Association of Food Insecurity and Metabolic Syndrome among NHANES Participants 1999-2014

true
true

Abstract

Introduction

In the early 1980's there began to be a recognition in the United States that many households faced limited or uncertain access to adequate food differing from malnutrition and chronic hunger. Therefore, in 1995 the 18 item U.S. Food Security Survey Module was added to the Current Population Survey (CPS) to measure the prevalence of food insecurity in the US (1). The USDA defines food insecurity as "limited or uncertain availability of nutritionally adequate and safe foods or uncertain ability to acquire acceptable foods in socially acceptable ways"(2). In 2011, it was estimated that 14.9 percent of households were food insecure at least some of the year and that the typical food secure household spent 24 percent more on food than the typical food-insecure household of the same size and composition(3). Households reporting food insecurity may be more likely to consume low-nutrient energy dense foods (4) and report a decrease in the frequency of consumption of fruits and vegetables(5). Previous research has found an association between food insecurity and hyperglycemia, hypertension, diabetes(6,7), peripheral arterial disease (8), poor cardiovascular health (9), increased in BMI in young women(10), and poor health outcomes in disabled adults(11). Berkowitz et al. also found an association between food insecurity and poor metabolic control in adults with diabetes(12).

Metabolic syndrome is the presence of multiple interrelated risk factors for cardiovascular disease (CVD) and diabetes. Metabolic syndrome is associated with a two-fold increased risk for developing CVD and a five-fold increase in type 2 diabetes mellitus. (13) According to the CDC, in 2014 heart disease was the leading cause of death and diabetes was the 7th leading cause of death(14). A better understanding of the association between food security and poor cardiovascular and metabolic health can improve the effectiveness of public health interventions. To date, no studies have explored the association between food security and early indicators of poor cardiometabolic health other than BMI, but evidence suggests BMI may be a poor indicator(15).

Methods

Data
This study used publicly available de-identified data from the CDC collected as part of the National Health and Nutrition Examination Study (NHANES), a cross-sectional, annual survey representative of the non-institutionalized US population(16). The survey is conducted annually using a complex survey design and data are bundled into two-year cycles. Data was combined from eight NHANES cycles (1999 - 2014). Only individuals who were selected for the morning examination are included as fasting glucose and triglyceride samples were only collected in those sessions. Individuals under 18 and over 65 were excluded as were pregnant women. Participants with missing exposure, outcome, and covariate data were also excluded from analysis.

Food insecurity was measured by the Adult Food Security Category. This information was captured during the Food Security Questionnaire. NHANES used the 12-month scale of the US Household Food Security Survey Module (FSSM), which consists of 18 items and has a three-stage design(16). The screening design keeps respondent burden to a minimum as most households are asked only three questions (five in households

with children). The USDA evaluated the reliability of the questionnaire using both traditional methods such as Spearman-Brown, Rulon's and Cronbach's alpha and novel methods to account for the high proportion of respondents that answer all questions in the negative(17). All measures gave values greater than .69 indicating good reliability. Responses are scored into four categories. In 2006, the food security category names were changed but the criteria did not (16,18). 'Full Food Security' was defined as no to all items, 'Marginal Food Security' as yes to 2 or less items, 'Low Food Security' as yes to three to five items and 'Very Low Food Security' as yes to six to ten items. (Only 10 items are used in the scoring of adult food security, the remaining eight are used for child food security.) Responses to individual questions was not provided for confidentiality reasons. Food insecurity was defined as those individuals whose reported food security was 'full food security' or 'marginal food security' following guidance by the USDA(2).(Table 1)

Table 1: Food Security Categories and Status

Number of Yes Responses	Food Security Categoty	Food Security Status
0	Full Food Security	Food Secure
1-2	Marginal Food Security	" "
3-5	Low Food Security	Food Insecure
6-10	Very Low Food Security	" "

Metabolic syndrome was defined using the harmonization criteria proposed in the joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity(13). Individuals who met three or more of the following criteria were deemed to have metabolic syndrome: 1) waist circumference: $\geq$ 102 cm for men and $\geq$ 88 cm for women 2) blood pressure: average systolic $\geq$ 130 mm Hg or average diastolic $\geq$ 85 mm Hg or reported taking a prescribed drug to lower blood pressure 3) triglycerides: $\geq$ 150 mg/dL or reported taking a prescribed drug to lower cholesterol 4) HDL: $\geq$ 40 mg/dL men and $\geq$ 50 mg/dL women 5)fasting glucose: $\geq$ 100mg/dL or reported taking a prescribed drug to lower blood sugar (Table 2).

Table 2: Individuals with 3 or more criteria were classified as having metabolic syndrome

	Criteria
Waist Circumference	$\geq$ 102 cm for men and $\geq$ 88 cm for women
Blood Pressure	average systolic $\geq$ 130 mm Hg or average diastolic $\geq$ 85 mm Hg or reported taking a prescribed drug to lower blood pressure
Triglycerides	$\geq$ 150 mg/dL or reported taking a prescirbed drug to lower cholesterol
HDL	$<$ 40 mg/dL men and $<$ 50 mg/dL women
Fasting Glucose	$\geq$ 100mg/dL or reported taking a prescribed drug to lower blood sugar

Covariates known to be associated with metabolic syndrome and/or food security were included. Included covariates were age, gender, race/ethnicity, education, income, physical activity and smoking status. In 2011, NHANES started collecting data for Asians, however to preserve continuity the old race/ethnicity variable was used for all years. Annual family income was used, some participants answered "over $20,000" in lieu of the finer income categories, these responses were excluded as it was felt this category was to coarse. Moderate physical activity was determined as a yes to any question about performing more than 30 min of

moderate activity on a typical day, as part of work, or in the last 30 days. In order to look at differences in prevalence of metabolic syndrome and food insecurity by age and NHANES cycle, age was categorized for those analyses only. Age categories were 20-29, 30-39, 40-49, and 50-59.

Analysis

All analysis was performed using the survey package v(2.0.32) (19) in R version 3.3.2 (2016-10-31) (20). The complex survey design was incorporated in all estimations. All participants with a non-zero fasting subsample MEC weight were included in the design object and those participants meeting inclusion/exclusion criteria were indicated by a subset variable. 16-yr sub-sample weights were calculated according to the formula recommended by NHANES. (21) Relative risk regression (binomial generalized linear regression with a log link function) was used to obtain all relative risks. Gender, age, and race/ethnciity were all evaluated for effect modification. The association between food insecurity and metabolic syndrome was evaluated both at the dichotimous food secure/food insecure level and for each categorical food security level (marginal, low, very low) using full food security as the reference group. All covariates that were not found to be effect modifiers were adjusted for. Significance of interaction terms for effect modification was determined using partial-F tests. P-values less than 0.05 were considered significant.

Results

There were 23,505 participants who were selected for the morning examination (fasting subsample MEC weight not equal to zero) of which 15,623 were 18-65 years old, 677 were excluded for pregnancy. 1,153 were missing information on metabolic syndrome, 274 were missing information on food security, and 2,448 were missing covariate information; these participants were also excluded from the analysis, giving a final n = 11,071. (Fig 1) Unweighted participant characteristics and missing food security and covariate information are given in Table 3.

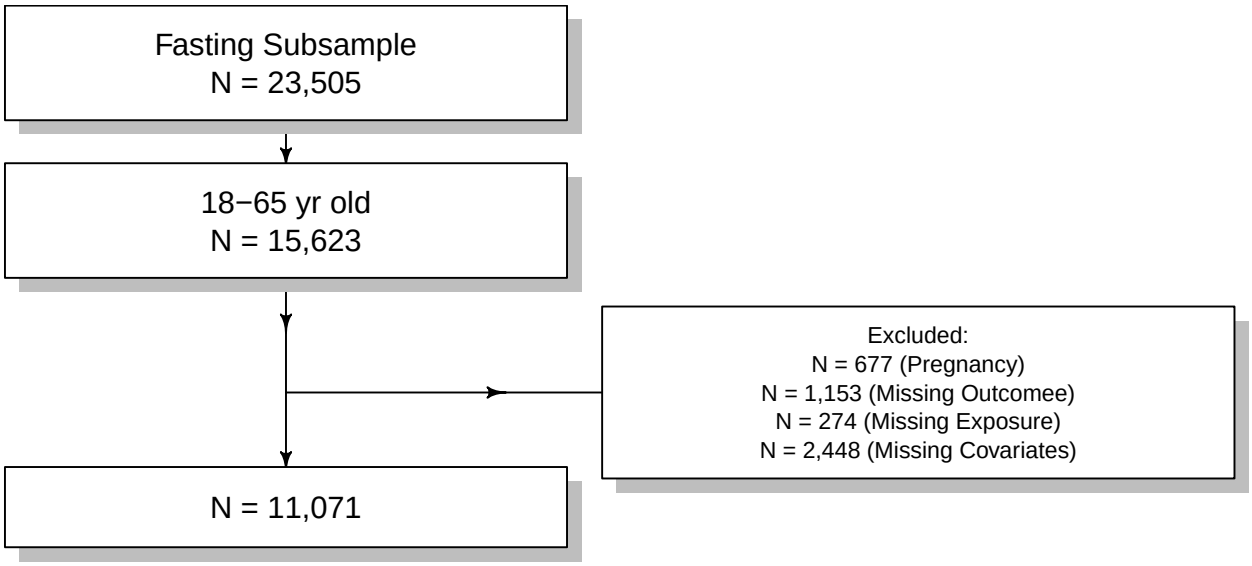

Figure 1: Inclusion/Exclusion Criteria

Table 3: Charactersitcs of Study Participants by Food Security Category

	Full Food Security (n= 9,600)	Marginal Food Security (n= 1,530)	Low Food Security (n= 1,502)	Very Low Food Security (n= 887)	Missing (n= 274)
	N(%)	N(%)	N(%)	N(%)	N(%)
Gender					
Female	4661(49)	806(53)	747(50)	460(52)	134(49)
Race					
Non-Hispanic White	4569(48)	409(27)	387(26)	352(40)	86(31)
Mexican American	1631(17)	458(30)	508(34)	179(20)	81(30)
Other Hispanic	685(7)	156(10)	166(11)	102(11)	17(6)
Non-Hispanic Black	1856(19)	421(28)	361(24)	215(24)	71(26)
Other (including multiracial)	337(4)	32(2)	42(3)	18(2)	12(4)
Missing	522(5)	54(4)	38(3)	21(2)	7(3)
Education					
Less than 9th Grade	618(6)	190(12)	304(20)	133(15)	27(10)
9-11th Grade	1315(14)	343(22)	391(26)	226(25)	51(19)
High School Grad	2260(24)	419(27)	354(24)	240(27)	86(31)
Some College/AA	2906(30)	441(29)	352(23)	252(28)	73(27)
College Graduate or above	2497(26)	132(9)	100(7)	35(4)	36(13)
Missing	4(0)	5(0)	1(0)	1(0)	1(0)
Income					
< $20,000	1645(17)	594(39)	687(46)	493(56)	13(5)
$20,000 - $54,999	3315(35)	670(44)	596(40)	331(37)	92(34)
$55,000-$74,999	1227(13)	112(7)	65(4)	22(2)	29(11)
≥ $75,000	2861(30)	80(5)	44(3)	9(1)	26(9)
Missing	552(6)	74(5)	110(7)	32(4)	114(42)
Smoking Status					
Never	5047(53)	729(48)	678(45)	341(38)	138(50)
Former	1935(20)	240(16)	229(15)	117(13)	50(18)
Current	1838(19)	407(27)	440(29)	351(40)	50(18)
Missing	780(8)	154(10)	155(10)	78(9)	36(13)
Moderate Phys Act					
Yes	5657(59)	828(54)	775(52)	490(55)	144(53)
No	3942(41)	701(46)	726(48)	397(45)	129(47)
Missing	1(0)	1(0)	1(0)	0(0)	1(0)
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
Age	41(14)	38(14)	39(14)	39(14)	39(15)

Table 4: Weighted Charactersitcs of Study Participants by Food Security Category

	Food Secure (n= 135,319,985)	Food Insecure (n= 19,836,878)	Fully Food Secure (n= 122,427,895)	Marginal Food Security (n= 12,892,090)	Low Food Security (n= 11,778,849)	Very Low Food Security (n= 8,058,029)	p-value
	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	
Gender							0.17
Female	66,695,440(49)	9,968,327(50)	59,909,429(49)	6,786,011(53)	5,889,069(50)	4,079,258(51)	
Moderate Phys Act							<0.01
No	50,559,587(37)	8,805,427(44)	44,995,299(37)	5,564,288(43)	5,363,157(46)	3,442,270(43)	
Race							<0.01
Non-Hispanic White	98,437,478(73)	10,480,189(53)	92,393,838(75)	6,043,639(47)	5,718,990(49)	4,761,199(59)	
Mexican American	10,340,803(8)	3,247,641(16)	7,875,168(6)	2,465,635(19)	2,386,064(20)	861,578(11)	
Other Hispanic	6,575,147(5)	1,756,020(9)	5,310,281(4)	1,264,866(10)	939,415(8)	816,604(10)	
Non-Hispanic Black	14,110,826(10)	3,655,731(18)	11,419,702(9)	2,691,124(21)	2,219,931(19)	1,435,800(18)	
Other (including multiracial)	5,855,731(4)	697,296(4)	5,428,906(4)	426,825(3)	514,449(4)	182,848(2)	
Education							<0.01
Less than 9th Grade	5,212,109(4)	2,448,762(12)	3,989,142(3)	1,222,966(9)	1,587,782(13)	860,979(11)	
9-11th Grade	14,120,024(10)	4,750,264(24)	11,644,487(10)	2,475,537(19)	2,919,312(25)	1,830,952(23)	
High School Grad	31,023,507(23)	5,008,015(25)	27,286,262(22)	3,737,245(29)	2,727,771(23)	2,280,243(28)	
Some College/AA	43,197,178(32)	6,269,125(32)	39,072,196(32)	4,124,982(32)	3,575,655(30)	2,693,470(33)	
College Graduate or above	41,767,167(31)	1,360,713(7)	40,435,808(33)	1,331,359(10)	968,328(8)	392,384(5)	
Income							<0.01
< $20,000	19,759,001(15)	9,644,081(49)	15,025,307(12)	4,733,693(37)	5,295,747(45)	4,348,334(54)	
$20,000 - $54,999	46,860,369(35)	8,477,535(43)	40,773,026(33)	6,087,344(47)	5,088,881(43)	3,388,654(42)	
$55,000-$74,999	20,364,453(15)	956,909(5)	19,113,815(16)	1,250,637(10)	781,001(7)	175,908(2)	
≥ $75,000	48,336,162(36)	758,352(4)	47,515,747(39)	820,415(6)	613,220(5)	145,132(2)	
Smoking Status							<0.01
Never	74,509,958(55)	8,474,294(43)	68,203,357(56)	6,306,601(49)	5,575,873(47)	2,898,422(36)	
Former	30,456,064(23)	3,134,453(16)	28,039,675(23)	2,416,388(19)	1,884,735(16)	1,249,718(16)	
Current	30,353,963(22)	8,228,130(41)	26,184,863(21)	4,169,100(32)	4,318,241(37)	3,909,889(49)	
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	
Age	42(0.2)	39(0.4)	42(0.2)	38(0.5)	39(0.5)	39(0.7)	<0.01

The prevalence of metabolic syndrome increased with age but has not changed over time. However the prevalence of food insecurity while decreasing with age, has been increasing in over time. (Figs 2 & 3).

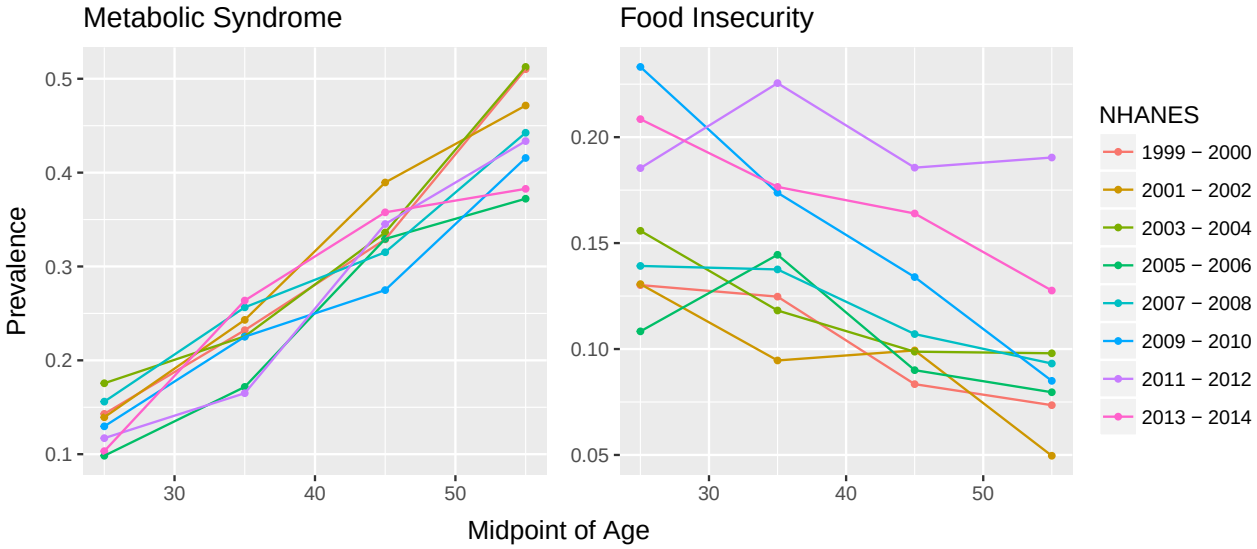

Figure 2: Prevalence of Metabolic Syndrome and Food Insecurity by Age and NHANES Cycle

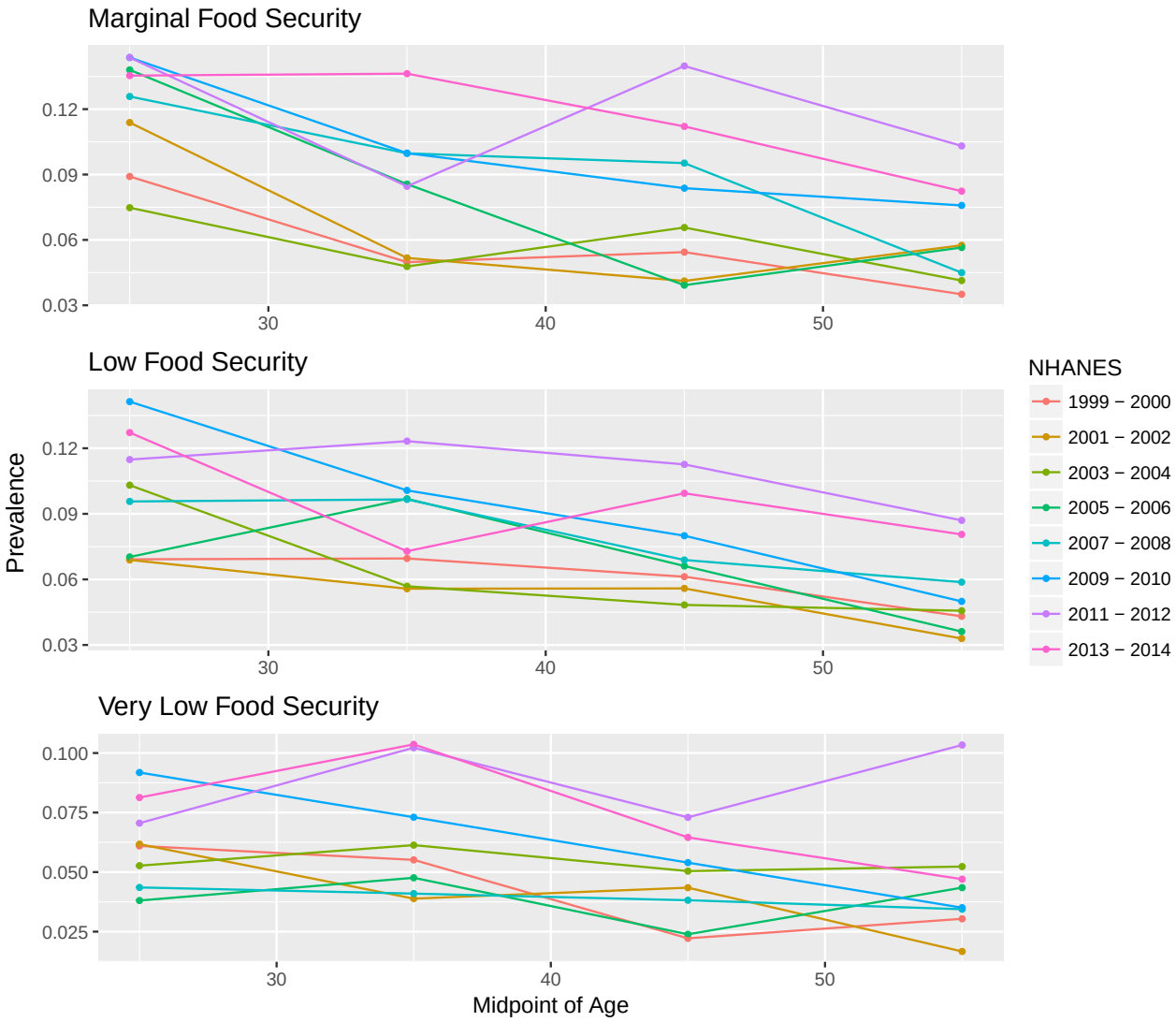

Figure 3: Prevalence of Food Security Categories by Age and NHANES Cycle

Table 5: Unadjusted Prevalence and Relative Risk of Metabolic Syndrome

	Metabolic Syndrome
Unadjusted Prevalence	
Food Secure	0.30(0.29-0.32)
Food Insecure	0.33(0.30-0.36)
—	—
Full food security	0.30(0.28-0.31)
Marginal food security	0.32(0.28-0.35)
Low Food security	0.33(0.29-0.37)
Very low Food security	0.34(0.29-0.39)
Crude Relative Risk	
vs. Food Secure	
Food Insecure	1.10(1.00-1.22)
vs. Full Food Security	
Marginal Food Security	1.06(0.95-1.19)
Low Food Security	1.09(0.98-1.22)
Very Low Food security	1.13(0.97-1.32)

Table 6: Adjusted Risk Ratio Metabolic Syndrome by Food Insecurity Status/Category

	Male	Female
Adjusted Risk Ratio		
vs. Food Secure		
Food Insecure	1.06(0.77-1.46)	1.41(1.04-1.91)
vs. Full Food Security		
Marginal Food Security	1.20(0.74-1.94)	1.28(0.8-2.06)
Low Food Security	1.19(0.79-1.79)	1.85(1.26-2.73)
Very Low Food security	0.99(0.58-1.70)	1.49(0.85-2.59)

Discussion

The biggest limitation of this study is the cross-sectional design. Metabolic syndrome increases over time as would be expected as poor diet and lifestyle take time to

Conculsions

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