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

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Abstract

Background: In 2011, it was estimated that 14.9 percent of households were food insecure at least some of the year. Heart disease is the leading cause of death in the US and diabetes is seventh. Metabolic syndrome (MetS) is associated with a twofold increased risk of developing cardiovascular disease and a fivefold increase risk in developing type 2 diabetes. A better understanding of the association between food security and poor metabolic health can improve the effectiveness of public health interventions.
Methods: This study used data from 13,793 18-65yr old participants collected as part of NHANES 1999-2014. The association between food insecurity and MetS was estimated using relative risk regression. We adjusted for race/ethnicity, age, physical activity, smoking status, education and income. Food insecure was analyzed as both a binary (food secure/food insecure) and ordinal (full/marginal/low/very low food security) variable. Age, gender, and race/ethnicity were evaluated for effect modification.
Results: The unadjusted prevalence of MetS in food secure individuals was 0.30(0.29-0.32) and in food insecure individuals was 0.33(0.30-0.36). Food insecurity was associated with MetS in females [adjusted relative risk (ARR) 1.41(1.04-1.91)] but not in males [ARR 1.06(0.77-1.46)]. Low food security was associated with MetS (when compared to full food security) in females [ARR 0.8007147] but not males [ARR 1.19(0.79-1.79)].
Conclusions: Food insecurity is associated with a moderately increased risk of MetS in females. Further research is required to access the reasons for these gender differences. It is important for public health professionals to consider access to affordable high quality food when working to promote good metabolic and cardiovascular health.

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 that differed from malnutrition and chronic hunger that was especially prevalent in developing countries[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" and hunger as "the uneasy or painful sensation caused by a lack of food, the recurrent and involuntary lack of access to food. Hunger may produce malnutrition over time. Hunger is a potential, although not necessary, consequence of food insecurity"[2]. 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]. 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 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, heart disease was the leading cause of death and diabetes was the 7th leading cause of death in 2014[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]. This study aimed to explore the association between food insecurity and poor metabolic health before clinical disease may be present. This study will add to the scientific knowledge of how resource scarcity can contribute to poor health.

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 on all items, 'Marginal Food Security' as yes on 2 or less items, 'Low Food Security' as yes on three to five items and 'Very Low Food Security' as yes on 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 'low food security' or 'very low 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 for income; 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 sub-sample 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/ethnicity were all evaluated for effect modification. The association between food insecurity and metabolic syndrome was evaluated both at the dichotomous 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 log likelihood. P-values less than 0.05 were considered significant.

Results

There were 23,505 participants who were selected for the morning examination (fasting sub-sample 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, weighted participant characteristics and p-values in Table 4. Food secure individuals were significantly more likely to be non-Hispanic white, have higher levels of education and have higher incomes. They were also moderately more likely to be never smokers. Food secure individuals were only slightly more likely to be male and to report engaging in moderate physical activity.

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)
$\geq$ $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)	
$\geq \$75,000$	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

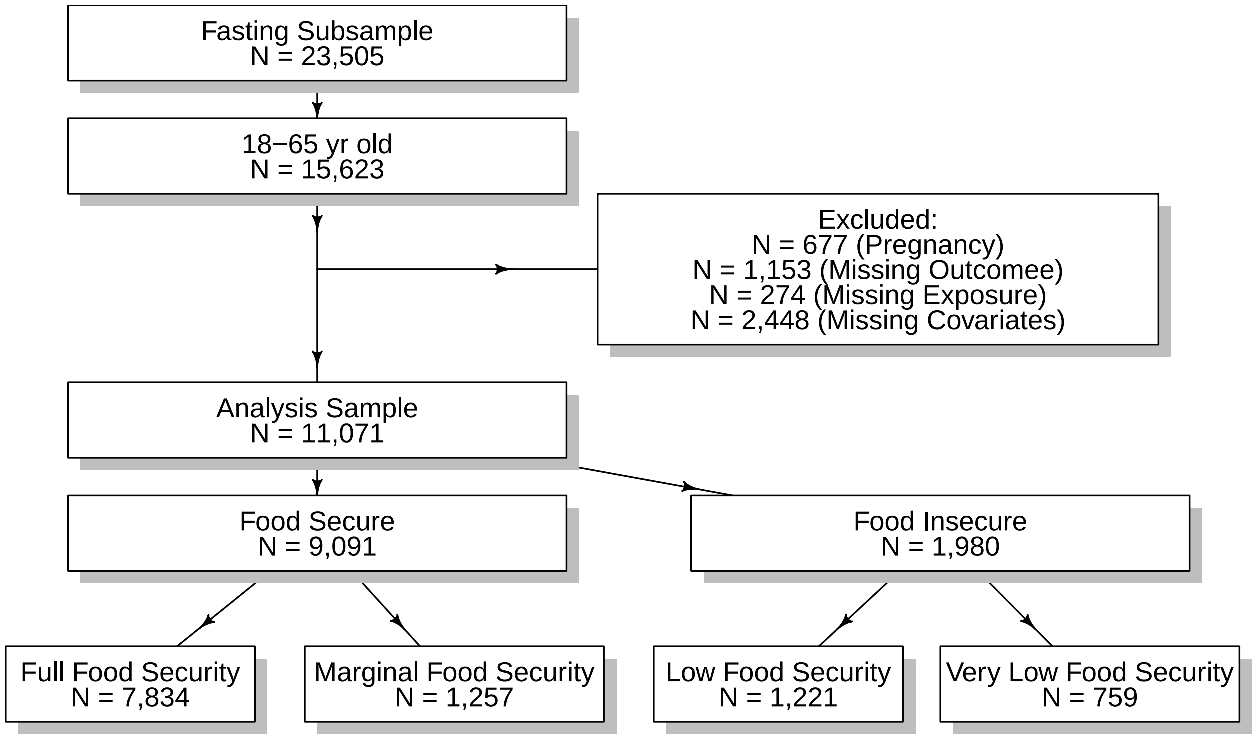

Figure 1: Cohort Flow Chart

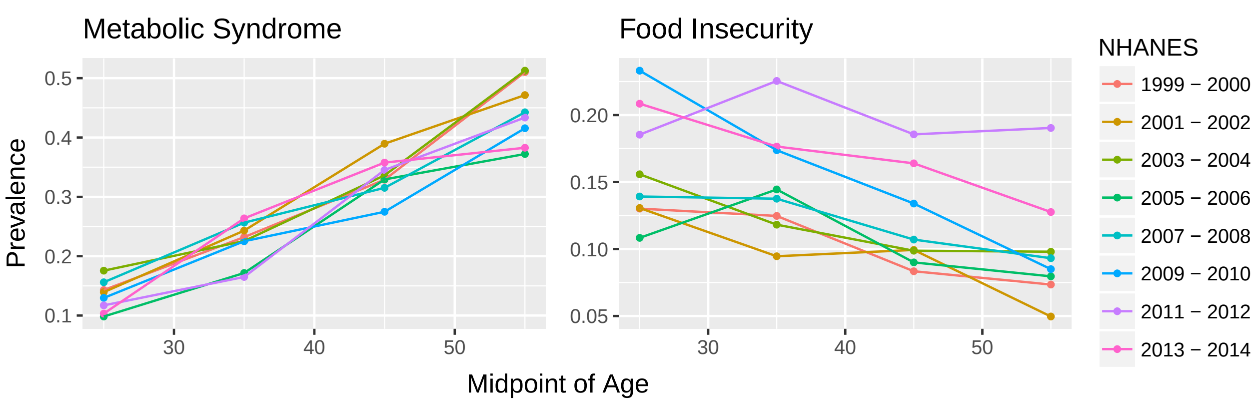

Figure 2: Prevalence of Metabolic Syndrome and Food Insecurity by Age and NHANES Cycle

The prevalence of metabolic syndrome generally increased with age but has not changed over time. In contrast, the prevalence of food insecurity while generally decreasing with age, has generally been increasing over time. (Figs 2 & 3). The unadjusted prevalence of metabolic syndrome trends higher with increasing food security, but not significantly. (Table 5) There was not a significant interaction between age or race/ethnicity and food security, but there was a significant interaction between gender and food insecurity ($p < 0.0001$). Food insecurity was significantly associated with metabolic syndrome in females [adjusted risk ratio (ARR): 1.41 95% CI: 1.04 - 1.04] but was not not significantly associated with metabolic syndrome in males [ARR: 1.06 95% CI: 0.77 - 0.77]. Low food security was also significantly associated with metabolic syndrome in females [ARR: 1.85 95% CI: 1.26 - 2.73] but very low food security was not [ARR: 1.49 95% CI: 0.85 - 2.59]. In males, there was a non-significant decrease in the association between increasing food insecurity and metabolic syndrome (Table 6).

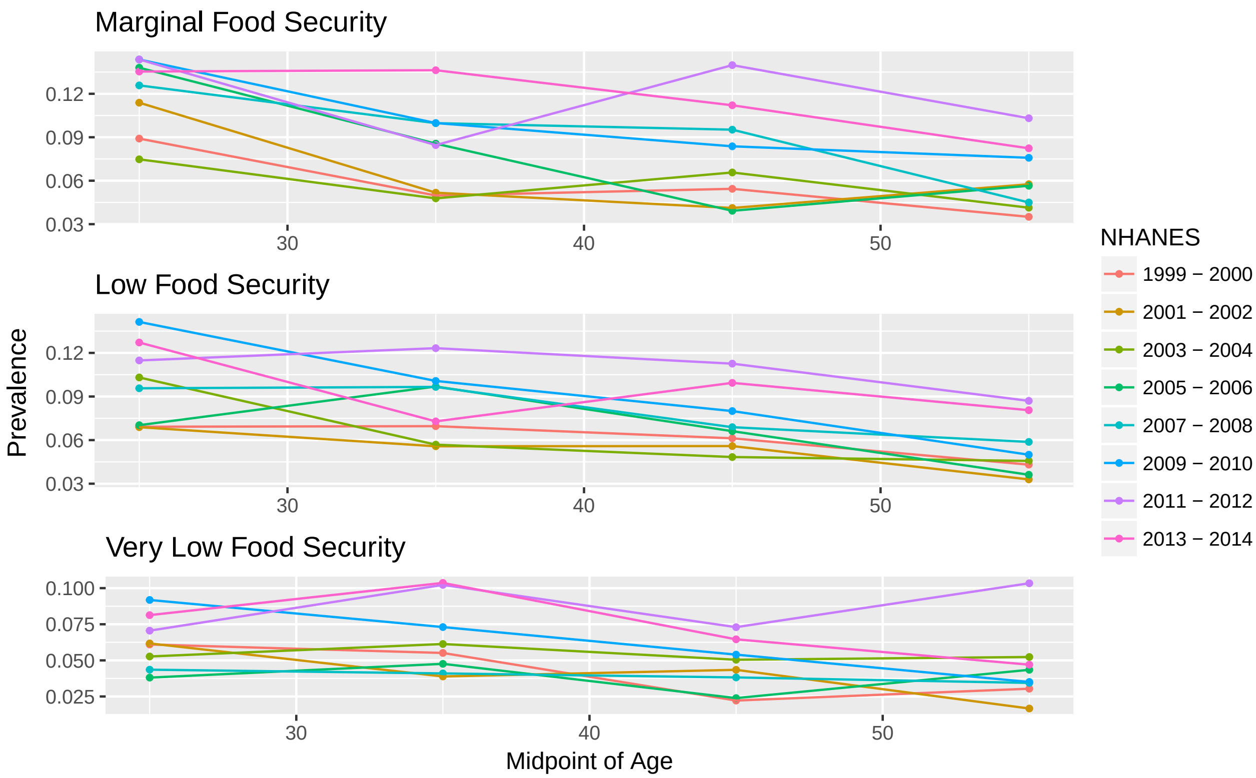

Figure 3: Prevalence of Food Security Categories by Age and NHANES Cycle

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)

Discussion

Food security was significantly associated with metabolic syndrome in females suggesting that attempting to address these risk factors with diet and exercise without regard to resource scarcity may be ineffective. Females experiencing food insecurity may be more likely to consume high calorie nutrient poor foods that make metabolic syndrome more likely.

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(0.80-2.06)
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)

The biggest limitation of this study is the cross-sectional design. The prevalence of metabolic syndrome is higher in older ages and is likely a result of years of poor diet. The prevalence of food insecurity, however, goes down with age as wages and other causes of poverty tend to decrease. Due to the cross-sectional nature of this study, we were unable to analyze the effects of many years of food insecurity previously in individuals who are not food insecure currently on metabolic syndrome. The relative risk of metabolic syndrome in individuals classified as "very low food security" compared to "full food security" is also lower than in those classified as "low food security". This may be because individuals who have very low food security may be experiencing hunger or malnutrition. While these conditions would have negative health effects, they may be less likely to cause metabolic syndrome.

The Food Security Survey Module assesses food insecurity at the household level, which may not accurately reflect the food security status of the individual. In addition, the classification of metabolic syndrome relied on a single measurements at a specific moment in time which may have resulted in the misclassification of some individuals. The large sample size minimizes the effect that we would expect this to have on the results.

Previous studies have also found gender differences in associations between food insecurity and health outcomes[22–24]. Jansen et al, in a study of preschoolers, found an association between girls who became food insecure and increased BMI and between girls who became food secure and increased diet quality. No such relationship was found in the boys.[25] The gender differences in response to low food security warrant further exploration. Dhurandhar has suggested that social status effects the physiological responses to food insecurity, arguing that food scarcity leads to increased body fat stores in low social status individuals[26]. The negative trend line in males suggests that food insecurity is not only not significantly associated with metabolic syndrome in males, but that individuals respond to food insecurity in gender specific ways. Whether this is caused by physiological, environmental, or sociological factors or any combination of the three requires further research.

Conculsions

Food insecurity in females was associated with a 41% (95% CI: 4% - 91%) increased risk in metabolic syndrome compared to food secure females. Low food secure females had a -98% (95% CI: -99% - -97%) higher risk for metabolic syndrome when compared to full food secure females. Metabolic syndrome is associated with a twofold increased risk for cardiovascular disease and a fivefold increased risk for diabetes, the number one and number seven causes of death in the US. By addressing food security in individuals before they develop chronic disease, prevention efforts may be more effective.

References

1. Carlson SJ, Andrews MS, Bickel GW. Measuring food insecurity and hunger in the united states: Development of a national benchmark measure and prevalence estimates. *J Nutr.* 1999;129(2S Suppl):510s-516s.

2. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to measuring household food security, revised 2000. 2000. https://www.fns.usda.gov/sites/default/files/FSGuide_0.pdf.

3. Coleman-Jensen A, Nord M, Andrews M, Carlson S. Household food security in the united states in 2011. 2012;ERR-141. https://www.ers.usda.gov/webdocs/publications/err141/30967_err141.pdf.

4. Drewnowski A, Darmon N. Food choices and diet costs: An economic analysis. *J Nutr.* 2005;135(4):900-904.

5. Kendall A, Olson CM, Frongillo J E. A. Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc.* 1996;96(10):1019-1024. doi:10.1016/s0002-8223(96)00271-4.

6. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income nhanes participants. *J Nutr.* 2010;140(2):304-310. doi:10.3945/jn.109.112573.

7. Gucciardi E, Vahabi M, Norris N, Del Monte JP, Farnum C. The intersection between food insecurity and diabetes: A review. 2014;3:324-332. doi:10.1007/s13668-014-0104-4.

8. Redmond ML, Dong F, Goetz J, Jacobson LT, Collins TC. Food insecurity and peripheral arterial disease in older adult populations. *J Nutr Health Aging.* 2016;20(10):989-995. doi:10.1007/s12603-015-0639-0.

9. Saiz J A. M., Aul AM, Malecki KM, et al. Food insecurity and cardiovascular health: Findings from a statewide population health survey in wisconsin. *Prev Med.* 2016;93:1-6. doi:10.1016/j.ypmed.2016.09.002.

10. Gooding HC, Walls CE, Richmond TK. Food insecurity and increased bmi in young adult women. *Obesity (Silver Spring).* 2012;20(9):1896-1901. doi:10.1038/oby.2011.233.

11. Brucker DL. Food security among young adults with disabilities in the united states: Findings from the national health interview survey. *Disabil Health J.* 2016;9(2):298-305. doi:10.1016/j.dhjo.2015.10.003.

12. Berkowitz SA, Baggett TP, Wexler DJ, Huskey KW, Wee CC. Food insecurity and metabolic control among u.S. adults with diabetes. *Diabetes Care.* 2013;36(10):3093-3099. doi:10.2337/dc13-0570.

13. Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: A 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. *Circulation.* 2009;120(16):1640-1645. doi:10.1161/circulationaha.109.192644.

14. CDC. march 17, 2017 2017. https://www.cdc.gov/nchs/fastats/deaths.htm.

15. Tomiyama AJ, Hunger JM, Nguyen-Cuu J, Wells C. Misclassification of cardiometabolic health when using body mass index categories in nhanes 2005-2012. *Int J Obes (Lond).* 2016;40(5):883-886. doi:10.1038/ijo.2016.17.

16. CDC. National Center for Health Statistics. *National Health and Nutrition Examination Survey Data.* U.S. Department of Health; Human Services, CDC, 2005; 2005.

17. Hamilton WL, Cook JT, Thompson WW, et al. Household food security in the united states in 1995: Technical report of the measurement project. 1997.

18. Eisenmann JC, Gundersen C, Lohman BJ, Garasky S, Stewart SD. Is food insecurity related to overweight and obesity in children and adolescents? A summary of studies, 1995-2009. *Obes Rev.* 2011;12(5):e73-83. doi:10.1111/j.1467-789X.2010.00820.x.

19. Lumley T. Analysis of complex survey samples. *J of Statistical Software.* 2004;9(1):1-19.

20. R Core Team. *R: A Language and Environment for Statistical Computing.* Vienna, Austria: R Founda-

tion for Statistical Computing; 2016. https://www.R-project.org/.

21. CDC. National Center for Health Statistics. *Continuous Nhanes Tutorial*. U.S. Department of Health; Human Services, CDC, 2005; 2005. http://www.cdc.gov/nchs/tutorials/Nhanes/index_current.htm.

22. Hernandez DC, Reesor L, Murillo R. Gender disparities in the food insecurity-overweight and food insecurity-obesity paradox among low-income older adults. *J Acad Nutr Diet*. 2017. doi:10.1016/j.jand.2017.01.014.

23. Strings S, Ranchod YK, Laraia B, Nuru-Jeter A. Race and sex differences in the association between food insecurity and type 2 diabetes. *Ethn Dis*. 2016;26(3):427-434. doi:10.18865/ed.26.3.427.

24. Liu J, Park YM, Berkowitz SA, et al. Gender differences in the association between food insecurity and insulin resistance among u.S. adults: National health and nutrition examination survey, 2005-2010. *Ann Epidemiol*. 2015;25(9):643-648. doi:10.1016/j.annepidem.2015.06.003.

25. Jansen EC, Kasper N, Lumeng JC, et al. Changes in household food insecurity are related to changes in bmi and diet quality among michigan head start preschoolers in a sex-specific manner. *Soc Sci Med*. 2017;181:168-176. doi:10.1016/j.socscimed.2017.04.003.

26. Dhurandhar EJ. The food-insecurity obesity paradox: A resource scarcity hypothesis. *Physiol Behav*. 2016;162:88-92. doi:10.1016/j.physbeh.2016.04.025.