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Food Insecurity and Dyslipidemia in a Representative Population-Based Sample in the US

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Abstract

Objective—The association of food insecurity with dyslipidemia has not been firmly established. The main objective of this study was to assess whether food insecurity was associated with dyslipidemia.

Method—A population-based sample of 1,663 adults from the 2008–2011 Survey of the Health of Wisconsin was used. Food insecurity was defined as an affirmative response to either of the questions: 1) “In the last 12 months, have you been concerned about having enough food for you or your family?” 2) “In the last 12 months, have your food choices been limited because there wasn’t enough money?” High total cholesterol was defined as total cholesterol (TC) >240 mg/dL or taking prescribed lipid-lowering medication. Low high-density lipoprotein cholesterol (HDL-C) was defined as <40 mg/dL in men and <50 mg/dL in women.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Results—Food insecurity was not associated with high TC either among men or women. Food insecurity was associated with a higher likelihood of low HDL-C among women (adjusted odds ratio [AOR]: 2.31 {95% confidence interval [CI]: 1.42, 3.76}), but not among men. Obesity appears to be a partial mediator of the association among women (P from the Sobel test= 0.01).

Conclusion—These findings suggest that food insecurity may contribute to an increased risk of low HDL-C in women.

Keywords

dyslipidemia; food insecurity; HDL-C; population-based studies; Survey of the Health of Wisconsin

Introduction

An estimated 17.6 million (14.5%) of U.S. households experienced food insecurity in 2012 (Coleman-Jensen et al., 2013). This proportion suggests approximately 48.9 million adults struggled to obtain nutritionally adequate and safe foods due to a lack of sufficient resources at some time during 2012 (Coleman-Jensen et al., 2013). In a recent analysis, we estimated that more than 740,000 adults are suffering from food insecurity in Wisconsin (Guerrero et al., 2014).

Food insecurity is the perceived state of lack of food and food availability measured over a certain period of time. A lack of access to food is often associated not only with dietary quantity (i.e. food shortages due to insufficient food availability) but also dietary quality (e.g. lower intake of fruits and vegetables)(Laraia, 2013). Restricted dietary options, a number of coping strategies of dietary behavior to overcome hunger and/or energy deficiency, and subsequent stress among individuals experiencing food insecurity may lead to changes in physical status, poor nutrition, and development of chronic disease (Laraia, 2013).

Previous studies suggest that food insecurity is associated with adverse health outcomes in adults, including poor general health status (Stuff et al., 2004; Vozoris and Tarasuk, 2003), type 2 diabetes mellitus (Seligman et al., 2010, 2007; Vozoris and Tarasuk, 2003), hypertension (Seligman et al., 2010; Vozoris and Tarasuk, 2003), and cardiovascular disease (Vozoris and Tarasuk, 2003). Also, a paradoxical relationship between food insecurity and increased obesity has been observed in the U.S. adult population, especially among women (Dinour et al., 2007; Gooding et al., 2012; Holben and Pheley, 2006; Laraia et al., 2010; Townsend et al., 2001). It has been hypothesized that food insecurity predisposes individuals to chronic disease by inducing unhealthy dietary behaviors, such as reducing dietary variety and giving preference to a few low-cost, energy-dense, and nutritionally poor foods (Seligman and Schillinger, 2010). Further, fluctuations in availability of food over time have been associated with psychological stress (Polivy, 1996), which induces metabolic changes that promote fat storage (Adam and Epel, 2007; Torres and Nowson, 2007).

Dyslipidemia, i.e. abnormal serum lipid levels, is a major modifiable risk factor for cardiovascular disease (Fodor, 2010), the leading cause of death and disability in the U.S.

(Go et al., 2013). Currently more than half of the U.S. adult population (53%) has dyslipidemia: 13.4% has high total cholesterol (TC), 26.9% has high low-density lipoprotein cholesterol (LDL-C), and 23.3% has low high-density lipoprotein cholesterol (HDL-C) (Tóth et al., 2012). Typically, obesity-related dyslipidemia is characterized by high triglycerides, low HDL-C, and normal or slightly high LDL-C (Klop et al., 2013).

Although food insecurity is associated with increased obesity, a known risk factor for dyslipidemia, previous studies on the associations between food insecurity and dyslipidemia have shown inconsistent results (Dixon et al., 2001; Seligman et al., 2010; Tayie and Zizza, 2009). The purpose of this study was to assess the association between a recent history of food insecurity and dyslipidemia in a representative sample of Wisconsin adults.

Methods

We used the combined Survey of the Health of the Wisconsin (SHOW) samples from 2008 to 2011. The SHOW is a cross-sectional sample of the Wisconsin adult population. It consists of a series of independent annual representative surveys (Nieto et al., 2010). Two-stage, probability-based cluster sampling is used to select households and recruit non-institutionalized/non-active duty adult residents ages 21–74 years (Nieto et al., 2010). In each one-year cycle, approximately 400–1000 adult participants are recruited and are administered an in-home interview (Time 1); a self-administered questionnaire (Time 2); and a clinic visit in a mobile or fixed center that includes a physical exam, laboratory tests, and additional interviews (Time 3). Both SHOW and this study were approved by the University of Wisconsin-Madison Health Sciences Institutional Review Board (IRB). Informed consent was obtained from all study participants.

Data on the main exposure, a recent food security history, was collected using audio computer-assisted self-administered interviews (ACASI) at Time 3. Two questions were included in defining food insecurity as a construct related to both the self-perceived stress about food and access.

- “In the last 12 months, have you been concerned about having enough food for you or your family?”
- “In the last 12 months, have your food choices been limited because there wasn’t enough money?”

The first question is from the Social Context Module in the Behavioral Risk Factor Surveillance System (BRFSS) that is used to estimate the prevalence of food insecurity in many states (Centers for Disease Control and Prevention, 2000). The second question is slightly modified from the National Health and Nutrition Examination Survey (NHANES) food security module to assess whether quality and/or quantity of food is limited due to financial constraints (NHANES 2005–2006 Data Documentation, 2008). Individuals who answered “yes” to either of these two questions were classified as “having a recent history of food insecurity”. We validated the use of these measures amongst a subset of SHOW participants who additionally completed the United States Department of Agriculture (USDA) Adult Food Security 10 item Survey Module (USDA, 2012).

Serum lipid levels, the main outcome of interest, were measured as part of the SHOW exam (Nieto et al., 2010). Dyslipidemia was defined as high TC or low HDL-C. High TC was defined as a serum TC level ≥ 240 mg/dL (National Cholesterol Education Program, 2001) or self-reported use of prescribed lipid-lowering drug. Low HDL-C was defined as a serum HDL-C < 40 mg/dL in men and < 50 mg/dL in women (National Cholesterol Education Program, 2001). Also, standing body height (to the nearest half centimeter) and weight (to the nearest 100 gram) were measured with the participants wearing light clothing and no shoes. Obesity was defined as a body mass index (BMI) ≥ 30 kg/m² (WHO, 2000). Sociodemographic data (including education, income, and occupation), habits (smoking, alcohol intake, and physical activity), and health insurance access were obtained using standardized interviews. Based on the response to the first question of the Short-Form 12 (SF-12) questionnaire (Ware et al., 1996), self-reported health was dichotomized as “fair or poor” vs. “excellent, very good, or good”.

We compared differences in baseline characteristics between participants with and without a recent history of food insecurity using Student’s t-test for continuous variables and Chi-square test for categorical variables. We accounted for the complex survey design by weighting all the strata by the inverse of the probability of selection into SHOW (Korn and Graubard, 1991). We used gender-stratified multivariate weighted logistic regression analyses to assess the association between food insecurity and dyslipidemia (high TC, low HDL-C) while controlling for confounding variables. We conducted separate analyses for high TC and low HDL-C. Covariates in our regression models comprised factors known to be associated with outcomes and/or food insecurity, including age (21–39 years; 40–49 years; 50–59 years; 60–74 years) (Gowda et al., 2012; Wenger, 2004), race/ethnicity (self-reported non-Hispanic white; other) (Frank et al., 2014; Gowda et al., 2012), education (less than high school; high school degree or higher) (Gowda et al., 2012; Mahley et al., 2005; Sun et al., 2014), household income (less than \$20K/year; \$20K–\$45K/year; $> \$45$ K/year) (Chichlowska et al., 2008; Gowda et al., 2012; Sun et al., 2014), self-reported physical activity (physically active; physically inactive) (Monda et al., 2009), smoking (current; former; never smoker) (Craig et al., 1989; Gowda et al., 2012), and heavy alcohol intake (yes; no) (Brien et al., 2011).

We postulated that obesity was a partial mediator of the putative association between food insecurity and dyslipidemia. To assess this hypothesis, the independent association between food insecurity and dyslipidemia was quantified in models with and without obesity, and the mediating effect of obesity was estimated as the difference between the effects of a history of food insecurity in both models (Baron and Kenny, 1986). We used both the Sobel test and the bootstrapping approach to test the presence of mediation (Preacher and Hayes, 2008).

We performed sensitivity analyses. First, we used two slightly different definitions of food insecurity. For that purpose, the history of food insecurity was defined based on the participant’s affirmative response to each of two questions, respectively (i.e. self-reported concern about food, self-reported limited choices of food). Second, we did sensitivity analyses after excluding individuals who received benefits from food assistance programs. We used Stata/MP13 (Stata Corporation, College Station, Texas, US) for all analyses.

Results

2,479 individuals participated in SHOW between 2008 and 2011 (survey response rate: 56.0%). We excluded 530 participants because they did not have information on either food security history or serum lipid levels. We excluded another 286 participants because of missing information on covariates. These exclusions resulted in 1,663 study participants with complete data for all of our analyses. Among male participants, those included in our analysis were comparable to those who were excluded with respect to recent history of food insecurity, BMI, and serum lipid levels. Likewise, BMI, TC, and HDL-C levels were comparable among women included and excluded from the analysis. However, women included in this analysis had a slightly lower proportion of a recent history of food insecurity (21 vs. 29%) and high TC (26 vs. 41%) than those who were excluded.

The overall prevalence of a recent history of food insecurity was 22.1% (95% confidence interval [CI]; 19.2–25.3). Compared with participants who had not experienced food insecurity last year, those reporting a recent history of food insecurity included a larger proportion of younger individuals, racial minorities, lower educated, lower income, unemployed, individuals lacking health insurance, self-reporting poor or fair health status, and current smokers (Table 1).

The age-adjusted prevalence of obesity was significantly higher among women who had a recent history of food insecurity than in those who did not (51.9 vs. 34.5%; Table 2), but no significant difference was found among men (39.3 vs. 37.1%; Table 3). The age-adjusted prevalence of high TC did not differ by food security history in either men or women (Table 2 and Table 3). On the other hand, the age-adjusted prevalence of low HDL-C was significantly higher in women with compared to those without a recent history of food insecurity (67.4 vs. 46.7%; Table 2), but was similar in both groups of men (57.1 vs. 51.1%; Table 3).

After multivariate adjustment, a recent history of food insecurity was significantly associated with a higher prevalence of obesity among women (OR: 2.09; $P=0.003$; Table 4, model 1), but not among men (OR: 1.09; $P=0.73$). The interaction between gender and food insecurity with regard to obesity was statistically significant ($P=0.04$). A recent history of food insecurity was not associated with high TC in either men (OR: 1.01; $P=0.96$) or women (OR: 0.62; $P=0.11$). However, a recent history of food insecurity was associated with a higher likelihood of low HDL-C among women (OR: 2.31; $P=0.001$), but not among men (OR: 1.14; $P=0.58$). This interaction was statistically significant ($P=0.01$).

The relationship between food insecurity and low HDL-C among women seemed to be mediated by obesity. The OR of low HDL-C was attenuated from 2.31 (Table 4, model 1) to 2.04 (model 2) after adjusting for obesity (P -value for the Sobel test for mediation: 0.01). Consistent results were obtained with the bootstrapping approach to test the presence of mediated effects.

In sensitivity analyses, our findings were materially unchanged both when two alternative definitions of a history of food insecurity were used and when individuals who received

benefits from food assistance programs were excluded from the analyses (results not shown).

Discussion

Our analyses from a representative population-based sample of Wisconsin adults showed that a recent history of food insecurity was significantly associated with a higher likelihood of low HDL-C levels and a higher prevalence of obesity among women, but not among men. Furthermore, our results suggest that obesity partially mediated the association between a recent history of food insecurity and low HDL-C among women. On the other hand, a recent history of food insecurity was not associated with high TC among either men or women.

Previous studies have reported inconsistent associations between food insecurity and dyslipidemia. For example, Holben and Pheley (2006) found no relationship between food insecurity and TC level using a sample from rural Ohio. Seligman et al. (2010) reported that food insecurity was not associated with clinical hyperlipidemia, defined as TC ≥ 240 mg/dL or LDL-C ≥ 160 mg/dL or taking cholesterol-lowering medication among nonelderly (aged 18–65 years) low income adults. Also, Dixon et al. (2001) reported that food insecurity was associated with lower HDL-C level but not with TC level among older adults (aged ≥ 60 years). Potential sources of inconsistencies in the reported association between food insecurity and dyslipidemia could be attributed to age difference, differences in ways to measure food insecurity, and variation in clinical markers to define dyslipidemia. More importantly, heterogeneity of results could be explained by lack of accounting for gender-by-exposure interactions.

Our results suggest that food insecurity has an impact on low HDL-C among women, but not among men. This result is consistent with the findings of at least one other study based on NHANES data that found a significant association between intermediate-level food insecurity (e.g., marginal food security and low food security) and high LDL-C, high triglycerides/HDL-C ratio, and high triglycerides only among women (Tayie and Zizza, 2009). While reasons for these gender differences are not entirely clear, they are consistent with the findings from our own study as well as from previous studies showing that food insecurity is associated with obesity only among women (Dinour et al., 2007; Gooding et al., 2012; Townsend et al., 2001). It is possible that women experiencing food insecurity make different nutritional choices than men in the same situation. In fact, some researchers hypothesized that when experiencing food insecurity women preferentially give available nutritious food to their children and choose to consume unhealthy foods themselves (Dinour et al., 2007). Of course, one cannot rule out that constitutive gender differences on metabolism and hormonal regulation of body fat and lipids mediate this heterogeneous response to food insecurity (Magkos and Mittendorfer, 2009; Shi and Clegg, 2009). We also showed that food insecurity was not associated with high TC among either men or women. This was consistent with most of previous studies (Dixon et al., 2001; Holben and Pheley, 2006; Seligman et al., 2010; Tayie and Zizza, 2009).

There are possible mechanisms whereby food insecurity may increase the risk of low HDL-C among women. We have shown that obesity may be a partial mediator of the relationship

between food insecurity and low HDL-C among women. It is well known that obesity decreases HDL-C by inducing hypertriglyceridemia, impairing lipolysis of chylomicrons, and increasing exchange of cholesteroesters and triglycerides between very low-density lipoproteins (VLDL) and HDL and LDL by cholesterylester-transfer-protein (Klop et al., 2013). Food insecurity may also be associated with low HDL-C through poor dietary choices, such as suboptimal intakes of micronutrients which are important for regulation of serum lipid levels (Bowman, 2007; Kirkpatrick and Tarasuk, 2008; Mello et al., 2010).

Our findings should be readily generalizable to the adults living in Wisconsin, as we studied a representative sample of this population. Also, food security history, covariates, and outcomes were assessed at the individual level, and, therefore, the possibility of bias due to exposure misclassification is decreased compared to studies that assessed food security history at the household level. In addition, food security referred to a period of 12 months before the physical exam, which would be a more specific measurement than those from assessments without a period of reference.

We measured food security history in non-standard way using two items. However, sensitivity and specificity of our definition of food insecurity in comparison with low and very low food security definitions used by the USDA were 93.3% and 90.0%, respectively. This may have resulted in some degree of exposure misclassification and bias towards the null, since exposure and outcome measurements were obtained by independent, mutually blinded methods. Also, serum triglycerides, a hallmark of obesity-related dyslipidemia, and LDL-C were not included in our analysis, since participants were not asked to fast before their blood sample was drawn. Furthermore, an analysis of continuous outcomes was not possible because some participants were taking lipid-lowering drugs. Our sample is predominantly made up of white-on-Hispanic individuals, thus this sample composition limits the generalizability of our findings to the racial minority population which is generally at increased risk of food insecurity. Finally, the cross-sectional nature of the data precludes establishing causality for observed associations between food insecurity and dyslipidemia. In addition, there is a potential temporal issue for some participants, in that our study defined food insecurity in the last 12 months, and the relationship between food insecurity and dyslipidemia may evolve over a longer window of exposure than we were able to show here.

Conclusions

Despite these limitations, this study improves current understanding of how food insecurity is associated with dyslipidemia by providing important population-based data. Gender differences are important to note in understanding high risk populations and designing effective education and training. Our study suggests that a recent history of food insecurity is associated with a higher likelihood of low HDL-C among women, but not among men. Obesity appears to be a partial mediator of the association between the food insecurity and low HDL-C. Various interventions to reduce food insecurity and to encourage healthy diet may have the potential to prevent the development of obesity and low HDL-C among women.

Further research is warranted to identify the causal mechanisms mediating the associations of food insecurity with obesity and dyslipidemia, for the final goal of developing cost-effective, sustainable, and effective public health programs.

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Abbreviations

ACASI	audio computer-assisted self-administered interviews
AOR	adjusted odds ratio
BMI	body mass index
CI	confidence interval
FPL	federal poverty level
HDL-C	high-density lipoprotein cholesterol
IRB	institutional review board
LDL-C	low-density lipoprotein cholesterol
MET	metabolic equivalent of task
NHANES	National Health and Nutrition Examination Survey
OR	odds ratio
SHOW	Survey of the Health of Wisconsin
TC	total cholesterol
USDA	United States Department of Agriculture
VLDL	very low-density lipoproteins

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Highlights

- The association of food insecurity with dyslipidemia was examined.
- Food insecurity was not associated with high total cholesterol.
- Food insecurity was associated with a higher likelihood of low HDL-C only in women.
- Obesity appears to be a partial mediator of the association in women.

Table 1

Characteristics of Adults Living in Wisconsin With and Without a Recent History of Food Insecurity, 2008–2011

Characteristic	Food Insecure (n=336)		Food Secure (n=1327)		P-value
		95% CI		95% CI	
Age (years) (mean)	40.8	39.1, 42.6	47.8	46.6, 49.0	<0.001
Female (%)	52.6	46.3, 58.8	46.8	44.1, 49.4	0.12
Race/Ethnicity (%)					
Non-Hispanic White	80.8	75.4, 85.3	91.0	88.8, 92.8	<0.001
Other minorities	19.2	14.7, 24.6	9.0	7.2, 11.2	
Education <high school (%)	9.9	6.3, 15.3	4.6	3.4, 6.2	0.02
Annual household income (US \$) (%)					
<\$20K	24.9	19.2, 31.7	8.4	6.3, 11.0	<0.001
\$20–\$45K	37.8	31.4, 44.6	21.7	19.3, 24.3	
>\$45K	37.3	30.2, 45.0	69.9	66.6, 73.1	
Poverty (%)					
<100% of FPL	21.3	16.1, 27.6	5.1	3.6, 7.0	<0.001
100–200% of FPL	31.5	25.2, 38.4	12.8	10.5, 15.5	
>200% of FPL	47.2	39.6, 55.0	82.1	78.5, 85.3	
Lack of health insurance (%)	26.4	20.9, 32.8	9.9	8.1, 12.0	<0.001
Self-reported poor or fair health (%) ^a	18.8	13.7, 25.1	7.3	5.9, 8.9	<0.001
Unemployed (%)	12.5	8.2, 18.7	5.0	3.6, 6.8	0.01
Current smoker (%)	33.6	27.2, 40.6	15.0	12.4, 18.0	<0.001
Physically active (%) ^b	63.8	56.5, 70.5	65.3	62.4, 68.2	0.70
Heavy drinker (%) ^c	14.8	10.1, 21.3	16.0	13.0, 19.6	0.72

Abbreviations: CI, confidence interval; FPL, federal poverty level

^a Self-reported poor or fair health: self-reported general health status is poor or fair based on the first question of Short Form-12 (SF-12) health survey

^b Physically active: self-reported physical activity is 600 MET (metabolic equivalent of task)-minutes/week or higher

^c Heavy drinker: >14 drinks/week for males or >7 drinks/week for females

Age-Adjusted Prevalence of Obesity and Dyslipidemia by Food Security History Among Women Living in Wisconsin, 2008–2011

Table 2

Characteristic	Food Insecure (n=189)		Food Secure (n=711)		P-value
	95% CI		95% CI		
Obesity (%)	51.9	41.2, 62.6	34.5	30.5, 38.5	0.003
High TC (%)	22.1	15.0, 29.1	23.3	19.7, 26.9	0.77
Low HDL-C (%)	67.4	58.9, 75.9	46.7	41.6, 51.9	<0.001

Abbreviations: BMI, body mass index; HDL-C, high-density lipoprotein cholesterol TC, total cholesterol

Table 3

Age-Adjusted Prevalence of Obesity and Dyslipidemia by Food Security History Among Men Living in Wisconsin, 2008–2011

Characteristic	Food Insecure (n=147)		Food Secure (n=616)		P-value
	95% CI		95% CI		
Obesity (%)	39.3	29.6, 49.0	37.1	31.5, 42.7	0.73
High TC (%)	27.9	20.5, 35.3	30.8	26.1, 34.6	0.58
Low HDL-C (%)	57.1	47.3, 67.0	51.1	46.3, 55.8	0.28

Abbreviations: BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; TC, total cholesterol

Table 4

Adjusted Odds Ratios of Obesity and Dyslipidemia Associated With a Recent History of Food Insecurity, by Gender, Among Adults Living in Wisconsin, 2008–2011

Outcome	Men				Women				<i>P</i> for interaction ^c
	Model 1 ^a		Model 2 ^b		Model 1 ^a		Model 2 ^b		
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	
Obesity	1.09	0.66, 1.79			2.09 ^d	1.28, 3.41			0.04
High TC	1.01	0.60, 1.71	0.95	0.56, 1.62	0.62	0.34, 1.12	0.57	0.31, 1.02	0.40
Low HDL-C	1.14	0.72, 1.80	1.10	0.68, 1.80	2.31 ^d	1.42, 3.76	2.04 ^d	1.15, 3.64	0.01

Abbreviations: CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; OR, odds ratio; TC, total cholesterol

^aModel 1: adjusted for age, race, education, household income, smoking, alcohol intake, and physical activity

^bModel 2: adjusted for variables in model 1 plus obesity

^cInteraction between food insecurity and sex with regard to outcome

^d*P*-value <0.05