ORIGINAL RESEARCH

Household Food Insecurity and Obesity, Chronic Disease, and Chronic Disease Risk Factors

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ABSTRACT. *Context.* Studies examining the association between food insecurity and obesity in adults have produced conflicting results, and information is limited on the relationship between food insecurity and adult chronic health conditions, particularly in a high-risk population.

Objective. To examine the association between household food insecurity and self-reported weight status and chronic disease in the Lower Mississippi Delta.

Design. A two-stage stratified cluster sample representative of the population in 36 counties in the Lower Delta. Data were collected in a cross-sectional telephone survey using list assisted random digit dialing telephone methodology.

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Setting and Participants. A randomly selected sample of 1,457 adults from a free-living population.

Main Outcome Measures. US Food Security Survey Module, self-reported height and weight status (obesity = body mass index > 30 kg/m^2), and self-reported hypertension, high cholesterol, diabetes, heart disease, stroke, and a marker for metabolic syndrome.

Results. In food-insecure adults, 42.3% were obese, a significantly higher rate than food secure adults (33.2%). After controlling for demographic variables, food insecurity was not independently associated with obesity. Income and the interaction between race and gender were significant predictors of obesity. Food insecure adults were significantly more likely to report hypertension (45.1% vs. 29.5%) diabetes (15.0% vs. 9.3%), heart disease (13.5% vs. 6.8%) and metabolic syndrome (10.1% vs. 4.4%). After controlling for demographic variables, food insecurity was associated with high cholesterol (Odds Ratio [OR] 1.65; 95% Confidence Interval [CI], 1.0 to 2.7), heart disease (OR 2.7; 95% CI, 1.5 to 4.8), and metabolic syndrome (OR 2.8; 95% CI, 1.4 to 5.5).

Conclusions. The relationship between food insecurity and obesity in a high-risk population, may be due to income and demographic variables. Individuals in a rural high-risk population with high cholesterol, heart disease, and metabolic syndrome have a high likelihood of being food-insecure. Nutritional interventions targeting high-risk populations should address food insecurity. doi:10.1300/J477v01n02_04 *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <http://www.HaworthPress.com>*

KEYWORDS. Food insecurity, obesity, chronic disease

INTRODUCTION

Food insecurity, obesity, and chronic diseases are common and interrelated public health problems. Among residents in the Lower Mississippi Delta (LMD), food insecurity is twice[1] that of the US population,[2] obesity is 1.5 to 2 times greater,[3,4] and chronic illness and chronic disease risk factors are 1.5 times greater[3,4] than corresponding rates nationwide from a comparable time period.[5-7] Food insecurity has been defined as the "limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways."[8] A related concept, food

insufficiency, is defined as inadequacy in the amounts of food intake because of a lack of money or resources to access enough food.[9] Several studies have investigated an association between food insecurity or food insufficiency and obesity,[10-12] but few studies have investigated their association with specific chronic disease. Because of the co-existence and high prevalence of food insecurity, obesity, and chronic disease, data from residents in the LMD may help clarify the purported relationship between food insecurity and obesity and inform the relationship between food insecurity and chronic disease.

The paradoxical relationship between food insecurity and obesity was first described by Dietz[13] "as an adaptive process to food shortages whereby increasing the consumption of inexpensive energy dense foods, results in increasing body mass." Subsequent studies have given conflicting results regarding the association between food insecurity and obesity. One study found food insecurity was associated with obesity in women,[12] two studies found food insufficiency[9] associated with overweight status in women[11,14] but not with obesity,[14] and another study found food insufficiency was not associated with measures of underweight or overweight[15] after adjustment for confounding variables. Plausible mechanisms[16] that explain why limited availability of food may lead to obesity[13] include cheaper costs, and overconsumption, of energy-dense foods;[13,16] overeating when food becomes available; metabolic changes that permit more efficient use of energy;[17] fears of food restriction;[18-20] preoccupation with eating,[21,22] and higher susceptibility to hunger, disinhibition and environmental cues.[23]

Obesity[24] and other chronic diseases such as Type 2 diabetes, and cardiovascular disease risk follow a socioeconomic gradient whereby disease burden is greatest among those with limited resources, racial-ethnic minorities, and the poor.[25] Among women, obesity is inversely related to income, especially in non-Hispanic blacks and Mexican Americans.[26] Because food insecurity and disease are associated with a variety of common socioeconomic factors, it is important to control for important potentially confounding variables, like household income, which may be the independent cause of the apparent relationship.

Immediate consequences of household food insecurity are irregular household food supply, perturbed eating patterns, and poor diet quality.[27-29] In turn, these consequences could decrease nutrient intake and other diet factors[30-32] that play key roles in the prevention and control of chronic disease, and thereby increase the likelihood of chronic disease. In a model proposed by Campbell,[33] food security status performs both as an *outcome variable* (from economic inadequacy) and a *determinant*

variable (for other conditions such as poorer health) via diminished nutrient and diet quality. Despite its importance, few studies have fully investigated the interrelationship between food insecurity and chronic disease. In one study, Vozoris et al. reported that food-insufficient adults in Canada[15] had a 1.6 to 2.5 times greater risk of reporting heart disease, diabetes, high blood pressure or food allergies than food-sufficient individuals. Two other studies found that food insecurity prevented optimal control of diabetes.[34,35]

To address the limitations that exist in identifying the associations between household food insecurity and self-reported weight status (obesity) and chronic disease, the following study was conducted. In a representative sample of adults living in the LMD regions of Louisiana, Arkansas, and Mississippi, household food security status measured by the US Food Security Survey Module[8] and self-reported measures of height, weight, and chronic diseases were collected. The following questions were examined: (1) Is household food insecurity in the LMD associated with adult obesity? (2) If so, do associations between food insecurity and obesity persist after adjusting for important demographic variables? (3) Is household food insecurity in the LMD associated with other chronic conditions, such as hypertension, high cholesterol, diabetes, heart disease, metabolic syndrome, and stroke? (4) If so, do associations between food insecurity and chronic diseases persist after adjusting for important demographic variables?

METHODS

Residents of the Lower Mississippi Delta region comprise a unique but largely unstudied high-risk population with respect to nutritional health. This predominantly rural, traditionally agricultural region bordering the Mississippi River in Arkansas, Louisiana, and Mississippi has a high prevalence of poverty[1,36] and diet-related chronic diseases relative to their peers elsewhere in the U.S.[4,37] The Lower Mississippi Delta Nutrition Intervention Research Initiative (Delta NIRI) was established to collect baseline data on the nutritional health of Delta residents in order to develop and evaluate nutrition interventions.[38]

Study Design

Prior to launching interventions, Delta NIRI conducted a survey on the nutritional health of the region in Foods of Our Delta (FOODS) 2000,

across-sectional telephone survey of a representative sample of the population three years of age and older conducted between January and June 2000 in 36 LMD counties in Arkansas, Louisiana, and Mississippi. A stratified cluster sampling plan was used to assign 36 Delta NIRI counties to nine strata according to percent urban,[36] percent black, and percent living below the federal poverty level. Eighteen counties (two from each stratum) were selected with probability proportional to size to represent the stratum in the telephone sample. List-assisted random digit dialing[39] methodology was used to select a random sample of telephone numbers from the eligible blocks of numbers in these 18 counties; non-residential and non-working numbers were identified and removed.

Of the 3455 eligible households, 1293 or 37.4% refused to participate. A total of 1751 adults completed the first interview (dietary intake and health data, including self-reported weight and height) and 1662 completed the next interview (food security survey). Three of the 1662 were later found to be teenagers and were excluded, yielding a final sample size of 1659. A total of 1457 households who had complete data for outcome and predictor variables were used in the present analyses.

Data Collection

A computer-assisted telephone interview was conducted to determine the eligibility of households. An eligible household was one that had at least one member 18 years of age or older; the telephone number was not for business use only; and the household was located in one of the 18 Delta NIRI sample counties. During this initial interview, information on age, gender, ethnicity, and the presence of children in the household was determined. All members of the household were enumerated and one adult per household was selected randomly.[40]

In the opening statements during the recruitment interview, potential respondents were told of the voluntary nature of participation in the survey and protection of their privacy, and that participation would not affect government benefits. A brochure was available for respondents who asked for additional information. The names of two contact persons were provided for respondents who had additional questions or concerns. The survey was reviewed by and received approval from the Institutional Review Board at each of the participating institutions.

A second non-scheduled telephone call was made to collect information using a two-part questionnaire that included a 24-hour dietary recall, and a series of trailer questions about the usual intake, water

consumption, height, weight, the presence of selected chronic health conditions, and general self-reported health. Approximately one to two weeks later, the adult in the household who had completed the dietary interview was contacted again to answer questions including the food security status of the household.

Predictor Variable: Household Food Security Status

In this survey food security status was evaluated using the 18 question US Food Security Survey Module[8] to construct the 12-month food security scale that classifies households as food-secure or food-insecure with or without hunger. *Food-Secure* is defined as households that show no or minimal evidence of food insecurity; *Food-Insecure without hunger* is evident in the household with concerns and adjustments to household food management, including reduced quality of diets. Little or no reduction in household members' food intake reported; *Food-Insecure with hunger* is the situation where the food intake for adults and children in the household has been reduced to the extent that they have repeatedly experienced the physical sensations of hunger. For the present analysis, food security status was collapsed to a dichotomous variable (food secure and food insecure) because the 3-level variable when cross-tabulated with levels of other variables resulted in few responses in some cells.

Health Outcomes

Body Mass Index (BMI) (Kg/M^2)

Adults in the study self-reported their height and weight, from which the body mass index was computed, defined as weight in kilograms divided by height in meters squared (kg/m^2). All individuals were classified in one of the following weight categories. Normal weight (BMI $<$ 25), overweight (BMI $\geq$ 25 but $<$ 30), or obese (BMI $>$ 30.0). These weight categories conform to the guidelines for criteria of obesity from the US Department of Health and Human Services and the World Health Organization.[41]

Other Chronic Conditions

Based on the health component of the 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII 1994-1996),[42] respondents were

asked whether they had a particular condition, or had been told by a doctor that they had the condition. A recent report found good agreement between self-report questionnaires and medical record data for diabetes, hypertension, cardiac infarction, and stroke.[43] The self-reported physician-diagnosed chronic diseases relevant to the present study were high cholesterol, hypertension, heart disease, diabetes, and stroke. Dietary behavior is implicated either in the etiology, or in the management of each of these conditions.

Metabolic syndrome is defined according to Adult Treatment Panel III criteria by the presence of ≥ 3 of the following five risk factors,[44] namely, (1) abdominal obesity, (2) high triacylglycerol concentrations, (3) low HDL-cholesterol concentrations, (4) high blood pressure, and (5) high fasting plasma glucose concentrations. The metabolic syndrome was approximated by respondents who had at least three or more of the following self-reported conditions–high cholesterol, high blood pressure, diabetes, or heart disease.

Categorization of Variables

The outcome variables and covariates used in the analysis were categorized as follows. Weight status was categorized as normal weight, overweight or obese. Presence of self-reported health condition (high cholesterol, heart disease, diabetes, hypertension, or stroke) was either present or not; food security status was computed according to standard measures of the 18-question US Food Security Survey Module[8] and summarized by two categories, Food-Secure or Food-Insecure. Total household income for the previous 12 months was self-reported in increments of $5000 or $10,000 ranging from less than $5000 to $50,000 or more, and income categories were summarized intro three categories ($0-14,999, $15,000-29,999, and < $30,000). Age was categorized into three categories: 18 to 44, 45 to 64, and > 65 years. Education was categorized into three categories: Less than high school, high school graduate or equivalent, and college graduate. Household size was continuous, one to 11 people supported by household income. Ethnic groups were whites and blacks of non-Hispanic origin.

Statistical Methods

The procedures for weighting and statistical adjustments for the complex survey design have been previously described.[1,4] Research questions 1 and 3 were analyzed by computing the unadjusted association between

food security status and obesity (or chronic disease) using Cochran-Mantel-Haentzel Chi square analyses. Research questions 2 and 4 were analyzed by computing the relationship between each outcome variable (presence or absence of obesity or chronic disease condition) and food security status, adjusted for important covariates, using four separate logistic regression models. The full model contained the independent variables: race and gender, age group, household size, education, household food security status, and household income. In the next model, income was dropped from the full model to determine the full effect of food insecurity. In the subsequent model, food security status was dropped and income reentered, and in the last model education was dropped from the full model. SUDAAN V8.0 was utilized to compute appropriate statistical tests accounting for survey design.

RESULTS

The present analysis of the FOODS 2000 sample was comprised of 1457 households. In the full sample, 22% were food-insecure and 35% were obese. Thirty-two percent (31.8%) had income < $14,999 (Table 1). Over half of the sample was female (63.6%), about half (50.4%) were black, and about half (48.7%) were between the ages of 18 and 44 years. The final sample reflected the demographic characteristics of the target population.

As shown in Table 2, a significant difference in the proportional distribution of weight categories (normal, overweight, or obese) was observed between food-security status. The prevalence of obesity was higher among food insecure households ($P = 0.004$).

The association between food insecurity and obesity varied by race, gender, or household income is shown in Table 3. Females had a higher prevalence of obesity in food-insecure household (44.6%) versus food-secure households (33.7%)($P = 0.03$). This association was not significant among males. Among black or white adults, obesity was not significantly associated with household food insecurity status. Adult obesity was significantly more prevalent among food-insecure adults than food-secure adults (57.8% vs. 29.4%) in the higher-income households (≥ $30,000), ($P = 0.004$).

A model testing the association between food insecurity and obesity controlling for relevant covariates is presented in Table 4. Results are based on the adjusted logistic regression analyses of a full model where an interaction term between race and gender emerged as significant and

TABLE 1. Characteristics of Free-Living Adults in Lower Mississippi Delta*

Characteristic	n (%)†
Sex	
Male	531 (36.4)
Female	926 (63.6)
Race/ethnicity	
Black	734 (50.4)
White	723 (49.6)
Household income ($)	
<14,999	463 (31.8)
15,000-29,999	402 (27.6)
>30,000	592 (40.6)
Age group (years)	
18-44	709 (48.7)
45-64	469 (32.2)
≥65	279 (19.1)
Education	
<High school	350 (24.0)
High school or equivalent	835 (57.3)
College	272 (18.7)
Food-security status	
Food-Secure	1137 (78.0)
Food-Insecure	320 (22.0)
Total	1457

Estimates are from a subset of participants in Foods of Our Delta Survey, 2000. (References 1, 3)
*All variables are self-reported.
†weighted percents.

showed that black females had the highest risk of obesity. Food insecurity was not a significant predictor of obesity, after adjusting for race and gender, household income, and household size for either the entire sample (Table 4) or in separate analyses with females only (data not shown). Income was a significant predictor of obesity ($P = 0.004$), as well as age ($P < 0.001$). Results testing the association between food security status and self-reported chronic disease are displayed in Table 5. Only the prevalence of high cholesterol was not greater among food-insecure than food-secure households. Models of self-reported

TABLE 2. Proportion of Food-Secure and Food-Insecure Households Having a Body Mass Index (BMI)* Indicative of Normal Weight, Overweight, or Obesity

Weight Status	Food-Secure (n = 1137)		Food-Insecure (n = 320)	
	% (SE)	n	% (SE)†	n
Obese	33.2 (1.5)*	377	42.3 (3.0)*	135
Overweight	35.2 (1.8)	388	24.9 (2.6)	91
Normal	31.5 (1.5)	372	32.9 (3.1)	94

*Normal weight, BMI < 25; overweight, BMI ≥ 25 but < 30; or obese, BMI ≥ 30.0.
†Cochran-Mantel-Haenszel test of association for food security status and three categories of adult weight (P- value = 0.004).

TABLE 3. Prevalence of Obesity* by Food Security Status and Stratified by Race/Ethnicity, Gender, and Household Income

	Food-Secure (n = 1137)	Food-Insecure (n = 320)	P-Value
	% obese, mean (SE)	% obese, mean (SE)	
Total sample	33.2 (1.5)	42.3 (3.0)	0.009
Race			
Black	38.5 (2.7)	46.1 (3.6)	NS
White	30.2 (1.9)	31.0 (4.7)	NS
Gender			
Female	33.7 (1.9)	44.6 (4.1)	0.03
Male	32.7 (2.4)	38.3 (4.9)	NS
Household Income ($)			
≤14,999	31.0 (3.2)	39.3 (4.5)	NS
15,000-29.999	42.1 (3.4)	43.0 (6.1)	NS
≥30,000	29.4 (2.2)†	57.8 (8.1)‡	0.004

*Obesity = BMI ≥ 30.0.
†Sample number for being food-secure and highest-income tertile, n = 557.
‡Sample number for being food-insecure and highest-income tertile, n = 35.

chronic disease by food security status controlling for relevant covariates are shown in Table 6. Controlling for relevant covariates, food insecurity significantly increased the odds of high cholesterol (P = 0. 04), heart disease (P = 0. 001), and metabolic syndrome (P = 0. 003). An interaction term between race and gender emerged as significant and showed that white males had the highest risk of heart disease. Income was also a significant predictor for heart disease (P = 0. 01).

TABLE 4. Adjusted Odds Ratio for Obesity Among Adults by Food Security Status and Other Characteristics

Variable	Level	Odds Ratio (95% CI)	*P*-Value
Intercept	Intercept	0.32 (0.21,0.49)	<0.0001
Race × gender	White male	0.60 (0.43,0.83)	0.0001
	White female	0.42 (0.30,0.58)	
	Black male	0.53 (0.34,0.83)	
	Black female	1.00	
Age (years)	18 to 44	1.23 (0.85,1.79)	<0.0001
	45 to 64	2.17 (1.43,3.30)	
	>65	1.00	
Household size	Continuous	1.14 (1.03,1.26)	0.01
Education	College	1.06 (0.67,1.68)	NS
	High school	1.28 (0.90,1.81)	
	<High school	1.00	
Food security status	Food-Insecure	1.17 (0.85,1.62)	NS
	Food-Secure	1.00	
Income ($)	>30,000	0.88 (0.64,1.20)	0.004
	15,000-29,999	1.46 (1.08,1.98)	
	<14,999	1.00	

TABLE 5. Prevalence of Self-Reported Chronic Disease by Food Security Status

Disease	Food-Secure (n = 1137) (%)	Food-Insecure (n = 320) (%)	*P*-Value[‡]
Hypertension	29.5 ± 1.5[*]	45.1 ± 3.3	<0.0001
High cholesterol	17.8 ± 1.1	20.4 ± 2.5	NS
Diabetes	9.3 ± 1.1	15.0 ± 2.0	0.03
Heart disease	6.8 ± 0.7	13.5 ± 2.2	0.007
Metabolic syndrome[†]	4.4 ± 0.6	10.1 ± 1.9	0.007
Stroke	1.8 ± 0.4	5.2 ± 1.4	0.03

[*] Values are mean ± SEM.
[†] Individuals who had at least three or more of the following self-reported conditions: diabetes, high cholesterol, high blood pressure, or heart disease.
[‡] Probability that disease prevalence differed by food security status.

DISCUSSION

Although advances in nutrition research over the past decades have demonstrated the role of nutrition in the prevention of disease,[45] our knowledge of how food insecurity and fluctuations in nutritional adequacy

TABLE 6. Adjusted Odds Ratio for Self-Reported Chronic Disease Among Adults by Food Security Status and Other Characteristics

		High Cholesterol		Heart Disease		Metabolic Syndrome	
Variable	Level	Odds Ratio (95% CI)	*P*	Odds Ratio (95% CI)	*P*	Odds Ratio (95% CI)	*P*
Intercept	Intercept	0.48 (0.29,0.81)	0.007	0.33 (0.17,0.62)	<0.001	0.17 (0.06,0.44)	<0.001
Race × Gender	White male	1.60 (0.93,2.77)	NS	3.28 (1.72,6.19)	<0.001	1.58 (0.73,3.41)	NS
	White female	1.38 (0.85,2.24)		1.42 (0.77,2.62)		0.99 (0.50,1.97)	
	Black male	1.15 (0.66,2.00)		0.68 (0.28,1.66)		1.33 (0.49,3.66)	
	Black female	1.00		1.00		1.00	
Food Security status	Food Insecure	1.65 (1.02,2.65)	0.03	2.69 (1.51,4.81)	0.001	2.79 (1.42,5.48)	0.003
	Food Secure	1.00		1.00		1.00	
Income ($)	>30,000	1.10 (0.71,1.71)	NS	0.36 (0.18,0.73)	0.005	0.81 (0.33,2.04)	NS
	15,000-29,999	0.75 (0.49,1.16)		0.43 (0.24,0.76)		0.54 (0.27,1.10)	
	<14,999	1.00		1.00		1.00	

contribute to obesity, disease, and other negative health outcomes is limited. This study examined the relation between food insecurity and specific health outcomes among adults using standardized sampling techniques in a representative probability sample. These findings are representative of adults in 36 counties of the Delta region of Arkansas, Louisiana, and Mississippi, a high-risk region susceptible to food insecurity, obesity, and chronic disease.

The first aim of this study was to determine the association between food insecurity and obesity. Adults in food-insecure households were more likely to be obese than their food-secure counterparts. However, the magnitude of the association between food insecurity and obesity was attenuated and became non-significant after controlling for several demographic variables. Income became a significant predictor of obesity even in the presence of food insecurity. Our findings confirm those of Laraia et al.[46] who analyzed data from two states contributing to the Behavioral Risk Factor Surveillance System, and found a strong relationship between food insufficiency and obesity but was strongly accounted for by the influences of socioeconomic variables. A recent report by Bhattacharya et al.[47] found a moderately weak ($P = 0.10$) relationship between selected questions of the Food Security Module and BMI in adults in the NHANES III survey. Other studies confirming our results are those of Vozoris et al.[15] and Basiotis[14] who found no association in women between food insufficiency and being obese (defined as having a BMI > 30). Taken together these findings suggest that an apparent relationship between obesity and food insecurity is complex, involving the strong interrelationship of both factors with socioeconomic status. The increased risk of disease as socioeconomic level decreases is one of the most pervasive and enduring observations in public health. Poverty impacts the ability to obtain food, housing, and medical care,[25,26] and is perhaps a proxy for susceptibility to multiple health risks.

Another explanation for the inconsistency between these current findings and others[11,12] for the relationship between food insecurity and obesity/overweight may rest on methodological differences in the measurement of outcome and predictor variables. We and others[12] used obesity as the primary outcome defined by the cut point of BMI > 30;[48] Townsend[11] used overweight as the primary outcome, defined by the cut point of BMI > 27. In the present study food security status was assessed by the most comprehensive instrument yet developed,[49] the US Food Security Survey Module,[8] others used single questions,[11] non-standard selections of questions from established measures,[12] or by a modified 10-item food security scale.[50]

In the study conducted in California women,[12] food insecurity was associated with an increased likelihood of obesity in non-whites, but not in non-Hispanic white women. A closely related finding in the present study, was the significant interaction between gender and race, such that black females had the highest rate of obesity, consistent with previously reported high rates of obesity among black women.[26] Causes of their obesity among this subgroup have been attributed to over consumption of high energy, low nutrient dense foods, physical inactivity, and less inclination to change their physical activity.[51-53]

Our previous findings[54] and those of others[55] examined the association of food-security status with general health and physical and mental health status. The third aim of this study was to determine the association between food insecurity and chronic disease outcomes. Our findings isolated the relationship of food insecurity to heart disease, high cholesterol, and metabolic syndrome, controlling for important covariates. These results confirm the findings of Vozoris et al.[15] who found food insufficiency related to heart disease, diabetes, and high blood pressure.

Previous studies have shown that food insecurity entails adjustments in the household food supply, which diminish the quality, variety of foods,[27-29]and nutritional quality of the diet.[30,31,56] Our findings suggest that perturbations of the nutrient and dietary patterns associated with food insecurity may have a relationship to heart disease, diabetes, and high blood pressure. A healthy nutrient and food pattern, that is, low intake of cholesterol and saturated fats, and high intake of minerals, micronutrients, and antioxidants can reduce the risk of developing diabetes, high cholesterol, heart disease, and the metabolic syndrome. For example, at least eight to ten servings of fruits and vegetables decrease blood pressure.[57] In contrast, the diets consumed by low-income individuals tend to have higher levels of intake for refined grains, sweets, fats, and low-cost energy-dense foods, unlikely to provide recommended levels of micronutrients, lean meat, fish, fresh vegetables, and fruit.[16] We have previously shown that the dietary pattern of residents from the Lower Mississippi Delta[58] consisted of low fruit and vegetable intakes, a pattern similar to that reported in Southerners from the NHANES III survey and associated with higher levels of hypertension.[59] Compliance with recommended dietary management can be seriously compromised by episodes of food insecurity. Therefore, dietary deficiencies may explain higher rates of chronic illness among the food-insecure.

LIMITATIONS

This study was limited by several factors. First, both predictor and outcome variables, while measured with instruments with accepted reliability and validity, are self-reported and not based on clinical interviews. Second, the cross-sectional design limits causal interpretations. We cannot determine whether health deficits are the consequences of food deficiencies, or whether altered health status and physical limitations curtail the ability to either acquire food or to maintain employment and earn income that sustains food security and prevents hunger. Longitudinal data are needed to ascertain the directionality of associations. Limited access to health care could also contribute to poor health status. Access to health care providers, health clinics, insurance and prescription coverage is restricted in this rural region.

CONCLUSIONS AND IMPLICATIONS

This study was conducted to examine the relationship between household food insecurity and measures of chronic health and obesity. Our findings have three major implications. First, food insecurity could emerge as an important potential risk factor in some chronic disease, since adherence to healthy lifestyle behaviors that lower chronic disease risk is more difficult in resource-poor regions. Second, knowledge of these results can be used to design more efficient, community-based efforts to address food adequacy issues. Specifically, community members and researchers in the Lower Mississipi Delta region may develop nutritional interventions, taking into account the association between food insecurity and chronic disease, using the community-based participatory model.[60] Finally, both the measurement of food insecurity and efforts to address nutritional interventions accounting for food insecurity are immediate and important priorities for high-risk, minority, and medically underserved populations, such as that in the Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi.

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Drs. Stuff and Simpson had full access to all the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. Drs. Bogle, Casey, and Champagne contributed towards the Study concept and design. Drs. Bogle, Casey, Champagne, and Simpson were responsible for acquisition of data. Analysis and interpretation of data were carried out by Drs. Simpson, Gossett, Stuff, and Connell. Drs. Stuff, Casey, and Connell were responsible for the drafting of manuscript. Drs. Bogle, McCabe-Sellers, Harsha, Champagne, Weber, Szeto, Casey, Connell, and Stuff conducted a critical revision of manuscript for important intellectual content. Statistical expertise was provided by Drs. Simpson and Gossett.

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REFERENCES

1. The Lower Mississippi Delta Nutrition Intervention Research Consortium, Stuff JE, Horton JA et al. High prevalence of food insecurity and hunger in households in the rural Lower Mississippi Delta. *J Rural Health.* 2004;20:173-180.

2. Nord M, Kabbani N, Tiehen L, Andrews M, Bickel G, Carlson S. Household food security in the United States, 2000. Washington D.C.: Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture, Food Assistance and Nutrition Research Report. No. 21 2002:1-41.

3. Casey P, Horton J, Bogle M et al. Self-reported health status of residents of the Lower Mississippi Delta of Arkansas, Louisiana and Mississippi. FASEB J. 2002; 16:A233 (abstr).

4. Lower Mississippi Delta Nutrition Intervention Research Consortium. Self-reported health of residents of the Mississippi Delta. *J Health Care Poor Underserved.* 2004;15:645-662.

5. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA.* 2002;288:1723-1727.

6. Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States, 1991-1998. *JAMA.* 1999;282: 1519-1522.

7. Patterson PD, Moore CG, Probst JC, Shinogle JA. Obesity and physical inactivity in rural America. *J Rural Health.* 2004;20:151-159.

8. Bickel G, Nord M, Price C, Hamilton W, Cook J. *Measuring Food Security in the United States. Guide to Measuring Household Food Security. Revised 2000.* Alexandria, VA: Food and Nutrition Service, Office of Analysis, Nutrition, and Evaluation, U.S. Department of Agriculture 2000.

9. Briefel RR, Woteki CE. Development of food sufficiency questions for the Third National Health and Nutrition Examination Survey. *J Nutr Educ.* 1992;24: 24S-28S.

10. Olson CM. Nutrition and health outcomes associated with food insecurity and hunger. *J Nutr.* 1999;129:521S-524S.

11. Townsend MS, Peerson J, Love B, Achterberg C, Murphy SP. Food insecurity is positively related to overweight in women. *J Nutr.* 2001;131:1738-1745.

12. Adams EJ, Grummer-Strawn L, Chavez G. Food insecurity is associated with increased risk of obesity in California women. *J Nutr.* 2003;133:1070-1074.

13. Dietz WH. Does hunger cause obesity? *Pediatrics.* 1995;95:766-767.

14. Basiotis PP, Lino M. Food insufficiency and prevalence of overweight among adult women. Insight 26. *Family Economics and Nutrition Review.* 2003;15:55-57.

15. Vozoris NT, Tarasuk VS. Household food insufficiency is associated with poorer health. *J Nutr.* 2003;133:120-126.

16. Drewnowski A, Specter SE. Poverty and obesity: The role of energy density and energy costs. *Am J Clin Nutr.* 2004;79:6-16.

17. Alaimo K, Olson CM, Frongillo EA, Jr. Low family income and food insufficiency in relation to overweight in US children: is there a paradox? *Arch Pediatr Adolesc Med.* 2001;155:1161-1167.

18. Cade J, Upmeier H, Calvert C, Greenwood D. Costs of a healthy diet: Analysis from the UK Women's Cohort Study. *Public Health Nutr.* 1999;2:505-512.

19. James WP, Nelson M, Ralph A, Leather S. Socioeconomic determinants of health: The contribution of nutrition to inequalities in health. *BMJ.* 1997;314:1545-1549.

20. Kasper J, Gupta SK, Tran P, Cook JT, Meyers AF. Hunger in legal immigrants in California, Texas, and Illinois. *Am J Public Health.* 2000;90:1629-1633.

21. Polivy J, Zeitlin SB, Herman CP, Beal AL. Food restriction and binge eating: A study of former prisoners of war. *J Abnorm Psychol.* 1994;103:409-411.

22. Polivy J. Psychological consequences of food restriction. *J Am Diet Assoc.* 1996;96:589-592. 10.1016/S0002-8223(96)00161-7.

23. Provencher V, Drapeau V, Tremblay A, Despres JP, Lemieux S. Eating behaviors and indexes of body composition in men and women from the Quebec family study. *Obes Res.* 2003;11:783-792.

24. Sobal J, Stunkard AJ. Socioeconomic status and obesity: A review of the literature. *Psychol Bull.* 1989;105:260-275.

25. Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: How education, income, and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health.* 1992;82:816-820.

26. Jeffery RW. Socioeconomic status, ethnicity and obesity in women. *Ann Epidemiol.* 1996;6:263-265.

27. Kendall A, Olson CM, Frongillo EA, Jr. Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc.* 1996;96:1019-24. 10.1016/S0002-8223(96)00271-274

28. Klesges LM, Pahor M, Shorr RI, Wan JY, Williamson JD, Guralnik JM. Financial difficulty in acquiring food among elderly disabled women: Results from the women's health and aging study. *Am J Public Health.* 2001;91:68-75.

29. Tarasuk VS. Household food insecurity with hunger is associated with women's food intakes, health and household circumstances. *J Nutr.* 2001;131:2670-2676.

30. Rose D, Oliveira V. Nutrient intakes of individuals from food-insufficient households in the United States. *Am J Public Health.* 1997;87:1956-1961.

31. Dixon LB, Winkleby MA, Radimer KL. Dietary intakes and serum nutrients differ between adults from food-insufficient and food-sufficient families: Third National Health and Nutrition Examination Survey, 1988-1994. *J Nutr.* 2001;131:1232-1246.

32. Lee JS, Frongillo EA, Jr. Nutritional and health consequences are associated with food insecurity among U.S. elderly persons. *J Nutr.* 2001;131:1503-1509.

33. Campbell CC. Food insecurity: A nutritional outcome or a predictor variable? *J Nutr.* 1991;121:408-415.

34. Nelson K, Brown ME, Lurie N. Hunger in an adult patient population. *JAMA.* 1998;279:1211-1214.

35. Nelson K, Cunningham W, Andersen R, Harrison G, Gelberg L. Is food insufficiency associated with health status and health care utilization among adults with diabetes? *J Gen Intern Med.* 2001;16:404-411.

36. U.S. Department of Commerce, Economic and Statistics Administration Bureau of Census. Census 1990. Summary File 3. 1990 Census of Population and Housing. 1992.

37. Harsha D, Thornton A. *Health Status of Adults*. In: Harrison G, ed. Lower Mississippi Delta Nutrition Intervention Research Consortium. Nutrition and health status in the Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi: A review of existing data. Rockville, MD: Westat 1997:89-92.

38. Harrison G, ed. The Lower Mississippi Delta Nutrition Intervention Research Consortium. Nutrition and Health Status in the Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi: A Review of Existing Data. Rockville, MD: Westat, 1997.

39. Waksberg J. Sampling methods for random digit dialing. *J Am Stat Assoc.* 1978;73:40-46.

40. Kish L. Survey Sampling. New York, NY: John Wiley and Sons, Inc., 1965.

41. National Institutes of Health. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults:The Evidence Report. National Institutes of Health. *Obes Res.* 1998;6 Suppl 2:51S-209S.

42. Tippett KS and Cypel YS. US Department of Agriculture,Agricultural Research Service,Continuing Survey of Food Intakes by Individuals 1994-96. Design and operation: The Continuing Survey of Food Intakes by Individuals and the Diet and Health Knowledge Survey 1994-96. Nationwide Food Surveys Rep. No. 96-1. Tippett KS and Cypel YS. 1997.

43. Okura Y, Urban LH, Mahoney DW, Jacobsen SJ, Rodeheffer RJ. Agreement between self-report questionnaires and medical record data was substantial for diabetes, hypertension, myocardial infarction and stroke but not for heart failure. *J Clin Epidemiol.* 2004;57:1096-1103.

44. Expert Panel on Detection,Evaluation,and Treatment of High Blood Cholesterol in Adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA.* 2001;285: 2486-2497.

45. Committee on Diet and Health. *Diet and Health: Implications for Reducing Chronic Disease.* Washington DC: National Academy Press, 1989.

46. Laraia BA, Siega-Riz AM, Evenson KR. Self-reported overweight and obesity are not associated with concern about enough food among adults in New York and Louisiana. *Prev Med.* 2004;38:175-181.

47. Bhattacharya J, Currie J, Haider S. Poverty, food insecurity, and nutritional outcomes in children and adults. *J Health Econ.* 2004;23:839-862.

48. Burton BT, Foster WR, Hirsch J, Van Itallie TB. Health implications of obesity: An NIH Consensus Development Conference. *Int J Obes.* 1985;9:155-170.

49. Keenan DP, Olson C, Hersey JC, Parmer SM. Measures of food insecurity/security. *J Nutr Educ Behav.* 2001;33 Suppl 1:S049-S058.

50. Kaiser L, Townsend MS, Melgar-Quinonez HR, Fujii ML, and Crawford PB. Choice of instrument influences relations between food insecurity and obesity in Latino women. *Am J Clin Nutr.* 2004; 80: 1372-1378.

51. Sanderson BK, Foushee HR, Bittner V et al. Personal, social, and physical environmental correlates of physical activity in rural African-American women in Alabama. *Am J Prev Med.* 2003;25:30-37.

52. Ainsworth BE, Wilcox S, Thompson WW, Richter DL, Henderson KA. Personal, social, and physical environmental correlates of physical activity in African-American women in South Carolina. *Am J Prev Med.* 2003;25:23-29.

53. Diez-Roux AV, Northridge ME, Morabia A, Bassett MT, Shea S. Prevalence and social correlates of cardiovascular disease risk factors in Harlem. *Am J Public Health.* 1999;89:302-307.

54. Stuff JE, Casey PH, Szeto KL et al. Household food insecurity is associated with adult health status. *J Nutr.* 2004;134:2330-2335.

55. Pheley AM, Holben DH, Graham AS, Simpson C. Food security and perceptions of health status: A preliminary study in rural Appalachia. *J Rural Health.* 2002;18:447-454.

56. Cristofar SP, Basiotis PP. Dietary intakes and selected characteristics of women ages 19-50 years and their children ages 1-5 years by reported perception of food sufficiency. *J Nutr Educ.* 1992;24:53-58.

57. Appel LJ, Moore TJ, Obarzanek E et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. *N Engl J Med.* 1997;336:1117-1124.

58. Champagne CM, Bogle ML, McGee BB et al. Dietary intake in the Lower Mississippi Delta region: Results from the Foods of our Delta Study. *J Am Diet Assoc.* 2004;104:199-207. 10.1016/j.jada.2003.11.011

59. Hajjar I, Kotchen T. Regional variations of blood pressure in the united states are associated with regional variations in dietary intakes: The NHANES-III data. *J Nutr.* 2003;133:211-214.

60. Israel BA, Schulz AJ, Parker EA, Becker AB. Review of community-based research: assessing partnership approaches to improve public health. *Annu Rev Public Health.* 1998;19:173-202. 10.1146/annurev.publhealth.19.1.173.

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