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Food Insecurity and Cardiovascular Risk Factors in U.S. Adolescents

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Introduction

Food insecurity is a prevalent public health problem in the US. Despite the nation's economic wealth, nearly 19.2% of, or 7.5 million, US households with children aged 0 to 17 years were food insecure in 2014.[1] Food insecurity is defined as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" and describes the range of experiences from anxiety over food shortage in the household to reduced food intake by 1 or more members of the household.[2] Although children and adolescents are generally shielded from more pronounced characteristics of food insecurity within a household, children themselves experienced food insecurity in about 10.0% of households, and children went hungry, skipped meals, or did not eat for a whole day in 1.0% of households with children.[3]

Food insecurity in children and adolescents has been associated with detrimental nutritional, developmental, and health outcomes, including iron deficiency anemia,[4] lower bone mineral content,[5] developmental and mental health problems,[6,7] behavioral problems,[8] and lower academic achievement.[9] A number of studies have also established associations between food insecurity and chronic conditions, including heart conditions, cerebral palsy, epilepsy, kidney disease, asthma, bronchitis, allergies,[10] and higher rates of overweight and obesity in children.[11,12] While socially unacceptable, food insecurity is likely to inflict long-term preventable health effects on impacted children.

Atherosclerotic cardiovascular diseases are a leading cause of death in the US. Pathophysiologic pathways underlying cardiovascular diseases are known to start in childhood. Evidence from large benchmark studies, such as the Bogalusa Heart Study and the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) Study, demonstrate the association between exposure to cardiovascular risk factors, including abnormal blood lipids, blood pressure, blood glucose, body mass index, and tobacco use, and the development of subclinical atherosclerosis, a silently progressing chronic inflammatory disease in which blood vessels are infiltrated by lipids and white blood cells, in childhood and adolescence.[13-16] Furthermore, longitudinal studies show that risk factors existing early in life are linked to adult atherosclerosis; in fact, risk factors measured early in life are better predictors of atherosclerosis severity

in adulthood than risk factors measured at the time of subclinical atherosclerosis diagnosis in adulthood.[17] Thus, interventions to address cardiovascular risk factors early in life have been identified as essential to preventing cardiovascular diseases in adulthood.[18,19]

Evidence demonstrates that children and adolescents of lower socioeconomic status (SES) are at increased cardiovascular risk. This is particularly true considering the prevalence of overweight and obesity in this population.[20,21] In young Finnish adults, SES was inversely associated with BMI, waist circumference, glucose and insulin concentrations, alcohol consumption, and cigarette smoking and showed a greater increase in carotid intima-media thickness (IMT), a subclinical marker of atherosclerosis, in comparison to those of higher SES.[22] In rural South India, low SES among adolescents aged 13 to 18 years was associated with greater central adiposity and higher blood triglyceride levels.[23] In US adolescents, increased SES was associated with a decreased level of overweight.[21] However, improvement in SES by itself may not protect from increased risk of overweight in all groups of adolescents but depend on other contextual factors that need to be studied.[21] Previous study findings stemmed predominantly from international studies, did not consistently include adolescents, or did not comprehensively assess various factors involved in cardiovascular risk in relation to SES.

In adults and older adults, strong relationships among low SES, food insecurity, and cardiovascular diseases have been documented.[24-29] This is particularly true for diet-related cardiovascular diseases, including diabetes, hypertension, and hyperlipidemia, which constitute metabolic syndrome and promote atherosclerosis, thus increasing the risk for cardiovascular events and mortality. Food insecurity in adults has been associated with an increased prevalence of cardiovascular risk as measured by the Framingham score.[30] In addition, the term "food insecurity-obesity paradox" has been coined due to the association between food insecurity and overweight/obesity, a risk factor for cardiovascular disease, in adults. Seligman and Schillinger proposed a conceptual framework explaining the relationship between food insecurity and chronic disease by compensatory cycles of overconsumption of low-cost, low-quality foods high in refined grains, added sugars, fats, and sodium when resources are available and reduced caloric intake when resources become scarce. These likely lead to changes in weight and blood glucose levels, which either contribute to or exacerbate the management of existing chronic conditions.[28] This in turn increases the demand for medical care and forces individuals into

trade-off decisions among basic needs, including food and medications, as the vicious cycle continues.[31-33] Therefore, the relationships between food insecurity, food quality, consumption patterns, and trade-off decisions may partially explain the complex pathways underlying the relationship between SES and biomedical, behavioral, and psychosocial factors involved in cardiovascular risk in adults.

Little is known about the unique exposure of food-insecure adolescents to cardiovascular risk factors. To our knowledge, only one previous study examined the relationship between food security and metabolic syndrome in US adults and adolescents using data from the National Health and Nutrition Examination Surveys (1999-2006).[34] While the study found adults with marginal and very low food security in comparison to food-secure counterparts to have increased odds of metabolic syndrome after controlling for potential confounders, the study did not find similar results in adolescents. Since cardiovascular risk factors have been shown to progress from childhood to adulthood, enhancing our understanding of potential deleterious effects of the exposure to food insecurity on cardiovascular risk factors among adolescents is essential in order to formulate effective prevention interventions aimed at reducing the future burden of cardiovascular disease. Therefore, the primary objective of this study was to examine the relationship between food insecurity and cardiovascular risk factors in US adolescents by using the American Heart Association's Life's Simple 7 (LS7) criteria for cardiovascular risk.

Methods

Data and Sample

Pooled data from the National Health and Nutrition Examination Survey (NHANES; 2007-2008, 2009-2010, and 2011-2012) were used in this study. NHANES, a nationally representative, cross-sectional survey, was originally designed to monitor the health and nutritional status of the US civilian noninstitutionalized population; the NHANES sample was selected using a complex, stratified, multistage probability cluster sampling design. A detailed description of NHANES has been published elsewhere.[35] Briefly, data from survey participants were collected in 2 phases. First, an in-home interview was conducted to collect information on self-reported demographic, socioeconomic, and health status of the participants. Second, personal interviews and clinical examinations were completed at mobile examination centers (MECs). Dietary data were collected via an in-person, 24-hour dietary recall at the MECs. NHANES 2007-2012 consisted of 2,944 adolescents aged 12 to 17 years. The sample was

restricted to adolescents aged 12 to 17 years with complete data on all variables of interest (n = 1,853; mean age 14.4±1.6 years, 52.3% male, 59.9% white). Compared to the excluded adolescents, included adolescents were more likely to live in households in which the reference person had college education (30.2% vs. 22.1%; p = 0.0003), was more likely to be non-Hispanic white (61.2% vs. 52.5%), and was less likely to be non-Hispanic black (12.8% vs. 18.4%) or of "other" race/ethnicity (26.1% vs. 29.2%; p = 0.0001). Except for Body Mass Index (BMI), included adolescents were more likely to attain ideal levels of all LS7 components than the excluded adolescents.

Measures

Cardiovascular risk. Cardiovascular risk was assessed using the LS7 health metric defined by the American Heart Association (AHA; see Table 1).[36] The LS7 metric is comprised of 7 cardiovascular risk factors, including blood glucose, total cholesterol, blood pressure, healthy diet, BMI, smoking, and physical activity, with each component being categorized in 3 levels as poor, intermediate, or ideal. The LS7 components were derived according to AHA definitions and adapted for adolescents where needed. In order to retain a larger sample, we expanded on the LS7 method to identify impaired glucose tolerance by using information not only on fasting plasma glucose levels but also measurements of glycosylated hemoglobin A1c (HbA1c) and 2-hour plasma glucose levels following an oral glucose tolerance test (OGTT; see Table 1). This is in line with current standards for the diagnosis of diabetes.[37] Blood pressure in children and adolescents was derived using systolic and diastolic blood pressure percentiles depending on gender, age, and height, in accordance with standards by the National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents.[38]

Body weight and height were measured using standardized methods during the physical examination, and BMI age- and sex-specific percentiles were calculated using the Centers for Disease Control and Prevention (CDC) growth charts. To obtain a measure of healthy eating, we used the 2010 Healthy Eating Index (HEI-2010), a measure of diet quality that assesses conformance to the 2010 Dietary Guidelines for Americans.[39] We used the HEI-2010 instead of AHA's healthy diet score because HEI-2010 scores are more widely accepted and used. In addition, NHANES data lacked sufficient detail on sugar-sweetened beverage and fish consumption needed for the AHA healthy diet score. Tobacco smoke exposure was assessed using an objective, biomarker-

based measure of smoking exposure (serum cotinine levels). This measure has the benefit of explaining firsthand as well as secondhand tobacco smoke exposure.[40]

For the purposes of this study, we derived a dichotomous measure comparing adolescents with ideal vs. non-ideal (poor or intermediate) levels of each component. For each adolescent, we also calculated the total number of ideal LS7 components. The total number of ideal LS7 components ranged from 0 to 7 and was dichotomized as 0-4 and 5-7, with higher numbers suggesting lower cardiovascular risk.

Table 1. Measurement of the AHA Life's Simple 7 Components

Variable	Life's Simple 7: Ideal Level
Blood glucose	HbA1c <5.7% or 2-hour blood glucose (OGTT) <140 mg/dl or fasting glucose <100 without diabetes medication
Total cholesterol	Serum total cholesterol <200 mg/dl, without lipid lowering medication
Blood pressure	Systolic BP <90th percentile or diastolic BP <90th percentile or systolic BP <120 or diastolic BP <80
Body mass index	BMI < 85th percentile
Healthy diet	Healthy Eating Index score ≥ 50
Smoking	Serum cotinine < 1 ng/ml
Physical activity	Minutes of vigorous or moderate intensity activity per day ≥ 60

Food security status. The 18–item US Department of Agriculture Household Food Security Survey Module (HFSSM) was used to screen households with children for food insecurity within the past 12 months.[41] Eight of the 10 items are specifically designed to detect food insecurity in

children and adolescents within a household. Food insecurity in adolescents was defined as affirmative response to at least 2 of the 8 child-specific items on the HFSSM. Based on affirmative responses to these questions, respondents were classified into one of the following categories: full food security (score of 0), marginal food security (score of 1), low food security (score of 2 to 4), and very low food security (score of 5 to 8). Food insecurity was defined as low or very low food security in children at the household level.

Other variables. Demographic, socioeconomic, health, and health care access factors found to be significantly associated with cardiovascular risk in previous research were included in the analysis. These factors included age (continuous); gender (male/female); marital status of the household reference person (married vs. single/divorced or separated/widowed); education of reference person (less than high school, high school, some college, college); poverty-to-income ratio (<100%, 100-200%, ≥200% of the Federal Poverty Level [FPL]); health insurance coverage (yes/no); self-perceived health (excellent, very good, good, fair/ poor); and having a usual source of health care (yes/ no).

Statistical Analysis

Bivariate and multivariate analyses were used to examine the association between food insecurity and ideal scores on LS7 components among adolescents aged 12 to 17 years. Chi-square tests were conducted to examine the association between food insecurity and ideal scores on each LS7 component and ideal scores on 5 to 7 LS7 components. Seven logistic regression models were used to estimate odds ratios (OR) and 95% confidence intervals (CI) for associations between food insecurity and the likelihood of attaining ideal scores on each LS7 component. A logistic regression model was also used to examine the association between food insecurity and likelihood of attaining ideal scores on 5 to 7 LS7 components. All multivariate models adjusted for age, gender, marital status, and level of education of the household reference person, poverty-to-income ratio, health insurance coverage, self-perceived health, and having usual source of health care.

The NHANES is a complex design survey. All analyses and estimates were weighted and adjusted for the complex sample design using the NHANES examination sample weights to account for differential probabilities of selection into the sample and nonresponse. The sample weights were also adjusted for pooling of 3 survey waves of NHANES. Standard errors were computed using Taylor series

linearization. All data analysis was conducted by using the STATA software.[42]

Results

Characteristics of the study population are presented in Table 2. Weighted estimates of percentages or means and their standard errors are presented. The mean age of the sample was 14.5 years, and 51.9% were males. Nearly 10% of the adolescents were food insecure sometime during the 12-month period prior to the interview, and 20% of the adolescents lived in households with incomes below the FPL. One in 10 (10.7%) did not have health insurance coverage. A total of 26.1% of adolescents failed to attain ideal scores on only 5 to 7 LS7 components. While the majority of the sample attained ideal levels on biological components of LS7 (i.e., blood glucose, total cholesterol, blood pressure), only about two-thirds of the sample (65.1%) attained ideal levels on BMI, and less than one-third attained ideal levels on healthy eating (30.5%).

Bivariate tests of the association between food security status and attainment of ideal scores on 5 to 7 LS7 components as well as sociodemographic and economic variables are presented in Table 2. Food-secure adolescents were more likely to have ideal scores on 5 to 7 LS7 components compared to food-insecure adolescents (75.1% vs. 63.0%, $p = 0.0089$). Food-secure adolescents were more likely to be non-Hispanic white, to be married, to have college education, to have annual household incomes above 200% of the FPL, and to report excellent health. Other factors, including race/ ethnicity, marital status, and level of education of the reference person, household poverty level, and self-perceived health were also significantly associated with the likelihood of attaining ideal scores on 5 to 7 LS7 components. Non-Hispanic whites and adolescents living in higher SES households were more likely to attain ideal scores on 5 to 7 LS7 components than adolescents from lower SES households (data not shown).

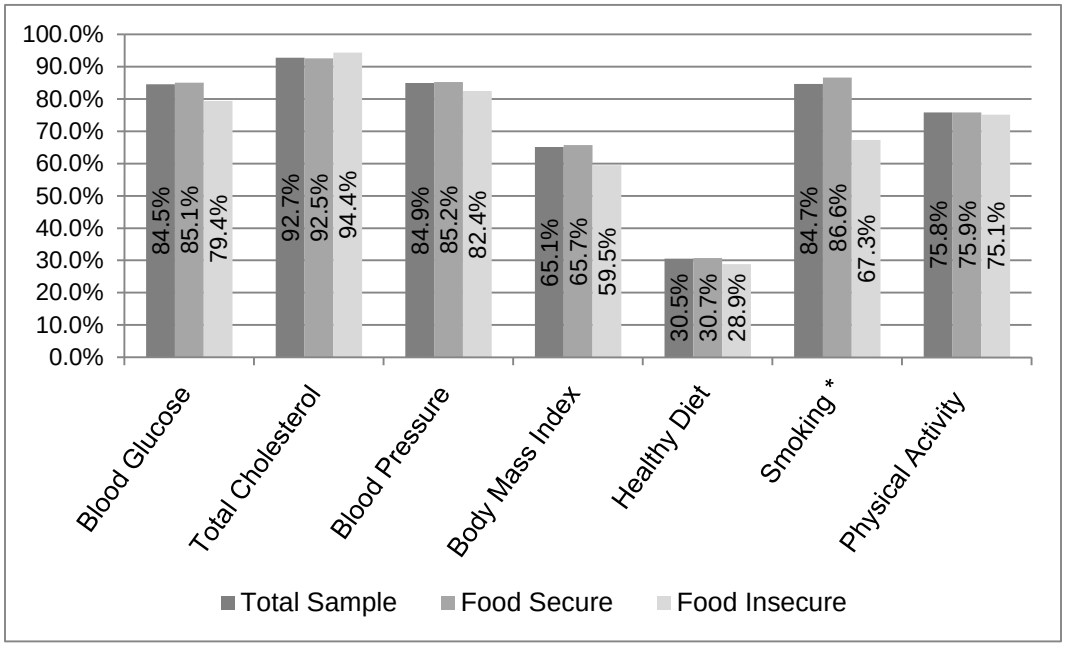
Figure 1 illustrates the bivariate relationship between attainment of ideal scores on each LS7 component by food security status. Food-secure participants were more likely to have ideal scores for tobacco smoke exposure compared with food-insecure participants (86.6% vs. 67.3%, $p<0.001$). There were no significant differences in attainment of ideal scores on other individual LS7 components between food-secure and food-insecure adolescents.

Table 2. Sample Description (NHANES 2007-2012, N = 1,853)

Variables	Total sample	Food secure (n = 250; 10.1%)	Food insecure (n = 1,603; 89.9%)	*p*-values*
	%	%	%	
Number of LS7** components with ideal score				0.0089
0-4	26.13	24.91	36.96	
5-7	73.87	75.09	63.04	
Gender				0.2924
Male	51.87	51.32	56.84	
Female	48.13	48.68	43.16	
Race				0.0035
Non-Hispanic white	61.16	62.71	47.38	
Non-Hispanic black	12.78	12.50	15.32	
Other	26.05	24.79	37.30	
Marital status of reference person				0.0000
Married	72.54	74.62	54.04	
Widowed, divorced, separated, or single	27.46	25.38	45.96	
Education of reference person				0.0000
Less than high school	19.36	17.48	36.15	
High school	19.59	19.22	22.89	
Some college	30.89	30.80	31.68	
College	30.16	32.50	9.28	
Poverty level				0.0000
<100% FPL	19.06	15.90	47.16	
100%–200% FPL	22.87	21.22	37.52	
≥200% FPL	58.07	62.87	15.31	
Health insurance				0.0757
Yes	89.32	89.83	84.81	
No	10.68	10.17	15.19	
Self-perceived health				0.0002
Excellent	40.45	41.63	29.95	
Very good	31.12	31.49	27.88	
Good	24.10	23.24	31.76	
Fair or poor	4.33	3.65	10.41	
Usual source of health care				0.6729
Yes	92.66	93.22	87.69	
No	7.34	6.78	12.31	

**P*-values are based on chi-square tests.
**LS7 = Life's Simple 7.

Figure 1. Percentage of Ideal AHA Life's Simple 7 Scores by Food Security Status



*Significantly associated with food insecurity status based on chi-square tests; $p \leq 0.05$.

Multivariate logistic regression models, adjusted for age, gender, race/ethnicity, marital status, level of education of household reference person, poverty level, health insurance coverage, self-perceived health status, and having usual source of health care, showed that food security status was not significantly associated with the likelihood of attaining ideal scores on 5 to 7 LS7 components (see Table 3A). However, food-insecure adolescents had lower odds of attaining ideal scores for tobacco smoke exposure than food-secure adolescents ([OR] = 0.32, 95% CI [0.20, 0.51]). In addition, adolescents with ideal scores on smoking exposure were also likely to have an ideal score on healthy eating ([OR] = 1.78, 95% CI [1.22, 2.60]).

Several other factors were associated with the likelihood of attaining ideal scores on the individual LS7 components in multivariate logistic regression models (see Tables 3A and 3B). Compared to those from higher SES households, adolescents from lower SES households had lower odds of attaining ideal scores on 5 to 7 LS7 components and to attain ideal scores on tobacco smoke exposure and physical activity. Females, compared to males, had higher odds of attaining ideal scores on blood glucose, blood pressure, and tobacco smoke exposure but lower odds of ideal scores on physical activity. Compared to whites, non-Hispanic blacks had lower odds of attaining ideal scores on blood glucose, blood pressure, and physical activity but were more likely to attain ideal scores on healthy diet and tobacco smoke exposure. Excellent self-perceived health was associated with higher odds of attaining ideal scores on 5 to 7 LS7 components.

Discussion

The primary aim of this study was to understand the relationship between food insecurity and cardiovascular risk factors in adolescents aged 12 to 17 years. In the nationally representative sample of adolescents examined in this study, food insecurity was not significantly associated with cardiovascular risk after accounting for differences in demographic characteristics, socioeconomic status, self-reported health status, and health care access factors. However, food insecurity was significantly associated with one individual risk factor: adolescents were significantly more likely to be exposed to firsthand and/or secondhand tobacco smoke in comparison to their counterparts. In addition, adolescents from households of low SES were found to be at greater cardiovascular risk, particularly due to tobacco exposure and low levels of physical activity.

The findings of this study expand on a study by Parker and colleagues who found no association between food insecurity and metabolic syndrome in US adolescents using data from NHANES (1999-2006).[34] The study was limited in that metabolic syndrome, as defined by the National Cholesterol Education Program Adult Treatment Panel III (ATP III),[43] was used instead of a comprehensive set of cardiovascular risk factors, inclusive of diet, exercise, BMI, and smoking exposure in addition to laboratory values for blood glucose, blood pressure, and blood lipids, as done in the present study. As a consequence, the full extent of cardiovascular risk and associations with individual risk factors were not captured. Our finding of an association between food insecurity and tobacco smoke exposure is consistent with previous research in adults.[44]

The harmful health and economic effects of smoke exposure on adults and children have been well documented.[45-47] These effects may be exacerbated by the experience of food insecurity. Food-insecure children are more likely than food-secure children to live in low-income families who are facing significant resource-constraint challenges. Spending on tobacco by low-income families may divert already limited economic resources needed for essential basic needs, such as nutritious foods or needed health care and medications. At first sight, it seems as if food-insecure families make especially poor lifestyle choices when faced with trade-off decisions among basic needs. However, the direction of the relationship between food insecurity and tobacco smoking is not clear—that is, it is not clear whether diverting resources to tobacco products contributes to food insecurity or if food insecurity leads to an increased prevalence of tobacco smoking through coping mechanisms. It is very plausible that tobacco smoking is a coping mechanism to deal with the circumstances and consequences of food insecurity. First, tobacco smoking may be used as a means of alleviating the stress caused by the psychological, physical, and social dimensions of food insecurity.[8] Second, nicotine exposure via tobacco smoking, which is known to reduce appetite, may be a coping mechanism to counteract reduced quality and quantity of food intake and the potential hunger experienced by food-insecure individuals.[48] Smoking cessation by members of food-insecure households may free resources needed to shift individuals out of food insecurity and improve cardiovascular health directly and indirectly.[47] However, more research is needed to understand the mechanisms behind the observed association between food insecurity and smoke exposure and its cumulative impact on cardiovascular and general health of adolescents. In light of tobacco smoking as a plausible coping

mechanism, it cannot be stressed enough that the source of the problem—a lack of nutritious foods—needs to be targeted to adequately prevent early development of health problems, including cardiovascular diseases.

There are several potential explanations for not finding significant relationships between other cardiovascular risk factors and food insecurity. First, although the diet quality of adolescents was suboptimal compared to recommendations made by the 2010 Dietary Guidelines for Americans, food-secure and food-insecure adolescents may have had comparable access to healthy foods through national food and nutrition assistance programs tailored specifically to low-income children and adolescents and administered at schools, childcare centers, and after-school programs. These include the National School Lunch Program, the School Breakfast Program, the Child and Adult Care Food Program, and the Summer Food Service Program. Nearly 84.0% of low-income households with food insecurity among children participated in one or more federal food and nutrition assistance programs.[1] However, the high prevalence of food insecurity among households with children and adolescents suggests that there is a need to evaluate adequate funding for, and efficacy and outreach of, existing programs and to take measures to improve or expand these programs. For example, the preliminary evaluation of expansion of Summer Food Service Program through Summer Electronic Benefit Transfer to Children (SEBTC) shows that a modest $30 increase in a family's food budget during summer can reduce food insecurity and improve nutrition.[49] Second, the accumulation of negative effects of food insecurity on cardiovascular risk factors may vary depending on the frequency and length of exposure to food insecurity. However, our study was limited to cross-sectional analysis of food insecurity using NHANES data; thus, we were unable to ascertain the longitudinal extent of food insecurity experienced by US adolescents. Third, younger individuals may be more resilient in regards to the health impacts of food insecurity. Longitudinal studies on food insecurity are needed to help clarify the relationship between food insecurity and comprehensive cardiovascular risk factors in adolescents 12 to 17 years of age.

In support of literature on health disparities,[50-52] we found adolescents living in low SES families to be at greater cardiovascular risk through lower overall scores on LS7 as well as lower scores for tobacco exposure and physical activity. In addition, this study found considerable variation in demographic and socioeconomic characteristics in relation to the prevalence of cardiovascular risk factors among adolescents.

Females, compared to males, were more likely to attain ideal levels of blood glucose, blood pressure, and tobacco smoke exposure while they were less likely to attain ideal levels of physical activity. Adolescents in poor households were more likely than those in middle- or high-income households to have increased cardiovascular risk as shown by failure to attain ideal levels on 5 to 7 LS7 components, as well as on 2 behavioral components, i.e., tobacco smoke exposure and physical activity. Such information may facilitate formulation of more tailored and effective primary prevention strategies. Community-based health promotion efforts should be cognizant of unique challenges faced by low-income households in complying with the recommended guidelines for maintaining good cardiovascular health. Moreover, these findings substantiate the relevance of accounting for sociodemographic and economic variations in examining cardiovascular risk factors in adolescents. Finally, the low prevalence of ideal cardiovascular risk levels on behavioral risk factors including healthy eating and BMI is alarming. A suboptimal diet has lasting effects on children's health. Being overweight or obese during childhood and adolescence has been associated with increased adult morbidity and mortality and poses one of the greatest challenges in efforts to reduce the cardiovascular disease burden in the future. Practitioners and policymakers should be innovative in finding effective strategies that emphasize adherence to clinical guidelines for effective prevention of cardiovascular diseases in at-risk adolescents. This may require practitioners to screen for and address underlying social determinants of health and may also necessitate appropriate referral and promotion of nutrition assistance programs as well as community resources in the case of food-insecure patients. Finally, nutrition assistance programs are an indispensable safety net for poor families with children and adolescents, most of whom may be able to move in and out of poverty due to availability of such assistance. Nutrition assistance programs have been shown to successfully improve food insecurity in vulnerable populations.[53] Given the high prevalence of poor health among food-insecure individuals later in life,[27] early intervention should make access to healthy nutrition and nutrition education a priority.

To our knowledge, this is the first study to examine the relationship between food insecurity and cardiovascular risk using a comprehensive and accepted measure of cardiovascular risk, including biological as well as behavioral risk factors, and validated measures of food insecurity and cardiovascular risk in a large nationally representative sample of adolescents aged 12 to 17 years. This study confirms that biological and behavioral cardiovascular risk factors are present during adolescence.

Food-insecure adolescents may be at risk, and adequate interventions and programs specifically tailored toward this vulnerable population may be needed.

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Table 3A: Factors Associated with Attainment of Ideal Scores on AHA Life's Simple 7** Components

Variables	Ideal score on 5-7 LS7 components	Blood glucose	Blood pressure
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Food secure			
No	0.84 (0.55,1.28)	0.89 (0.58,1.36)	0.82 (0.50,1.34)
Reference: Yes			
Age (years)	1.00 (0.91,1.11)	1.13* (1.01,1.26)	0.78* (0.70,0.87)
Gender			
Female	1.14 (0.86,1.51)	1.52* (1.06,2.18)	2.72* (1.64,4.51)
Reference: Male			
Race			
Non-Hispanic black	0.83 (0.61,1.12)	0.59* (0.43,0.81)	0.57* (0.35,0.93)
Other	1.30 (0.89,1.90)	0.69* (0.49, 0.98)	0.90 (0.56,1.44)
Reference: Non-Hispanic white			
Marital status of reference person			
Widowed, divorced, separated, or single	0.99 (0.72,1.36)	1.12 (0.81,1.54)	0.84 (0.57,1.25)
Reference: Married			
Education of reference person			
Less than high school	0.51* (0.31,0.82)	0.90 (0.57,1.40)	0.77 (0.43,1.38)
High school	0.44* (0.25,0.78)	1.13 (0.67,1.91)	0.82 (0.48,1.41)
Some college	0.44 *(0.27,0.72)	0.77 (0.50,1.18)	0.80 (0.45,1.41)
Reference: College			
Poverty level			
< 100% FPL	0.59* (0.40,0.86)	0.67 (0.39,1.14)	1.28 (0.84,1.94)

100% – 200% FPL	0.67* (0.45,0.99)	0.90 (0.56,1.45)	1.30 (0.87,1.94)
Reference: ≥ 200% FPL			
Health insurance coverage			
No	1.10 (0.73,1.65)	1.15 (0.73,1.81)	1.17 (0.66,2.06)
Reference: Yes			
Self-perceived health			
Very good	0.80 (0.56,1.14)	0.86 (0.60,1.24)	1.17 (0.76,1.80)
Good	0.61* (0.43,0.87)	0.87 (0.53,1.43)	1.26 (0.75,2.11)
Fair or poor	0.49* (0.28,0.84)	0.64 (0.37,1.14)	1.37 (0.70,2.68)
Reference: Excellent			
LS7 health components			
Blood glucose	--	--	1.73 (1.07,2.80)
Total cholesterol	--	0.93 (0.54,1.61)	1.05 (0.53,2.06)
Blood pressure	--	1.70* (1.05,2.76)	
Body Mass Index	--	0.89 (0.66,1.21)	2.61* (1.82,3.75)
Healthy diet	--	0.94 (0.65,1.36)	0.97 (0.68,1.36)
Smoking	--	1.19 (0.69, 2.05)	1.17 (0.76,1.78)
Physical activity	--	0.98 (0.71,1.36)	1.05 (0.70,1.59)
Usual source of health care			
No	1.20 (0.72,1.99)	1.28 (0.72,2.26)	0.77 (0.41,1.47)
Reference: Yes			

* p≤ 0.05

**AHA Life's Simple 7= American Heart Association Life's Simple 7

Table 3B. Factors Associated with Attainment of Ideal Scores on AHA Life's Simple 7** Components

Variables	BMI	Healthy Eating Index	Tobacco Smoke Exposure	Physical Activity
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Food secure				
No	1.02 (0.70,1.49)	1.13 (0.77,1.67)	0.54* (0.31,0.94)	1.24 (0.84,1.83)
Reference: Yes				
Age (years)	1.06 (0.96,1.17)	0.97 (0.89,1.06)	0.79* (0.71,0.88)	1.16* (1.06,1.28)
Gender				
Female	1.04 (0.75,1.44)	1.26 (1.00,1.6)	1.67* (1.16,2.39)	0.47* (0.35,0.61)
Reference: Male				
Race				
Non-Hispanic black	0.80 (0.61,1.04)	1.40*(1.01,1.94)	1.84* (1.14,2.96)	0.62* (0.45,0.85)
Other	0.89 (0.64,1.25)	1.46*(1.07,1.99)	6.39* 3.48,11.72)	0.77 (0.58,1.02)
Reference: Non-Hispanic white				
Marital status of reference person				
Widowed, Divorced, Separated, or Single	0.98 (0.74,1.30)	1.90*(1.35,2.66)	0.88 (0.55,1.43)	0.77 (0.55,1.08)
Reference: Married				
Education of reference person				
Less than high school	0.61*(0.39,0.94)	0.60*(0.38,0.96)	0.30* (0.13,0.68)	0.99 (0.61,1.61)
High school	0.59*(0.35,0.99)	0.51*(0.33,0.77)	0.29* (0.15,0.57)	0.95 (0.59,1.53)
Some college	0.53*(0.35,0.81)	0.56*(0.38,0.82)	0.46* (0.27,0.77)	1.15 (0.70,1.91)
Reference: College				
Poverty-income ratio				
< 100%	0.74 (0.51,1.06)	1.23 (0.85,1.78)	0.25* (0.13,0.49)	0.60* (0.38,0.95)

100% – 200%	0.86 (0.59,1.26)	0.87(0.57,1.33)	0.43* (0.23,0.81)	0.71 (0.44,1.14)
Reference: ≥ 200%				
Health insurance coverage				
No	1.14 (0.74,1.76)	1.14 (0.74,1.76)	0.9 (0.51,1.56)	1.40 (1.06,1.86)
Reference: Yes				
Self-perceived health				
Very good	0.83 (0.60,1.16)	1.13 (0.78,1.62)	0.69 (0.41,1.16)	0.80 (0.56,1.14)
Good	0.66*(0.49,0.89)	1.01 (0.67,1.53)	0.60*(0.38,0.96)	0.68 (0.45,1.02)
Fair or poor	0.47*(0.29,0.75)	1.24 (0.77,1.99)	0.32 (0.14,0.72)	0.48* (0.25,0.93)
Reference: Excellent				
LS7 components				
Blood glucose	0.88 (0.64,1.20)	0.94 (0.64,1.37)	1.19 (0.70,2.01)	0.98 (0.71,1.37)
Total cholesterol	1.70*(1.09,2.66)	1.67*(1.04,2.71)	0.83 (0.36,1.94)	1.00 (0.62,1.62)
Blood pressure	2.63*(1.84,3.74)	0.96 (0.69,1.35)	1.14 (0.73,1.78)	1.03 (0.68,1.55)
Body Mass Index	--	0.86 (0.65,1.14)	1.02 (0.72,1.44)	1.23 (0.90,1.69)
Healthy diet	0.87 (0.65,1.15)	--	1.76* (1.21,2.57)	1.21 (0.85,1.72)
Smoking	0.96 (0.68,1.36)	1.78*(1.22,2.60)	--	0.88 (0.56,1.37)
Physical activity	1.24 (0.90,1.70)	1.20 (0.85,1.71)	0.92 (0.60,1.42)	--
Usual source of health care				
No	1.47 (0.95,2.26)	1.07 (0.56,2.03)	0.93 (0.46,1.85)	0.67 (0.40,1.13)
Reference: Yes				

* p≤ 0.05
** AHA Life's Simple 7 = American Heart Association Life's Simple 7