorable health factors (total cholesterol, BP, and fasting blood glucose levels; Table 1). Unfortunately, over time, most children experience a decline in health factors and behaviors, resulting in loss of ideal cardiovascular health as they reach adulthood. It is well known that achieving sustained lifestyle changes in adults is difficult, and risk factor control through the use of medication cannot fully restore the low-risk state present in ideal cardiovascular health. Therefore, maintaining better levels of cardiovascular health through childhood is a desirable goal.

The advancement and sustainability of the AHA's goal ("By 2020, to improve the cardiovascular health of all Americans by 20% while reducing deaths from cardiovascular diseases and stroke by 20%") hinge directly on the promotion of ideal health behaviors for the maintenance of (or improvement in nonideal) health factors in children and adolescents. The collective goal of pediatric healthcare providers and researchers, and for society as a whole, should be to understand how ideal health behaviors and health factors are lost and how this decline might be prevented.
Table 1.  Poor, Intermediate, and Ideal Definitions: Health Metrics in Children and Adolescents

<table>
<thead>
<tr>
<th>Metric</th>
<th>Poor</th>
<th>Intermediate</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking status</td>
<td>Tried &gt;30 d ago</td>
<td>...</td>
<td>Never tried; never smoked whole cigarette</td>
</tr>
<tr>
<td>BMI</td>
<td>&gt;95th percentile</td>
<td>85th–95th percentile</td>
<td>&lt;85th percentile</td>
</tr>
<tr>
<td>Physical activity level</td>
<td>None</td>
<td>&gt;0 and &lt;60 min/d moderate or vigorous activity every day</td>
<td>≥60 min/d moderate or vigorous activity every day</td>
</tr>
<tr>
<td>Healthy Diet Score*</td>
<td>0–1 components</td>
<td>2–3 components</td>
<td>4–5 components</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>≥200 mg/dL</td>
<td>170–199 mg/dL</td>
<td>&lt;170 mg/dL</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>&gt;95th percentile</td>
<td>90–95th percentile</td>
<td>&lt;90th percentile</td>
</tr>
<tr>
<td>Fasting blood glucose</td>
<td>≥126 mg/dL</td>
<td>100–125 mg/dL</td>
<td>&lt;100 mg/dL</td>
</tr>
</tbody>
</table>

BMI indicates body mass index.

*The Healthy Diet Score is based on adherence to the following dietary recommendations: fruits and vegetables, ≥4.5 cups per day; fish, 2 or more 3.5-oz servings per week; sodium, ≤1500 mg/d; sugar-sweetened beverages, ≤450 kcal (36 oz) per week; and whole grains, ≥3 servings a day scaled to a 2000-kcal/d diet. Reprinted from Lloyd-Jones et al.1 Copyright © 2010, American Heart Association, Inc.

For the pediatric population, the following AHA health behavior criteria are suggested in AHA’s definition of cardiovascular health: abstinence from smoking, a BMI <85th percentile, ≥60 minutes of moderate or vigorous physical activity daily, and adherence to a diet emphasizing fruits, vegetables, fish, whole grains, low sodium, and few sugar-laden foods and drinks. AHA-recommended health factor metrics for ideal cardiovascular health in children are as follows: total cholesterol <170 mg/dL, BP <90th percentile, and a fasting plasma glucose level <100 mg/dL.1 Although the authors recognize that BMI could more objectively be viewed as a health factor, for purposes of agreement with “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond,” in this document, we have maintained its classification as a behavior. The issue of BMI classification merits further consideration in future definitions.

Although normal levels for childhood cardiovascular health factors have been defined using population-based distributions, definitions for elevated or high-risk levels have been based on clinical expert consensus32–37 as a result of the lack of long-term data relating elevated childhood cardiovascular risk factor levels to adult cardiovascular end points. Significant developmental changes during maturation are likely to reduce the strength of the associations between cardiovascular risk factors measured in childhood and adult cardiovascular risk factors and outcomes. For example, fluctuations in cardiovascular risk factor levels during puberty are well known.38–41 The International Childhood Cardiovascular Cohort Consortium data indicate that current childhood risk thresholds for lipids have low sensitivity and specificity for identifying elevated lipid classification in adulthood.42–45 The use of cross-sectional population-based cut points for defining risk in childhood can contribute to significant risk misclassification later in life. Thus, longitudinal data that track cardiovascular health metrics from very early in life through maturation and are linked to adult cardiovascular health metrics are essential for establishing improved surveillance tools.

REFINEMENT OF THE CARDIOVASCULAR HEALTH METRICS

In “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond,” pediatric cut points defining ideal cardiovascular health were provided as a first step toward improving primordial prevention of CVD.1 Some of these cut points are imperfect and pose challenges to the accurate identification of the at-risk child. These cut points are less than optimal because they are based on percentiles from general populations rather than on relations to outcomes. The values were chosen to coincide with definitions used in current guidelines and are available in NHANES (National Health and Nutritional Examination Surveys). Nevertheless, such metrics will aid in the assessment of educational and preventive programs and provide data on improvements in health behaviors (ie, as healthy diets and physical activity) and for reporting declines in prevalence of smoking, overweight, and obesity, as well as improvement in values for total cholesterol, BP, and the presence of elevated fasting blood glucose.46 Clearly, many aspects of ideal cardiovascular health are challenging to define and measure. The sections below offer perspectives on the challenges for addressing specific cardiovascular health factors.
Smoking

In “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond,” the ideal metric for smoking behavior is defined for youth 12 to 19 years of age as “never tried; never smoked a whole cigarette.” Determination of smoking habits, particularly in children and adolescents, is challenging. Questionnaires may underestimate the true smoking rate because of the perceived loss of confidentiality when parents or others are present. However, the CDC data may circumvent some of these limitations. Assessment is also affected by factors such as varying definitions of smoking, fear of reprisal, or desire to inflate one’s status in the eyes of others. To successfully estimate smoking behavior in pediatric populations, objective measurement techniques can be used (eg, cotinine levels) to estimate secondhand smoke exposure, light smoking, and heavy smoking.

The ability to perform such assessments in pediatric populations is particularly pertinent because ≈ 4.8 million US children <12 years of age are exposed to secondhand smoke in their homes. Furthermore, a report on neurobehavioral disorders in children exposed to secondhand smoke has shown a 2-fold increase in prevalence compared with those not exposed to secondhand smoke in their homes. Although cotinine levels are available in many population-based investigations, including in a subset of participants in NHANES, exposure to secondhand smoke was not included as a primary cardiovascular health metric in “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” because of insufficient evidence linking secondhand smoke exposure to adverse cardiovascular health among youth.

The number of youth who have used electronic cigarettes (or e-cigarettes) is also notably increasing. This is particularly concerning for the cardiovascular health of US children and adolescents because the use of e-cigarettes is associated with increased intention to smoke cigarettes among those who never smoked conventional cigarettes. E-cigarette use was also not listed as a primary cardiovascular health metric in “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” because insufficient data were available to evaluate its contribution to adverse cardiovascular health.

Body Mass Index

BMI is the most widely used measure of weight status in public health surveillance and in epidemiological research in children and adolescents. In large, diverse groups, BMI is well correlated with adiposity (ie, body composition). BMI is widely used to screen children and adolescents for overweight and obesity and is an easy-to-calculate metric. The CDC Growth Charts provide sex-specific BMI-for-age growth curves for children 2 to 20 years of age. With these charts, normal weight status is defined as an age/sex-specific BMI <85th percentile; overweight is defined as an age/sex-specific BMI ≥85th and <95th percentile; and obesity is defined as an age/sex-specific BMI ≥95th percentile. The criterion set for ideal cardiovascular health is a BMI <85th percentile. The recommended method for determining BMI is to objectively measure height and weight, calculate BMI as kilograms per meters squared, and either plot BMI on the CDC Growth Charts or use statistical analysis software to calculate the age/sex-specific BMI percentile. Although BMI is highly correlated with adiposity, it is not an ideal measure of fatness (ie, percent body fat) in children and adolescents. It is known that variability in lean weight is a source of error in estimates of adiposity that are based on BMI. A criterion measure of adiposity is provided by dual-energy x-ray absorptiometry, which provides highly reliable estimates of lean mass, fat mass, and percent body fat. Furthermore, skin-fold thicknesses and bioelectric impedance have been widely used to estimate percent body fat in research studies.

Healthy Diet

Healthy dietary behaviors directly influence multiple cardiovascular risk factors such as obesity, dyslipidemia, hypertension, and hyperglycemia. Two of the primary features of healthy eating include diet quality and energy balance; the latter is defined as caloric consumption matched with energy expenditure. Unfortunately, compared with the other 6 ideal health behaviors/factors categories, children in the United States score most poorly in regard to a healthy diet. Approximately 91% of US children are classified as having a poor diet score, 9% are classified as having an intermediate diet score, and <0.5% are classified as having an ideal diet score. Moreover, a higher percentage of children than adults are ranked in the poor category for diet quality. This worrisome finding is consistent across all pediatric age groups, races, and sex.

Dietary recommendations in “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” are clear but need to be scaled to account for the varying energy requirements across childhood. Avoidance of obesity in children is key. Balancing energy intake to match growth and activity needs can mean the difference between successful and compromised management of lifetime risk. Diet assessment remains challenging in the absence of...
Physical Activity

Physical activity has been defined as any bodily movement produced by skeletal muscles that requires energy expenditure. The “2008 Physical Activity Guidelines for Americans” recommend that children 6 to 17 years of age engage in ≥60 minutes of moderate- to vigorous-intensity aerobic physical activity per day. Furthermore, the guidelines recommend that this period of activity include muscle-strengthening and bone-loading activities at least 3 days a week. Physical activity is a complex behavior that is performed for many different purposes, in many different settings, and in a wide range of forms. Accordingly, no single measure of physical activity can validly assess all elements of a child’s physical activity pattern.

To determine compliance with the aforementioned federal physical activity guideline, the preferred method of assessment is accelerometry. An accelerometer is an electromechanical motion sensor that provides an objective measure of a child’s participation in physical activity across the entire range of physical activity intensities. The device is small and relatively unobtrusive and thus can be used to measure physical activity for multiple days, thereby providing a reliable reflection of a child’s usual physical activity level. Accelerometry has been incorporated into the protocol for NHANES, so this procedure now serves as the basis for producing prevalence estimates for compliance with physical activity guidelines in US children and adolescents. Accelerometry has been used to measure physical activity in children across the developmental continuum, and this method has been used extensively with children as young as 3 years of age to evaluate physical activity behavior of children attending childcare centers and preschools.

A positive attribute of accelerometry is that raw data can be stored indefinitely and reanalyzed as new data reduction strategies are developed.

Accelerometry, although providing an objective and reliable assessment of physical activity in children and adolescents, has some significant limitations. Accelerometry underdetects non–weight-bearing activity (eg, bicycle riding) and cannot be used to assess water-based activities (eg, swimming). There are also challenges with compliance in wearing accelerometers, particularly among children and adolescents. Importantly, accelerometry does not provide any contextual information about the type, location, and social setting in which physical activity is performed.

To complement accelerometry, self-report and surrogate report instruments have been developed to provide information about activity types and contexts. An example is the Youth Risk Behavior Surveillance System, which includes several items on physical activity behavior. This instrument is administered at regular intervals to nationally representative samples of American high school students. The Youth Risk Behavior Surveillance System provides student-reported information on frequency of participation in moderate- and vigorous-intensity physical activity, muscle-strengthening activities, physical education classes, and organized sports. In addition, SHPPS (School Health Policies and Practices Study), a CDC-managed surveillance system, provides information on the availability of school-based physical activity programs, including physical education, school sports, recess, and other physical activity opportunities, at the elementary, middle, and high school levels.
**Blood Lipids/Total Cholesterol**

The 2011 National Heart, Lung, and Blood Institute Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents noted that the 1992 guidelines targeted the identification of children with elevated low-density lipoprotein cholesterol, whereas the current guidelines address the increasingly predominant combined dyslipidemic pattern detected in children and adolescents, including moderate to severe elevation in triglyceride level, normal to mild elevation in low-density lipoprotein cholesterol, and lower high-density lipoprotein cholesterol levels. Key findings of this report are summarized in Table 2.

“Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” establishes a total cholesterol level of 170 mg/dL as ideal for children 6 to 19 years of age, but this wide age range presents some challenge. For example, during puberty, there is typically a reduction in total blood cholesterol of 10% to 15%, regardless of diet, and the mechanisms are poorly understood. Additionally, race and sex differences in lipids become more pronounced after puberty. Higher levels of low-density lipoprotein cholesterol and lower levels of high-density lipoprotein cholesterol are noted after puberty, especially in white boys. Counter-intuitively, lower levels of triglycerides are documented in black girls after puberty despite a higher prevalence of obesity. These effects of puberty may contribute to the differences noted by race in the postpubertal clustering of risk factors that typically occurs. Although total blood cholesterol level remains the strongest predictor of cardiovascular outcomes in NHANES, the increasingly more prevalent detection of combined dyslipidemia that accompanies the development of an obesity pattern (high triglycerides/low high-density lipoprotein cholesterol) may represent an important risk factor that should be addressed.

**Blood Pressure**

“Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” defines ideal BP as a level <90th percentile for children 8 to 19 years of age. As with BMI, the practitioner should evaluate BP levels using the sex/height-specific percentile charts, with the caveat that the charts do not account for known differences in BP levels by race. A major challenge of this definition is its reliance on the statistical distribution of BP levels from pooled epidemiological data rather than linking cut points to hard cardiovascular events.

<table>
<thead>
<tr>
<th>Table 2. Key Findings From the 2011 National Heart, Lung, and Blood Institute’s “Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: Summary Report”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal lipid levels in childhood are associated with increased evidence of atherosclerosis.</td>
</tr>
<tr>
<td>Early identification and control of dyslipidemia, including heterozygous familial hypercholesterolemia, throughout youth and into adulthood can reduce clinical cardiovascular disease risk beginning in young adult life.</td>
</tr>
<tr>
<td>Normal lipid and lipoprotein distributions have been documented in childhood, adolescence, and young adult life, and studies have revealed significant tracking of total cholesterol and LDL-C levels from childhood into adulthood, with the strongest correlation seen between results in late childhood and the third to fourth decades of life.</td>
</tr>
<tr>
<td>Puberty has a strong influence, with total and LDL-C levels falling 10%–20% or more. Nine to 11 y of age is considered a stable period for measuring blood lipids because most children in this age range will not have started puberty.</td>
</tr>
<tr>
<td>Relying on a family history of premature cardiovascular disease or dyslipidemia as the primary rationale for screening misses 30%–60% of children with dyslipidemia; thus, universal lipid assessment is recommended.</td>
</tr>
<tr>
<td>Non–HDL-C is considered a significant predictor of the presence of atherosclerosis and is more predictive of persistent dyslipidemia than total cholesterol, LDL-C, or HDL-C levels alone. Another advantage is that non–HDL-C can be accurately calculated in a nonfasting state.</td>
</tr>
<tr>
<td>In terms of other lipid measurements, most studies report that apolipoprotein A-1 and B levels provide no additional advantage over non–HDL-C, LDL-C, or HDL-C levels, although measurement of apolipoprotein(a) is useful in the assessment of children with both hemorrhagic and ischemic stroke. The offspring of parents with premature cardiovascular disease and no other identifiable risk factors have been noted to have elevations of apolipoprotein A1 and B and lipoprotein(a). More advanced measurement of lipoprotein subclasses and their sizes has not been shown to have clinical utility in children.</td>
</tr>
<tr>
<td>Obesity is often associated with a combined dyslipidemia pattern, with mild elevations in total cholesterol and LDL-C, moderate to severe elevation in triglycerides, and low HDL-C. This is the most common dyslipidemic pattern seen in childhood.</td>
</tr>
<tr>
<td>Dyslipidemia can occur secondary to disorders such as diabetes mellitus, nephrotic syndrome, chronic renal disease, postorthotopic heart transplantation, Kawasaki disease, chronic inflammatory disease, and hypothyroidism, among others, and requires evaluation.</td>
</tr>
<tr>
<td>Some inherited disorders are not completely phenotypically expressed until adulthood. The evaluation of children from high-risk families with familial combined hyperlipidemia can lead to earlier detection.</td>
</tr>
</tbody>
</table>

HDL-C indicates high-density lipoprotein cholesterol; and LDL-C, low-density lipoprotein cholesterol.

Although 24-hour ambulatory BP monitoring is considered the most accurate method to evaluate hypertension and to define BP-related cardiovascular risk and can reduce the uncertainty in classification resulting from day-to-day variability of BP levels, the cost and burden...
Fasting Blood Glucose

A fasting blood glucose level of <100 mg/dL was set as the ideal for pediatric patients in “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond.”1 This is a challenging metric because measurement of fasting blood glucose is not a current or proposed recommendation for routine pediatric care. Additionally, it is known that hyperinsulinemia is the first abnormality seen in obese pediatric patients developing metabolic derangement, with impaired fasting glucose occurring at a much later stage in the progression toward type 2 diabetes mellitus.83 The current definition of ideal cardiovascular health does not capture this aspect of cardiovascular risk.

The American Diabetes Association developed clear guidelines, applicable to both children and adults, that define impaired glucose tolerance as a fasting blood glucose between 100 and 125 mg/dL and diabetes mellitus as a fasting blood glucose ≥126 mg/dL.84 Whereas defining the upper limits of normal for diagnostic purposes is supported by high-quality evidence, establishing ideal levels for glucose and insulin is challenging because of differences in insulin levels based on measurement method,85–87 observed racial/ethnic differences in metabolic parameters in healthy children,79,88,89 and the physiological rise in insulin levels during puberty that makes a single cut point unreliable.80,82 Fortunately, puberty-related changes in glucose have not been documented, suggesting that the use of a single cut point for glucose may be reasonable.91

CURRENT STATUS OF CARDIOVASCULAR HEALTH IN US CHILDREN: UNDERSTANDING THE STATE OF CARDIOVASCULAR HEALTH IN ALL US PEDIATRIC AND YOUTH POPULATIONS

Developing strategies toward achieving the AHA Strategic Impact Goal1 in youth populations depends largely on estimating the current prevalence of cardiovascular health behaviors and factors and identifying the target behaviors and factors and the populations in need of improvement. “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond”1 for the 2020 goal baseline, in this document, the current status of cardiovascular health in children and adolescents was estimated from NHANES 2007 to 2008 data. However, additional population-based sources will be presented to gain additional estimates of cardiovascular health prevalence in areas where NHANES data may be limited. NHANES prevalence estimates for the status of cardiovascular health in US children and adolescents according to age, sex, and race/ethnicity are presented in Figure 1.
Smoking

The NHANES 2007 to 2008 survey includes questions about tobacco use for participants ≥12 years of age. Among participants 12 to 19 years of age, approximately one third were categorized as having poor current smoking status (ie, had tried a cigarette in the prior 30 days), with a slightly higher prevalence in boys (34%) than in girls (31%). When tobacco use was examined across major racial/ethnic groups, non-Hispanic black adolescents had the lowest prevalence of poor cardiovascular health status for smoking (26%), and Mexican Americans exhibited the highest prevalence of poor current smoking status (36%).

Body Mass Index

Obesity continues to be a challenging problem among children and adolescents. According to the NHANES 2007 to 2008 estimates, the prevalence of poor BMI (≥95th percentile) is higher across older age groups, ranging from 9% to 11% in 2- to 5-year-olds to 19% to 27% in 12- to 19-year-olds. At younger ages, girls have a higher prevalence of poor BMI status compared with
boys, but at 6 to 19 years of age, boys consistently exhibit a higher prevalence of poor BMI than girls. Younger children (2–5 years of age) also exhibit the highest prevalence of ideal BMI (78%–80%), whereas adolescents (12–19 years of age) exhibit the lowest prevalence of ideal BMI (girls, 52%; boys, 60%). Mexican American and non-Hispanic black children 2 to 5 years of age exhibit a notably greater prevalence of poor BMI than non-Hispanic white children. Mexican American children 6 to 11 years of age exhibit the highest prevalence of poor BMI (24%) compared with non-Hispanic white and non-Hispanic black youth. However, at 12 to 19 years of age, non-Hispanic black youth exhibit similar levels of poor BMI status compared with Mexican American youth (≥30%). Non-Hispanic black adolescents 12 to 19 years of age exhibit the lowest prevalence of ideal BMI (42%) compared with Mexican American (52%) and non-Hispanic white (56%) adolescents.

Physical Activity
The prevalence of compliance with the current physical activity guideline (≥60 minutes of moderate- to vigorous-intensity aerobic physical activity a day) was assessed via accelerometry in the 2003 to 2004 cycle of NHANES. Among children 6 to 11 years of age, 48.9% of boys and 34.7% of girls met the physical activity guideline. The prevalence of compliance was much lower among 12- to 15-year-olds in that only 11.9% of boys and 3.4% of girls met the guideline, and among 16- to 19-year-olds, only 10.0% of boys and 5.4% of girls met the guideline. In an examination of the prevalence of meeting the physical activity guideline in selected race/ethnicity groups, among 6- to 11-year-olds, compliance with the guideline was highest among non-Hispanic black children (50.4%) compared with non-Hispanic white (39.9%) and Mexican American (41.3%) children. Among 12- to 15-year-olds and 16- to 19-year-olds, compliance with the guideline was much lower than among 6- to 11-year-olds for each of the racial/ethnic groups and was not markedly different across racial/ethnic groups. The NHANES protocol also included child self-report of physical activity, which produced higher prevalence estimates of compliance with the physical activity guidelines compared with accelerometry. For example, self-reported data from 2007 to 2008 NHANES for adolescents 12 to 19 years of age showed that approximately two thirds of boys but only 50% of girls report ideal levels of physical activity, whereas 13% of boys and 21% of girls report poor levels of physical activity (ie, report no physical activity over the past 30 days).

Healthy Diet
The 2010 US Dietary Guidelines Advisory Committee reviewed the most recent NHANES data in determining mean dietary intake across all age groups. For children 2 to 18 years of age, the highest sources of energy intake (kcal/day) are simple carbohydrates (grain-based desserts, sugar-sweetened beverages). The impact of a diet based on these energy-dense, nutrient-poor foods is further heightened by inadequate intakes of vegetables, whole grains, and fiber. The components of the Healthy Diet Score and adherence to dietary recommendations in children are illustrated in Figure 2. Prevalence estimates for children and adolescents who meet the ideal levels of the Healthy Diet Score are the lowest of all cardiovascular health metrics. On the basis of 2007 to 2008 NHANES data, <1% of 2- to 19-year-olds report dietary intakes consistent with meeting 4 or 5 components of the Healthy Diet Score. At 5 to 11 years of age, the majority of children (boys, 86%; girls, 83%) met either 0 or 1 Healthy Diet Score component (ie, exhibited a poor Healthy Diet Score); these estimates were consistent with estimates in the 12- to 19-year age range. At 5 to 19 years of age, Mexican Americans were the least likely to have a poor diet score (79%–85%), whereas non-Hispanic white boys were most likely (88%–89%).

Total Cholesterol
In NHANES 2007 to 2008 children 6 to 11 years of age, more than one third have total cholesterol levels that are not ideal. Specifically, 27% of girls and 28% of boys 6 to 11 years of age exhibit intermediate status for total cholesterol, and 10% to 11% exhibit poor status. Prevalence is similar for adolescents 12 to 19 years of age, with 65% of girls and 73% of boys categorized as ideal and 26% to 35% of adolescents categorized as intermediate or poor for levels of total cholesterol. Across racial/ethnic groups, the prevalence of ideal total cholesterol was similar (63%–65%); Mexican American children exhibited the highest prevalence of ideal and non-Hispanic whites had the lowest prevalence of ideal total cholesterol. At 12 to 19 years of age, non-Hispanic adolescents exhibited the lowest prevalence of poor total cholesterol (7%) compared with Mexican Americans (9%) and non-Hispanic blacks (10%).

Blood Pressure
The prevalence of ideal BP for children and adolescents is the highest of all cardiovascular health metrics. Approximately 93% of boys and 90% of girls 8 to 11 years of age and 91% of boys and 88% of girls 12 to 19 years of age exhibit ideal BP. Differences in the prevalence of intermediate and poor status for BP are most notable when examined across racial/ethnic groups. Among children 8 to 11 years of age, the prevalence of poor BP is consistently <4% across non-Hispanic white, non-Hispanic black, and Mexican American youth. At 12 to 19 years of age, 6% of non-Hispanic white adoles-
Cardiovascular Health Promotion in Children

Fasting Blood Glucose

At 12 to 19 years of age, the prevalence of ideal fasting blood glucose is notably higher in girls (80%) than boys (63%), and between 20% and 38% of children exhibit intermediate or poor fasting plasma glucose. Mexican Americans exhibit the lowest prevalence of ideal fasting blood glucose (58%) compared with non-Hispanic whites (73%) and non-Hispanic blacks (79%) at the same age. Because a very small number of NHANES 2007 to 2008 participants 12–19 years of age were noted to have poor status for fasting blood glucose levels (n=5), the accuracy of the prevalence estimates from this sample is limited, and it is likely that many were not fasting. Another data source with specific prevalence estimates for type 2 diabetes mellitus (which is consistent with the AHA definition of poor fasting plasma glucose) is the SEARCH for Diabetes in Youth study. SEARCH is an observational, multicenter study focusing on physician-diagnosed diabetes mellitus in individuals <20 years of age. It provides estimates of the population prevalence of diabetes mellitus by type, age, sex, and ethnicity in a nationally representative sample of US children with wide ethnic and socioeconomic representation from 4 geographically defined populations and 2 national health plans. In 2009, the SEARCH estimate\(^94\) of the prevalence of type 2 diabetes mellitus among adolescents 10 through 19 years of age was 0.046%, with lower rates in boys (0.038%) than girls (0.058%). The highest prevalence of type 2 diabetes mellitus in children 10 to 19 years of age was observed in American Indians (0.120%), followed by black (0.106%), Hispanic (0.079%), and Asian/Pacific-Islander (0.034%) youth, and the lowest prevalence was seen in non-Hispanic white youth (0.017%). Children 10 to 14 years of age exhibited lower prevalence (0.023%) compared with those 15 to 19 years of age (0.068%). These estimates more precisely represent the prevalence of type 2 diabetes mellitus in youth. Estimates from the population-based surveillance study should be used in conjunction with estimates from the NHANES data to monitor changes in the prevalence of type 2 diabetes mellitus (eg, poor

Figure 2. Components of the Healthy Diet Score and adherence to dietary recommendations by age, sex, and race.

The Healthy Diet Score is based on adherence to the following dietary recommendations: fruits and vegetables, ≥4.5 cups per day; fish, 2 or more 3.5-oz servings per week; sodium, ≤1500 mg/d; sugar-sweetened beverages, ≤450 kcal (36 oz) per week; and whole grains, ≥3 servings a day scaled to a 2000-kcal/d diet.
status in levels of fasting blood glucose) in children <20 years of age.

**HOW TO IMPROVE INTERMEDIATE AND POOR CARDIOVASCULAR HEALTH**

Engaging in ideal health behaviors early in life can have a beneficial impact on all of the health factors. The maintenance of ideal health from birth throughout the life course is the prime goal. However, many children born healthy will, unfortunately, develop unhealthy behavioral patterns early in life. The life-course approach is an important tenet of the concept of ideal cardiovascular health. That is, a premium should be placed on assisting children to maintain the standards of ideal cardiovascular health early in life (primordial prevention) instead of taking a “wait and see” approach by addressing or treating health and risk factors later in adulthood when they have become entrenched. Although the level of intensity required to improve cardiovascular health classification (from poor to intermediate and from intermediate to ideal) may differ, the core principles and approaches are the same.

**Healthy Diet**

The eating pattern recommended to achieve nutrient adequacy while reducing sources of solid fats, added sugars, and non–nutrient-dense foods is the DASH (Dietary Approaches to Stop Hypertension) diet. The DASH diet is a plant-focused diet rich in fruits, vegetables, and nuts that includes low-fat and nonfat dairy products, lean meats, fish, poultry, mostly whole grains, and heart-healthy fats. It is ideal for growing children. This eating pattern was incorporated into the Cardiovascular Health Integrated Lifestyle Diet (CHILD 1) diet recommended by the 2011 Expert Panel on Integrated Guidelines.95,96 Rather than targeting nutrient-specific goals, this approach recommends servings of foods that meet nutrient needs.

Strengths of the CHILD 1 diet are the inclusion of evidence-based recommendations beginning at birth through 18 years of age that are consistent with US Dietary Guidelines and the DASH-type diet recommended for adults, as well as an emphasis on the benefits of breastfeeding and delayed introduction of solid foods. The CHILD 1 diet provides nutritious, preventive, energy-balanced guidelines appropriate for children, adults, and families.

Research is needed to address the influence of environmental, behavioral, and cultural factors that can enhance or detract from the adoption of the recommended guidelines and to develop methods for pediatric providers to best assess and address these factors within a busy clinical setting. Limited research has been initiated to test and evaluate possible approaches.97

To help children develop healthy eating habits, they should be introduced early and often to a wide variety of fruits, vegetables, fish, and whole grains. This requires help from parents and caregivers who need to recognize the advantages of role modeling. Our immediate goal should be to educate parents and children about the advantages of a diet that includes 2 to 3 age-appropriate servings of healthy diet components at each meal with a goal of achieving the following by 18 years of age: ≥4.5 cups of fruits and vegetables per day, 2 or more 3.5-oz servings of fish per week, 3 or more 1-oz servings of fiber-rich whole grains per day, <1500 mg sodium per day, and ≤450 kcal of sugar-sweetened beverages per week,1 as illustrated in the age-specific CHILD 1 diet.95 Parents are important change agents in achieving these goals and in contributing to halting and reversing adolescent obesity. There is consistent and growing evidence that the DASH-style eating pattern offers many advantages in providing nutrient quality and risk-reduction potential in growing children despite continuing questions about the role of specific nutrients or foods that may have the most effective impact long term.98

Healthcare providers can use motivational interviewing principles by asking parents what foods their children most enjoy. The healthcare providers can then help parents choose reasonable goals and approaches that the parents would be willing to initiate to improve their child's diet. A practical first step for many children is to include at least 1 more serving of a favorite fruit or vegetable or a fiber-rich whole-grain food on a daily basis. Gradual reduction of high-sodium foods and sugar-sweetened beverages is encouraged without a focus on immediate elimination of unhealthy foods. Creative approaches to food preparation (eg, finger-sized cut-up fruits served on colorful plates or in different shapes or made into faces or animals, fruit salsa served with whole-grain crackers, vegetable-laced pastas, pizza, lasagna) and encouraging the child to participate with the parent in food preparation and vegetable gardening and harvesting can enhance adherence to good dietary practices and habits. Similarly, preparing and serving mixed dishes that contain mild-flavored fish (eg, fish sticks or in a soft taco with salsa) increases the attraction while enhancing nutrient quality and energy balance (unless fried) and expanding nutritious meal options.

The documented association between sugar-sweetened beverages and childhood obesity has now been established.99,100 The “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” healthy diet advocates consumption of ≤450 kcal of sugar-sweetened beverages per week1 or no more than 70 kcal daily. (This is about half a 12-oz soda
a day.) The American Academy of Pediatrics and the CHILD 1 Diet recommend avoidance of all sugar-sweetened beverages. Although zero consumption is ideal, this may require gradual reduction, depending on the age of the child. In the youngest children, beverages should include primarily water and low-fat milk (except in the case of infants who are recommended to consume only breast milk in the first 6 months of life or formula if breast milk is not an option). If consumed at all, sugar-sweetened beverages should be reserved only for special occasions and consumed in small amounts.

Physical Activity

A large majority of children in the United States do not meet recommendations for physical activity, and their time spent in sedentary activities is higher than recommended.101,102 The Physical Activity Guidelines for Americans Midcourse Report: Strategies to Increase Physical Activity Among Youth summarized the evidence on the effectiveness of interventions to increase physical activity and youth.103 Interventions were categorized by settings: school, preschool and childcare center, community, family and home, and primary care. An expert panel conducted a literature review using a review-of-reviews approach.

A major conclusion of the report was that the strongest evidence of effectiveness is for school-based intervention strategies.103 Within the school setting, solid evidence exists to recommend multicomponent school interventions. Multicomponent school interventions typically include strategies such as enhanced physical education classes, classroom activity breaks, activity sessions before and after school, and active transportation to and from school. In addition, interventions that focused specifically and singly on enhanced physical education classes were found to be effective in increasing physical activity levels of youth. Several other school-based strategies were considered, but supportive evidence was either less robust or lacking. Some evidence supports strategies based on promotion of active transport to school and classroom exercise breaks. Evidence was insufficient for afterschool programs and physical environmental changes at the school site. The review of physical environmental interventions included consideration of modifications to children’s play spaces. Interventions in preschools and childcare settings have produced some positive results, and the same is true for community-based enhancements of the built environment.

At the present time, there is insufficient evidence to support home/family-based interventions and strategies implemented through healthcare settings. The report included a strong endorsement for more research on physical activity interventions to increase physical activity in youth, particularly in settings outside the school environment.

Smoking

Smoking is a clear and still present danger to the cardiovascular health of America’s children. Although tobacco use has declined,48,104,105 many youth are exposed to secondhand smoke or are primary tobacco or e-cigarette smokers.48,51,106 It is a risk factor that is eminently modifiable with a variety of techniques, including behavioral interventions, pharmacological interventions, and policy tools. A major goal for health professionals is to encourage smoking cessation in primary users, to reduce secondhand exposure, and to prevent smoking initiation. This could help those considered in the poor range of cardiovascular health metrics for smoking to move toward the ideal cardiovascular health metric for smoking.

A wealth of behavioral modification tools have been developed and have shown varying degrees of effectiveness.107,108 Behavioral change depends on the motivation of the smoker; therefore, interventions generally use a cognitive behavioral approach. Interventions include counseling, motivational enhancement, and, more recently, text message- or Internet-based messaging, as well as pharmacological approaches such as the use of bupropion or nicotine replacement therapies.109–113 In a recent meta-analysis, state-of-change interventions and motivational enhancement interventions were associated with a roughly 50% to 60% improvement in smoking cessation rates.108 The few studies available for review found that pharmacological interventions were not effective in smoking cessation for youth.

Secondhand smoking exposure renders multiple individuals vulnerable, including passersby, coworkers, spouses, and children (after birth and in utero). Educa
tion efforts to prevent smoking and intervention efforts to achieve nonexposure in children and adolescents have included messaging to pregnant women about the health risks to their unborn child. It is important to note that 40% of children worldwide are exposed to smoke.114 A recent study on the effectiveness of parent-directed interventions to protect children from secondhand smoke revealed that parent-reported outcomes improved by only 12% for individual smokers and 7% for intervention families, with some evidence for publication bias.115 However, modest effects over a broad base can add up to substantial change.

Broad-based effects can be achieved through assiduously implemented individual therapies or group- or population-based interventions. Population interventions are generally disincentives, including prohibition on smoking in public places or private locations likely to offer high exposure, taxes on cigarette purchases, and health insurance penalties. Policy-based incentive approaches are less common but include cessation-
treatment subsidies and inducements.\textsuperscript{116,117} The zenith of broad-based interventions is the prevention campaign. School-based prevention is modestly effective, reducing smoking initiation by $\approx 12\%$.\textsuperscript{118} Mass media messaging campaigns are popular, low-intensity avenues of intervention, but formal investigations into their effectiveness are warranted. The myriad health effects associated with smoking may call for the implementation of the World Health Organization’s Framework Convention on Tobacco Control mPOWER initiative in communities across America.\textsuperscript{119}

The 2012 “Preventing Tobacco Use Among Youth and Young Adults” report of the Surgeon General (http://www.surgeongeneral.gov/library/reports/preventing-youth-tobacco-use/factsheet.html)\textsuperscript{120} summarizes the continued need to address this important issue because for every death of an adult caused by smoking there are 2 new replacement smokers <26 years of age. Evidence on the urgency of addressing youth in this cardiovascular health promotion initiative is compelling: 9 of 10 smokers start by 18 years of age, with rare smokers starting after 26 years of age.

**HOW TO ACHIEVE IDEAL CARDIOVASCULAR HEALTH: FUTURE DIRECTIONS**

Historically, avoidance of excessive risk has been the basis for improvement of cardiovascular health. The lack of cardiovascular disease outcomes in childhood makes it difficult to rely on dichotomized levels of cardiovascular risk metrics and underscores the importance of addressing these metrics as a continuum of poor-intermediate-ideal levels. Future research needs to address whether current recommended cutoffs of ideal health metrics are appropriate.

In addition to the clear need for prevention strategies for outcomes with long lag times, continuing efforts are needed with respect to improved surveillance and public policy. There is a paucity of valid, large-scale, longitudinal assessments of cardiovascular health factors and behaviors. The benefits of surveillance are 2-fold: Data can assess the effects of interventions and can assist in predicting future health risks and health-related budgets. Rollout of tools and surveys to assess ideal cardiovascular health is urgently needed and should focus on continuous measurements as opposed to measuring only abnormal cardiovascular risk factors. Additionally, there is limited information in the literature on short-term improvements in cardiovascular health metrics in children as a result of lifestyle changes.

Although the application of primary and secondary prevention strategies has clearly played a role in the observed reduction, more attention to the retention of cardiovascular health metrics from childhood through the course of life is a rational strategy to pursue.\textsuperscript{121} Data are needed to translate that rational strategy to proven interventions. Core data needed to promote ideal cardiovascular health in children include differentiating between physiological maturation and pathological aberration, disentangling intertwined cardiovascular risk behaviors and factors, and quantifying effects across the long latency between childhood risk factor and adult outcome events.

**IMPROVED CARDIOVASCULAR HEALTH SURVEILLANCE IS NEEDED IN US CHILDREN AND ADOLESCENTS**

The AHA Strategic Impact Goal targets improving the cardiovascular health of all Americans, including individuals of all ages and races/ethnicities. However, the major data source for health surveillance of Americans (ie, NHANES) is limited with regard to the age ranges of children surveyed. Although BMI is assessed in NHANES participants as young as 2 years of age, no assessments are available that allow categorization of cardiovascular health status in children <12 years of age for smoking or fasting blood glucose.\textsuperscript{122} NHANES data are also limited in that surveillance of dietary intake is available for children <5 years of age but no surveillance of total cholesterol is available for children <6 years of age and no surveillance of BP is available for children <8 years of age. Because of the small numbers of individuals sampled across various racial/ethnic groups, NHANES data are also limited in providing prevalence estimates for the status of cardiovascular health in Asians/Pacific Islanders, American Indians, Alaskan Natives, and other Hispanic individuals besides Mexican Americans. More detailed surveillance of the majority of cardiovascular health components in all early childhood populations is needed, particularly across a wider range of race/ethnicities, to assess the effectiveness of current and future population-based strategies aimed at improving the cardiovascular health among children of all ages.

One potential opportunity to improve on current surveillance methods is to take advantage of “big data” and analytics to track trends in various health factors and health behaviors. In regard to health factors, data from the electronic health record could be used to complement data generated from ongoing studies such as NHANES to further refine surveillance. In addition, patient-generated data, including data obtained from wearable technologies such as accelerometers, could be prospectively collected and examined in the context of epidemiological studies of cardiovascular health. A recent scientific statement on mobile health illustrated a dearth of research validating wearable technology, although a large proportion of the adult population is already using it.\textsuperscript{123} Harnessing the power of big data...
and patient-generated data will address some of the limitations of existing cohort studies and form the basis for refining many of the ideal health factors and behaviors. Big data can also be harnessed to assist with problems inherent in existing data sets such as the lack of childhood cohort data with sufficient events for analyses. The personal and public health perspective on ideal health should include assessment beginning at birth and consideration for genomic basis for cardiovascular health.

CONCLUSIONS

In this document, we identified important strengths and limitations with the current approach to ideal cardiovascular health in children and adolescents. Although the overall concept is a very important one, the choice of health metrics and the development of the poor, intermediate, and ideal categories are limited by currently available national survey data. A new process by which cardiovascular health factors are identified independently of available data, with that process then driving decisions for NHANES and other population-based studies, would be an improvement. Optimally, availability of longitudinal data on these factors would allow evaluation of the process of loss of ideal cardiovascular health and connect that loss with later adverse cardiovascular health outcomes.

Overall, it is clear that much of the benefit of ideal cardiovascular health factors is lost in childhood and adolescence. This is due in large part to the adoption of unhealthful diet and physical activity behaviors. Assessment of best practices to maintain ideal cardiovascular health behaviors and factors is beyond the scope of this statement. Subsequent analyses should address the evidence base for counseling and other behavior change methods for young individuals and their families to maintain ideal cardiovascular health in practice.

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FOOTNOTES

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

This statement was approved by the American Heart Association Science Advisory and Coordinating Committee on January 15, 2016, and the American Heart Association Executive Committee on February 23, 2016. A copy of the document is available at http://professional.heart.org/statements by using either “Search for Guidelines & Statements” or the “Browse by Topic” area. To purchase additional reprints, call 843-216-2533 or e-mail kelle.ramsay@wolterskluwer.com.


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Cardiovascular Health Promotion in Children

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On behalf of the American Heart Association Atherosclerosis, Hypertension, and Obesity in the Young Committee of the Council on Cardiovascular Disease in the Young; Council on Cardiovascular and Stroke Nursing; Council on Epidemiology and Prevention; Council on Functional Genomics and Translational Biology; and Stroke Council

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