Food Insecurity and Chronic Disease in US Young Adults: Findings from the National Longitudinal Study of Adolescent to Adult Health

Jason M. Nagata, MD, MSc[1], Kartika Palar, PhD[2], Holly C. Gooding, MD, MSc[3], Andrea K. Garber, PhD, RD[1], Kirsten Bibbins-Domingo, PhD, MD, MAS[2,4], and Sheri D. Weiser, MD, MPH[2]

[1]Department of Pediatrics, University of California, San Francisco, San Francisco, CA, USA; [2]Department of Medicine, University of California, San Francisco, San Francisco, CA, USA; [3]Department of Pediatrics, Emory University School of Medicine, Atlanta, GA, USA; [4]Department of Epidemiology and Biostatistics, University of California, San Francisco, San Francisco, CA, USA.

BACKGROUND: Food insecurity, or the limited or uncertain access to food resulting from inadequate financial resources, is associated with a higher prevalence of chronic disease in adulthood. Little is known about these relationships specifically in young adulthood, an important time for the development of chronic disease.

OBJECTIVE: To determine the association between food insecurity and chronic disease including diabetes, hypertension, obesity, and obstructive airway disease in a nationally representative sample of US young adults.

DESIGN: Cross-sectional nationally representative data collected from Wave IV (2008) of the National Longitudinal Study of Adolescent to Adult Health was analyzed using multiple logistic regression models.

PARTICIPANTS: US young adults ages 24–32 years old

MAIN MEASURES: Food insecurity and general health; self-reported diabetes, hypertension, hyperlipidemia, "very overweight," and obstructive airway disease; measured obesity derived from body mass index; and inadequate disease control (hemoglobin A1c $\geq$ 7.0%, blood pressure $\geq$ 140/90 mmHg) among those with reported diabetes and hypertension.

KEY RESULTS: Of the 14,786 young adults in the sample, 11% were food insecure. Food-insecure young adults had greater odds of self-reported poor health (2.63, 95% confidence interval (CI) 1.63–4.24), diabetes (1.67, 95% CI 1.18–2.37), hypertension (1.40, 95% CI 1.14–1.72), being "very overweight" (1.30, 95% CI 1.08–1.57), and obstructive airway disease (1.48, 95% CI 1.22–1.80) in adjusted models compared with young adults who were food secure. Food insecurity was not associated with inadequate disease control among those with diabetes or hypertension.

CONCLUSIONS: Food insecurity is associated with several self-reported chronic diseases and obesity in young adulthood. Health care providers should screen for food insecurity in young adults and provide referrals when appropriate. Future research should evaluate the impact of early interventions to combat food insecurity on the prevention of downstream health effects in later adulthood.

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INTRODUCTION

Household food insecurity, defined as lacking "sufficient, safe, and nutritious food that meets individuals' dietary needs and preferences for an active and healthy life,"[1] affects nearly 50 million Americans.[2] The limited research on food insecurity among young adults (ages 24–32) estimates that food insecurity affects 14% of young women and 9% of young men in the USA.[3] Young adulthood represents an important developmental period that is distinct from adolescence and older adulthood.[4] Young adults have a higher prevalence of chronic diseases and are less likely to eat breakfast, exercise, and get regular medical and dental checkups than adolescents.[4] By age 32, fewer than 16% of young adults maintain optimal cardiovascular health, defined as normal blood pressure, glucose, and cholesterol without cardiovascular disease.[5, 6] Young adulthood is also a time of educational and economic transitions, which may increase risk for food insecurity.[7]

Food insecurity is associated with a number of adverse child and adult health outcomes. Among children and youth, food insecurity is associated with 1.4–2.6 times higher odds of having asthma, a type of obstructive airway disease.[8] Among adults, food insecurity is associated with diabetes, hypertension, and hyperlipidemia.[9, 10] Young adulthood represents a period during which individuals begin to develop these cardiometabolic disease risk factors;[11, 12] however, there is a paucity of research examining relationships between food insecurity and these chronic diseases in young adulthood. One of the few studies specifically in young adults found that food insecurity is associated with increased body mass index in young adult women.[3] However, the association between food insecurity and other cardiometabolic outcomes (diabetes, hypertension, and hyperlipidemia) in

young adulthood remains unknown. Furthermore, to our knowledge, there are no data on associations between food insecurity and obstructive airway disease, such as asthma, beyond the childhood period.[8]

The objective of this study is to determine the association between food insecurity and the prevalence of chronic diseases, specifically diabetes, hypertension, hyperlipidemia, obesity, and obstructive airway disease, after adjusting for potential confounders including socioeconomic status and health behaviors, using a nationally representative sample of young adult men and women in the USA. We hypothesize that food insecurity will be associated with greater prevalence of each of these chronic disease outcomes. Determining the association between food insecurity and chronic disease outcomes net of other risk factors may have relevance for public health and clinical practice as reducing food insecurity may be a specific target for interventions to reduce chronic disease.

METHODS

Study Population

This study uses cross-sectional data from the National Longitudinal Study of Adolescent to Adult Health (Add Health).[13] For this particular study, we used the nationally representative restricted-use cross-sectional sample from Wave IV of Add Health, collected in 2008 when participants were young adults (24–32 years). Wave IV was the only wave that collected information on food insecurity. The University of North Carolina Institutional Review Board approved all Add Health study procedures.

MEASURES

Primary Predictor Variable

Food insecurity: Food insecurity was based on self-report. Participants were asked, "In the past 12 months, was there a time when (you/your household were/was) worried whether food would run out before you would get money to buy more?" Response options were yes/no, with a 99.9% response rate. This single item has a 93% sensitivity and 85% specificity for detecting food insecurity as measured by the gold standard 18-item US Household Food Security Scale, and is considered the most inclusive question of the scale.[3, 14, 15] Negative impacts on chronic disease outcomes have been shown along the gradient of food insecurity including at "marginal" levels, which would be consistent with answering affirmatively to this question even if not to the questions on restricted intakes.[16] For the purposes of this study, we will refer to those with an affirmative response as "food insecure."[17, 18]

Outcome Variables

Poor health status: Self-reported poor health status was based on a response of "poor" to the interview question, "In general, how is your health?" Response options included "excellent," "very good," "good," "fair," or "poor."

Diabetes: Self-reported diabetes was based on an affirmative response to the interview question, "Has a doctor, nurse or other health care provider ever told you that you have or had: high blood sugar or diabetes (if female add, when you were not pregnant)?" Inadequate diabetes control was based on a measured hemoglobin A1c $\geq 7.0\%$ among those with self-reported diabetes.[9, 19]

Hypertension: Self-reported hypertension was based on an affirmative response to the interview question, "Has a doctor, nurse or other health care provider ever told you that you have or had: high blood pressure or hypertension (if female add, when you were not pregnant)?" Inadequate hypertension control was based on measured systolic blood pressure $\geq$ 140 mmHg or a measured diastolic blood pressure $\geq$ 90 mmHg[9, 20] using the average of two measurements 30 s apart from a factory-calibrated Microlife BP3MC1-PC-IB oscillometric blood pressure monitor (MicroLife USA, Inc.; Dunedin, FL) among those with self-reported hypertension.

Hyperlipidemia: Self-reported hyperlipidemia was based on an affirmative response to the interview question, "Has a doctor, nurse or other health care provider ever told you that you have or had: high blood cholesterol or triglycerides or lipids?"

"*Very overweight*": Self-report was based on a response of "very overweight" to the interview question, "How do you think of yourself in terms of weight?" Response options included "very underweight," "slightly underweight," "about the right weight," "slightly overweight," and "very overweight."

Obesity: Obesity was based on measured weight and height by the interviewer. Body mass index (BMI) was calculated using the standard formula weight (kilograms) divided by height (meters) squared ($BMI = weight/height^2$). Young adults with BMI ≥ 30 were classified as obese in accordance with guidelines from the US Centers for Disease Control and Prevention (CDC).[21]

Obstructive airway disease: Self-reported obstructive airway disease was based on an affirmative response to the interview question, "Has a doctor, nurse or other health care provider ever told you that you have or had: asthma, chronic bronchitis or emphysema?"

Covariates

Age, sex, and race/ethnicity were recorded based on self-report.[13] The highest level of education was based on self-report and categorized into less than high school (8th grade or less or some high school), high school graduate, some college (some college or vocational/technical training beyond high school), and college graduate (completed college, some

Table 1 Demographic and Health Characteristics of 14,786 Young Adult Participants in the National Longitudinal Study of Adolescent Health, Stratified by Food Security Status

	Food secure	Food insecure	*p*
	n = 13,139	*n* = 1,647	
	Mean ± SE/%[b]	Mean ± SE/%[b]	
Demographic characteristics			
Age, years	28.3 ± 0.1	28.4 ± 0.2	0.395
Sex			< 0.001
Female	48.2%	57.6%	
Male	51.8%	42.4%	
Race/ethnicity			< 0.001
White (non-Hispanic)	66.7%	58.0%	
Black/African American (non-Hispanic)	14.8%	25.3%	
Hispanic/Latino	12.2%	10.6%	
Asian/Pacific Islander (non-Hispanic)	3.6%	1.5%	
American Indian/Native American	1.8%	3.5%	
Other	1.0%	1.0%	
Educational attainment			< 0.001
Less than high school	7.9%	18.6%	
High school graduate	17.2%	23.4%	
Some college	42.4%	47.0%	
College graduate	32.6%	11.0%	
Household income, US dollars	63,473 ± 999	34,859 ± 1216	< 0.001
Smoker	28.1%	46.3%	< 0.001
Alcohol use	30.1%	22.0%	< 0.001
Physical activity (no. of bouts per week)	6.4 ± 0.1	6.0 ± 0.2	0.047
Health characteristics			
Poor health status, self-report	0.9%	3.1%	< 0.001
Chronic disease			
Diabetes, self-report	2.2%	5.1%	< 0.001
Hypertension, self-report	10.5%	15.7%	< 0.001
Hyperlipidemia, self-report	8.1%	7.5%	0.436
Obesity, measured body mass index	36.1%	43.3%	< 0.001
"Very overweight," self-report	12.7%	17.0%	< 0.001
Obstructive airway disease, self-report	14.3%	21.2%	< 0.001

All means and percentages are calculated with weighted data to reflect the representative proportion in the target US population
[b]*SE=standard error*

graduate school, or a masters or doctoral degree).[3] Household income was based on participant self-report. Participants were asked, "Thinking about your income and the income of everyone who lives in your household and contributes to the household budget, what was the total household income before taxes and deductions? Include all sources of income, including non-legal sources." Gaussian normal regression imputation method was used to impute household income for the 835 participants who either refused to answer the income question or stated they did not know. Household income was transformed to a measure expressed as a ratio of household income relative to the poverty level in 2008 based on number of household members reported by the participant using a similar approach as previous studies.[3, 17, 18] Presence of children in the household was based on participant report of any children currently living in the household. Physical activity was defined as the number of physical activity episodes for each of 49 possible activities from a pre-specified list reported in the past 7 days.[3] Physical activity duration and intensity data were not collected. Smokers were identified as those currently smoking tobacco more than 10 days in the prior 30 days.[3] Alcohol users were identified as those currently consuming alcohol on one or more days a week in the prior 30 days.[3] All prescription medications taken in the last 4 weeks were recorded and classified into therapeutic classifications,[22] including for diabetes[23] and hypertension[24] which have been described previously.

Statistical Analysis

Data analysis was performed in 2018 using STATA 15.0. Add Health's pre-constructed sample weights were used for all analyses to yield nationally representative estimates. Further details about the Add Health sampling strategy and application of sampling weights are described in detail elsewhere.[25, 26] Previous literature has shown that men and women have differential associations between food insecurity and BMI,[3] though most studies examining food insecurity and other chronic disease outcomes did not stratify by sex.[9, 10, 27] We therefore tested for an interaction between food insecurity and sex for each of the outcome variables. We did not find significant interactions between food insecurity and sex for any of the outcomes except for obesity. Consequently, our final models are not sex stratified other than for obesity. Multiple logistic regression analyses were used to identify associations with health outcomes (poor health status, diabetes, hypertension, hyperlipidemia, "very overweight," obesity, and obstructive airway disease) as the dependent variables, and food insecurity as the independent variable, adjusting for

Table 2 Association Between Food Insecurity and Chronic Disease in Young Adults 24–32 Years of Age, Adjusted for Demographic Variables and Health Behaviors

Health outcomes	Food insecurity	*p*	Food insecurity	*p*
	Odds ratio (95% CI)		Adjusted odds ratio[a] (95% CI)	
Poor health status, self-report	*3.34 (2.16–5.17)*	*< 0.001*	*2.63 (1.63–4.24)*	*< 0.001*
Chronic disease				
Diabetes, self-report	*2.40 (1.69–3.39)*	*< 0.001*	*1.67 (1.18–2.37)*	*0.004*
Hypertension, self-report	*1.60 (1.29–1.98)*	*< 0.001*	*1.40 (1.14–1.72)*	*0.002*
Hyperlipidemia, self-report	0.91 (0.72–1.15)	0.435	1.09 (0.85–1.40)	0.632
Obesity, measured body mass index	*1.35 (1.18–1.55)*	*< 0.001*	1.12 (0.97–1.29)	0.112
"Very overweight," self-report	*1.40 (1.17–1.68)*	*< 0.001*	*1.30 (1.08–1.57)*	*0.006*
Obstructive airway disease, self-report	*1.61 (1.35–1.91)*	*< 0.001*	*1.48 (1.22–1.80)*	*< 0.001*

Italics indicates $p < 0.05$
[a]*Adjusted for age, sex, race/ethnicity, education, household income relative to poverty level, children in household, smoking, alcohol, and physical activity*

race/ethnicity, age, education, household income relative to the poverty threshold, children in household, smoking, alcohol, and physical activity. Multiple logistic regression analyses were used to identify associations with inadequate disease control among participants with chronic disease (hemoglobin A1c ≥ 7.0% among participants with self-reported diagnosis of diabetes and blood pressure ≥ 140/90 mmHg for participants with self-reported diagnosis of hypertension) as the dependent variable, and food insecurity as the independent variable, adjusting for chronic disease–specific medications, race/ethnicity, age, education, household income relative to the poverty threshold, children in household, smoking, alcohol, and physical activity. $P < 0.05$ was considered statistically significant.

RESULTS

Of the 14,786 young adults (ages 24–32) included in Wave IV of Add Health, 11% were food insecure. The demographic and health characteristics of participants who were food secure versus food insecure are reported in Table 1 by sex. A greater proportion of young adults reporting food insecurity had poor health status, diabetes, hypertension, being "very overweight," obesity, and obstructive airway disease compared with young adults who reported being food secure.

Logistic regression analyses with food insecurity as the independent variable and self-reported health outcomes as the dependent variables are presented in Table 2. Food-insecure young adults had greater odds of self-reported poor health status (2.63, 95% confidence interval (CI) 1.63–4.24), diabetes (1.67, 95% CI 1.18–2.37), hypertension (1.40, 95% CI 1.14–1.72), "very overweight" (1.30, 95% CI 1.08–1.57), and obstructive airway disease (1.48, 95% CI 1.22–1.80) but not hyperlipidemia (1.09, 95% CI 0.85–1.40) compared with young adults reporting food security.

Although food insecurity was significantly associated with measured obesity by BMI in unadjusted models (1.35, 95% CI 1.18–1.55), this association was no longer statistically significant in fully adjusted models (1.12, 95% CI 0.97–1.29). Given a significant interaction between food insecurity and sex (1.54, 95% CI 1.08–2.19), we further stratified obesity analyses by sex. Food insecurity was associated with 1.12 (0.93–1.43) odds of obesity in females and 1.00 (0.78–1.28) odds in males, but neither association was statistically significant.

Among participants with self-reported chronic diseases, food insecurity was not associated with inadequate disease control measures among participants with diabetes and hypertension, even when controlling for potential confounders (Table 3).

DISCUSSION

This study finds that food insecurity is associated with poor health and multiple chronic diseases in a nationally represen-

Table 3 Association of Food Insecurity and Inadequate Disease Control Among Young Adults with a Chronic Disease Diagnosis, Adjusted for Demographic Variables and Health Behaviors

Health outcomes	Food insecurity	*p*	Food insecurity	*p*
	Odds ratio (95% CI)		Adjusted odds ratio[a] (95% CI)	
Inadequate diabetes control				
Hemoglobin A1c ≥ 7.0%	0.74 (0.36–1.51)	0.400	1.34 (0.74–2.44)	0.333
Inadequate hypertension control				
Systolic blood pressure ≥ 140 or diastolic blood pressure ≥ 90	0.91 (0.62–1.35)	0.640	1.17 (0.67–2.04)	0.570

[a]*Adjusted for age, sex, race/ethnicity, education, household income relative to poverty level, children in household, smoking, alcohol, physical activity, and chronic disease–specific medications*

tative sample of US young adults. We report an 11% prevalence of food insecurity among young adults, similar to the national average of 12% in the general US adult population[28] but lower than the 35–59% prevalence reported among young adult university students.[29, 30] Young adulthood is an important yet understudied time period when cardiometabolic disease risk factors begin to develop.[5, 6] We find that food insecurity is associated with self-reported poor health, diabetes, hypertension, being "very overweight," and obstructive airway disease in young adults.

Prior evidence has shown that food insecurity is associated with cardiometabolic disease such as diabetes, hypertension, and hyperlipidemia in the general adult population.[9, 10, 31] To our knowledge, this is the first study to investigate these associations with young adults using a nationally representative sample. Our findings in young adults confirm prior findings among the general adult population in terms of associations between food insecurity and diabetes and hypertension prevalence.[9, 10] Studies in the general adult population examining the relationship between food insecurity and hyperlipidemia have shown mixed findings;[9, 32–34] we did not find a significant association between food insecurity and hyperlipidemia. Food insecurity has also been linked to poorer general self-rated health in the general adult population,[27] and we confirm this finding in young adults.

Three mechanisms may explain the association between food insecurity and cardiometabolic disease. First, food insecurity has been linked to the consumption of cheaper, calorie-dense but nutrient poor foods that include increased fats and carbohydrates[10, 35, 36] and less consumption of fruits and vegetables. Second, the cyclic nature of food insecurity, reflective of monthly paychecks and food assistance, may promote insulin resistance due to alternating periods of food access and food shortage.[37, 38] Furthermore, alternating episodes of food availability and scarcity promotes binge eating behaviors and subsequent obesity.[39] Third, chronic stress and anxiety from food insecurity may contribute to insulin resistance, adiposity, and high blood pressure.[10, 40] Stress triggered by food insecurity can activate the hypothalamic-pituitary-adrenal axis and stimulate the release of glucocorticoids, which can alter metabolism, lead to increased visceral fat accumulation and storage, and amplify binge eating behaviors.[41, 42] Increased cortisol levels due to stress, in turn, increase blood glucose and insulin resistance, which play critical roles in the development of type 2 diabetes.[42, 43]

Chronic diseases may also contribute to food insecurity. Chronic diseases such as diabetes and hypertension may require medications and more frequent health care visits which can result in greater health care costs.[44] As individuals develop more severe chronic conditions, they may be less able to work and generate income.[45] Furthermore, dietary counseling and health education at health care visits may increase awareness of diet recommendations but also inability to afford healthy foods, which lead to an increased perception of food insecurity.[9]

Among participants with self-reported diabetes and hypertension, food insecurity was not associated with measures of inadequate disease control. Although prior studies among low-income adults found that food insecurity was associated with poor diabetes control as measured by hemoglobin A1c,[46, 47] we did not find a significant association. However, the same study did not find an association between food insecurity and hypertension disease control, similar to our findings.[9]

To our knowledge, our study is the first to demonstrate an association between food insecurity and obstructive airway disease in adults, specifically young adults. One study found that multiple hunger episodes were associated with asthma in children and youth.[8] Stress may lead to greater inflammation,[48] which is involved in the pathophysiology of asthma, and more frequent asthma exacerbations.[49] Food insecurity and malnutrition may lead to increased susceptibility to infections;[50] recurrent respiratory infections may increase risk for asthma and bronchitis. Asthma is related to food allergies and persons living with food insecurity may have less control over avoiding allergens including foods that exacerbate allergies.[51] Obstructive airway disease may decrease ability to work and health care costs associated with obstructive airway disease may exacerbate food insecurity.[45] It is also possible there are confounders related to poverty such as air pollution and household allergens we were not able to fully measure in analyzing the relationship between food insecurity and obstructive airway disease.

Our study has several limitations. First, the cross-sectional nature of the study precludes causal inferences. The predictor and most outcome measures were based on self-report, which may be subject to response bias. Food insecurity was assessed by a single-item food security measure, the first item of both the full 18-item US Household Food Security Scale and the validated 6-item short form.[15] Future research in young adults could assess food insecurity using the full US Household Food Security Scale. The clinical measures as ascertained in Add Health were not sufficient for a medical diagnosis; thus, we only assessed disease control. For instance, hypertension is based on measurements from the day of the interview in Add Health whereas repeated measures on three occasions would be required for a formal medical diagnosis.[20] Furthermore, we were unable to assess disease control in hyperlipidemia given limitations in the total cholesterol measure available in Add Health (reliability of 0.40, corresponding to a 17 mg/dl minimal detectable difference in total cholesterol between two independent samples).[52] The obstructive airway disease question combined asthma, chronic bronchitis, and emphysema into one category, so we are unable to determine the association of food insecurity with these specific diseases. We were not able to assess disease control for obstructive airway disease as there was no measurement such as peak flow or forced expiratory volume. Although we controlled for a number of potential confounders including age, race/ethnicity, education, household income adjusted relative to the poverty threshold, children in household, smoking, alcohol, physical activity, and

medication use, there is the possibility for unmeasured confounders. Nonetheless, the limitations were offset by strengths, including a large, nationally representative sample size of an understudied population of young adults.

Food insecurity is now recognized as an important social determinant of health [53]. Health care providers should ask patients about food insecurity, and short two-question screening tools are available.[14] Patients with food insecurity should be referred to appropriate social services and provided additional information on choosing healthy foods from these programs. Given the association between food insecurity and several chronic diseases net of other factors, it is plausible that interventions to reduce food insecurity may contribute to the reduction of chronic diseases and this is an area for future study in longitudinal or interventions research. The Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program) has a well-established infrastructure to reduce rates of food insecurity in the USA.[10, 54, 55] Future interventions to promote food security, healthy nutrition using programs like the SNAP,[54] and cardiometabolic health in young adults could be integrated. Future research could also assess food insecurity longitudinally from adolescence through the transition to adulthood to better determine causal inferences between food insecurity and health outcomes during this important time period in the life course.

CONCLUSION

Food insecurity is associated with several self-reported chronic diseases including diabetes, hypertension, and obstructive airway disease in a nationally representative sample of US young adults. Young adulthood may be an important time to screen for and address food security given the development of many of these chronic health conditions during this time period. Future research should examine the association between food insecurity and chronic disease longitudinally and integrate interventions to combat both food insecurity and chronic disease development in young adulthood.

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Corresponding Author: *Jason M. Nagata, MD, MSc; Department of Pediatrics University of California, San Francisco, 550 16th Street, 4th Floor, Box 0110, San Francisco, CA 94158, USA (e-mail: jason.nagata@ucsf.edu).*

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Compliance with Ethical Standards:

The University of North Carolina Institutional Review Board approved all Add Health study procedures.

Conflict of Interest: *The authors declare that they do not have a conflict of interest.*

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