Food Security and Glycemic Control Among Low-Income Patients with Diabetes

Julie B. Silverman

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Karin Nelson, MD, MSHS
James Krieger, MD MPH

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Abstract

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Julie B. Silverman, MD

Chair of the Supervisory Committee:
Karin Nelson, MD MSHS
Adjunct Associate Professor
Health Services

Background: Food insecurity – lack of dependable access to adequate foods – may play a role in poor diabetes control and be associated with poor health outcomes.

Objective: To determine the relationship between food security status and multiple health outcomes – including glycemic control, depression, diabetes distress and medication adherence – among low-income individuals with diabetes.

Design: Secondary analysis of baseline data from Peer Support for Achieving Independence in Diabetes, a randomized controlled trial that enrolled patients from November 2011 to October 2013.

Participants: Participants had poorly controlled type 2 diabetes (A1c ≥8.0%), household income <250% of the federal poverty level and were 30-70 years old, recruited from a large public hospital, VA medical center and community-health center in King County, Washington.

Intervention: Home-based diabetes self-management intervention delivered by community health workers.

Main Measures: Food security status determined by Department of Agriculture's 6-Item Food Security Module. Depression, diabetes distress and medication adherence measured by PHQ-8, Diabetes Distress Scale and Morisky Medication Adherence Scale, respectively. Hypoglycemic episodes per patient report. Glycosylated hemoglobin (A1c) values obtained through fingerstick blood sample.

Key Results: The prevalence of food insecurity was 47.4%. Food-insecure participants more likely to be depressed (74.1% vs. 35.6%, $p<0.001$), report diabetes distress (55.1% vs. 33.7%, $p<0.001$), have low medication adherence (52.9% vs. 37.2%, $p=0.02$) and higher incidence of hypoglycemia (57.7% vs. 45.2%, $p=0.04$). Those with food insecurity had significantly higher A1c levels (9.4% vs. 8.7%, $p=0.001$) after adjusting for socio-demographic characteristics, depression, diabetes distress and medication adherence.

Conclusions: The prevalence of food insecurity among low-income individuals with diabetes was high. Food insecurity was associated with multiple adverse health outcomes, including poor glycemic control. Without dependable access to safe and nutritious foods, optimal health and glycemic control likely remain out of reach for those with food insecurity.

Trial Registration: NCT02152852

INTRODUCTION

Food insecurity is defined as the lack of dependable access to adequate, safe and nutritious foods necessary for a healthy life.[1] In the United States, 1 in 7 households was food-insecure in 2013.[2] For those with diabetes, being food-insecure has been associated with poorer glycemic control[3, 4, 5] and increased risk of hypoglycemic events[6] and hypoglycemia-related emergency department visits.[7] The mechanisms through which food insecurity influences glycemic control are not well delineated.

Poor glycemic control in diabetes is due to a multitude of factors. Depression, a common comorbidity in diabetes, is associated with decreased glycemic control[8,9] and poorer adherence to diet and medication regimens.[10] Diabetes distress, which refers to the emotional distress related to the burdens of diabetes and its treatment, is similarly associated with poorer glycemic control and medication adherence.[11] Medication adherence, in and of itself, is associated with and predictive of glycemic control, with lower medication adherence resulting in higher glycosylated hemoglobin (A1c) values.[12,13]

Food insecurity has been associated with these factors. Food-insecure people report higher levels of poor mental health, including increased depression, stress and anxiety[9] and poor or fair self-rated health.[14,15] Medication adherence may be lower among food-insecure individuals, who report taking medication less often than prescribed due to costs and deferring paying for medication in order to have money for food.[16, 17] To our knowledge, no studies have examined the relationship between food insecurity and diabetes distress. In addition, while associations between food insecurity

and depression and food insecurity and medication adherence have been reported in the general population, few studies have examined these associations in patients with diabetes.[18]

The purpose of this study is to evaluate the relationships between food insecurity and depression, diabetes distress and medication adherence and to determine whether these factors are part of the pathway between food insecurity and glycemic control.

METHODS

We analyzed baseline data from the Peer Support for Achieving Independence in Diabetes (Peer-AID) study. Peer-AID is a NIH-funded randomized controlled study evaluating a home-based diabetes self-management intervention delivered by community health workers. The study took place in King County, Washington, with enrollment from November 2011 to October 2013.

Participants were recruited from three healthcare systems: a large public hospital, a VA medical center and a community-health center. Eligible participants had a diagnosis of type 2 diabetes (as documented in the electronic health record) with poor glycemic control (defined as an A1c of 8.0% or greater during the 3-month period prior to enrollment), a household income of less than 250% of the federal poverty level and were between 30 and 70 years of age residing in King County. Exclusion criteria included participation in another diabetes study, previous formal diabetes education in the past 3 years, being homeless, planning on moving out of King County or having dementia, end-stage renal disease or a terminal illness. Additional details are available

elsewhere.[19]

The institutional review boards of the University of Washington, VA Puget Sound and Sea Mar Community Health Centers approved the study.

Measures

Baseline data included self-reported age, race/ethnicity, primary language, education level, marital status, employment status and insurance status, duration of diabetes, prior diabetes-related education, and co-morbid medical conditions, including hypertension, hyperlipidemia and tobacco use.

Food security status was determined using the United States Department of Agriculture's validated Six-Item Short Form Food Security Survey Module.[20] Each response was given a score of 0 or 1. Those with a summed score of 0 or 1 were classified as food-secure; those with a summed score of 2 or greater were classified as food-insecure. Food insecurity was further divided into "low" (score 2 to 4) and "very low" (score 5 or 6). Details on the food security questions and participant responses are provided in an online supplement.

Health-related quality of life was measured with the SF-12, with higher scores representing better perceived health.[21] Alcohol consumption was assessed using the Alcohol Use Disorders Identification Test (AUDIT-C), a 3-item screening test for heavy drinking and/or abuse.[22] Health literacy was evaluated with a validated 3-question screen.[23] Depressive symptoms were assessed using the PHQ-8, with previously validated cut-points for mild, moderate and severe depression.[24,25] To assess diabetes-

related distress, a 17-item measure was used, with participants classified as having "little or no diabetes distress," "moderate diabetes distress" or "high diabetes distress."[26,27] Medication adherence was evaluated through a composite score of an eight-question survey, with participants classified as having low, medium or high adherence.[28]

Baseline hemoglobin A1c values were obtained through a fingerstick blood sample taken during the enrollment interview.[19] Pre-enrollment clinic A1c levels were used if this value was missing [n=29 (10%)]. Height, weight and blood pressure were measured at the initial visit. Body mass index (BMI) was calculated from measured height and weight. Obesity was defined as a BMI ≥30 kg/m^2.

Statistical analysis

We performed bivariate analyses to examine the differences in socio-demographic and health characteristics between food-secure and food-insecure individuals, with chi-square tests for categorical variables and t-tests for continuous variables. For obesity, depression, diabetes distress, low medication adherence and hypoglycemia – factors for which there was a significant difference between food-secure and food-insecure groups – we calculated odds ratios using multivariate logistic regression. For the logistic regression, we adjusted for age, gender, race/ethnicity, language, education, marital status and BMI; the model for obesity included all of these adjustors except for BMI. We used multivariable linear regression to model the relationship between glycemic control and food insecurity. We developed two regression models. In the first, we adjusted for age, gender, race/ethnicity, language,

education, marital status and BMI. In the second, we additionally adjusted for depression, medication adherence and diabetes distress, which may be on the pathway between food insecurity and glycemic control. Analyses were conducted using STATA 12.0 (StataCorp. 2011. *Stata Stastical Software: Release 12*. College Station, TX: StataCorps LP).

RESULTS

The prevalence of food insecurity among study participants was 47.4%, with 28.9% in the low food security category and 18.5% in the very low food security category. Patient socio-demographic characteristics, grouped by food security status, are reported in Table 1. Compared to food-secure individuals, those with food insecurity differed significantly by gender, race/ethnicity, marital status and employment status, with females, Hispanics, non-whites, unmarried individuals and those unable to work more likely to be food-insecure. There were no statistically significant differences in age, education level, health literacy status or health insurance status.

Health characteristics of participants are listed in Table 2. Participants with food insecurity had a higher average BMI and were more likely to be obese. The prevalence of depression was significantly higher in the food-insecure group, and the severity of depression was greater. Food-insecure individuals were also more likely to have diabetes distress. Additionally, their average levels of self-reported physical and mental health were lower than those of food-secure individuals. The prevalence of low medication adherence among food-insecure participants was greater than among food-

secure participants. There were no statistically significant differences in hypertension, hyperlipidemia, tobacco use or alcohol consumption.

Food-insecure individuals experienced hypoglycemic events at higher rates than food-secure individuals. Notably, only individuals with food insecurity attributed their hypoglycemia to inability to afford food. Among all patients, those on insulin therapy experienced hypoglycemia at higher rates than those patients not on insulin (58.7% vs. 34.5%; $p<0.001$). However, there was no statistically significant difference in hypoglycemic events between food-secure individuals on insulin and food-insecure individuals on insulin.

The results of the multivariate logistic regressions are shown in Table 3. Food-insecure participants were at increased risk of obesity, depression, diabetes distress, low medication adherence and hypoglycemic events, compared to those with food security.

We found a strong association between A1c level and food security status (Figure 1). The average A1c level for food-insecure individuals was 0.6% higher than that of food-secure participants [9.4% (95% CI: 9.1-9.7) vs. 8.8% (95% CI: 8.5-9.0), $p=0.003$]. The difference in average A1c levels remained after adjusting for sex, age, race/ethnicity, language, education, marital status and BMI [9.4% (95% CI: 9.1-9.7) vs. 8.8% (95% CI: 8.5-9.0), $p=0.002$]. After further adjustment for depression, diabetes distress and medication adherence, the difference in average baseline A1c levels between food-insecure and food-secure participants was 0.7% [9.4% 95% CI: 9.1-9.7) vs. 8.7% 95% CI: 8.4-9.0), $p=0.001$].

DISCUSSION

Food insecurity was associated with multiple adverse health outcomes among a diverse group of low-income individuals with poorly controlled diabetes. We found that lower medication adherence and increased diabetes distress and depression were more prevalent among people with food insecurity, associations not previously reported among patients with diabetes. Similar to other studies in safety net populations, food-insecure individuals had clinically significant higher A1c levels than their food-secure peers.[3] In this study, lower medication adherence, diabetes distress and depression did not appear to explain the relationship between food insecurity and glycemic control. This relationship may be mediated by higher consumption of unhealthy foods among food insecure people. Among adults with diabetes, food insecurity is associated with lower overall dietary quality and lower consumption of healthy foods.[29] Food-insecure individuals are limited to cheaper, more calorie-dense and high-sugar foods that promote high blood sugar.[30]

Strengths of our study include recruitment of patients from diverse clinical settings, as well as minimal exclusion criteria, which allow the results to be more generalizable. We used well-validated measures to assess health outcomes. However, our study has limitations. Our ability to determine causal associations is limited by the cross-sectional nature of the analysis. Though we aimed for completeness, we may have lacked data on all the factors that mediate the relationship between food insecurity and glycemic control. To assess hypoglycemia, we relied on patient self-report, which is subject to recall bias.

Our study validates the concerning association between food insecurity and hypoglycemia, which is a potentially fatal consequence of poor diabetes control. Of the patients who reported experiencing hypoglycemia in the past year, more than 40% of the food-insecure group – including 63% of the very low food security group – attributed their low glucose to not being able to afford food. This finding is consistent with a recent study of safety-net patients with diabetes, in which 43% of food-insecure subjects who reported a hypoglycemic event attributed it to inability to afford food.[6] Given increasing rates of emergency department use due to hypoglycemia[31] and the Healthy People 2020 objective to reduce emergency department visits for preventable adverse effects from medications[32] (e.g. hypoglycemia due to insulin use with inadequate food), screening of low-income populations with diabetes for food insecurity should be considered in future research and clinical practice. Screening may identify individuals at high risk for hypoglycemia, who may benefit from targeted interventions (such as counseling about risks of hypoglycemia when taking diabetes medications without adequate food or reducing food insecurity). As part of the Peer-AID study, we are currently evaluating whether a community health worker intervention that includes assessing and targeting food insecurity (through interventions such as applying for supplemental nutrition assistance program benefits and learning how to shop on a budget) improves glycemic control and other important health outcomes. Devoting resources to reducing or eliminating food insecurity may be an efficacious and cost-effective intervention to improve glycemic control, especially among low-income individuals. Without dependable access to safe and nutritious foods, optimal glycemic control likely remains out of reach of those with food insecurity.

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We have no conflicts of interest to report.

Legend for Figure

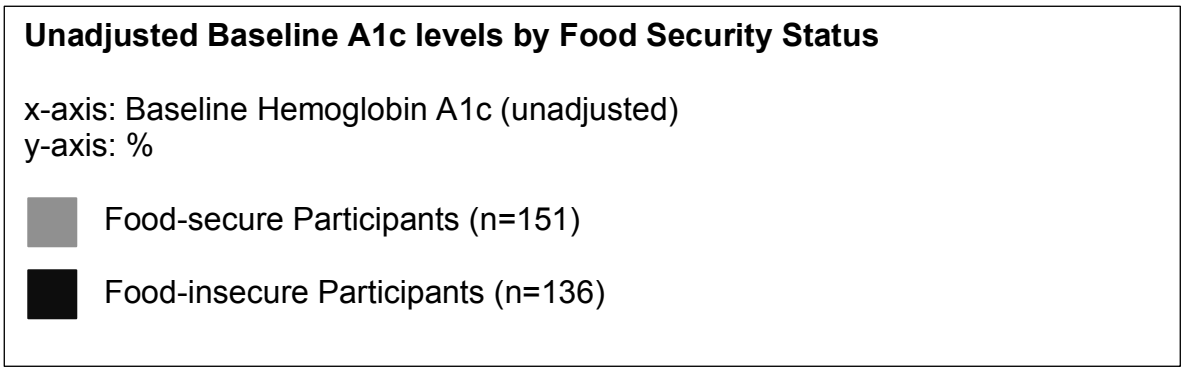


Table 1. Patient Socio-demographic Characteristics by Food Security Status

	Secure 52.6% (n=151)	Insecure 47.4% (n=136)	Total (n=287)	p-value
Female, %	39.1	59.6	48.8	**0.001**
Age, mean	52.6	52.4	52.5	0.83
Race/Ethnicity, %				**0.02**
White, non-Hispanic	20.5	21.3	20.9	
Black, non-Hispanic	19.9	30.9	25.1	
Other, non-Hispanic	8.6	14.0	11.2	
Hispanic, any race	51.0	33.8	42.9	
Speaks language other than English at home, %	53.6	40.4	47.4	**0.03**
Education, %				0.90
Less than High School or GED	35.1	33.3	34.3	
High School or GED	25.2	27.4	26.2	
More than High School or GED	39.7	39.3	39.5	
Low Health Literacy, %	23.2	26.5	24.7	0.52
Employment Status, %				**0.04**
Employed	32.5	24.3	28.6	
Unemployed	14.6	14.7	14.6	
Student/Homemaker/Retired	20.5	13.2	17.1	
Unable to work	32.5	47.8	39.7	
Marital status, %				**<0.001**
Married/In relationship	54.3	31.6	43.6	
Divorced/Separated	24.5	33.8	28.9	
Single	21.2	34.6	27.5	
Insurance status, %				0.35
Private Insurance	6.7	5.3	44.7	
Public insurance	46.7	55.3	36.3	
Uninsured	46.7	39.4	19.0	

Table 2. Patient Health Characteristics by Food Security Status

	Secure 52.6% (n=151)	Insecure 47.4% (n=136)	Total (n=287)	p-value
BMI, mean	32.5	34.7	33.6	**0.04**
BMI,%				**0.001**
Normal (18.5 ≤ BMI <25)	11.3	13.2	12.2	
Overweight (25 ≤ BMI <30)	39.1	18.4	29.3	
Obese (BMI≥30)	49.7	68.4	58.5	
Hypertension,%	68.9	72.1	70.4	0.56
High Cholesterol,%	62.3	67.7	64.8	0.34
Tobacco use,%	20.5	27.2	23.7	0.18
Positive Audit C,%	8.6	5.9	7.3	0.38
Depression (any) ,%*	35.6	74.1	53.9	**<0.001**
Mild %	20.1	33.3	26.4	**0.01**
Moderate or Severe,%	15.4	40.7	27.5	**<0.001**
DM Distress,%				**<0.001**
None/Low	66.2	44.9	56.1	
Moderate/High	33.7	55.1	43.9	
SF 12 Summary Score, mean				
Physical	41.5	37.1	39.3	**0.001**
Mental	48.9	44.6	46.8	**0.003**
Medication Adherence,%				**0.02**
Low	37.2	52.9	44.7	
Med	39.9	32.4	36.3	
High	23.0	14.7	19.0	
Episodes of Hypoglycemia in Past Year, %	45.2	57.7	51.1	**0.04**
Of these, % due to inability to afford food	0	42.3	21.9	**<0.001**
On Insulin, %	60.9	72.1	66.2	**0.05**

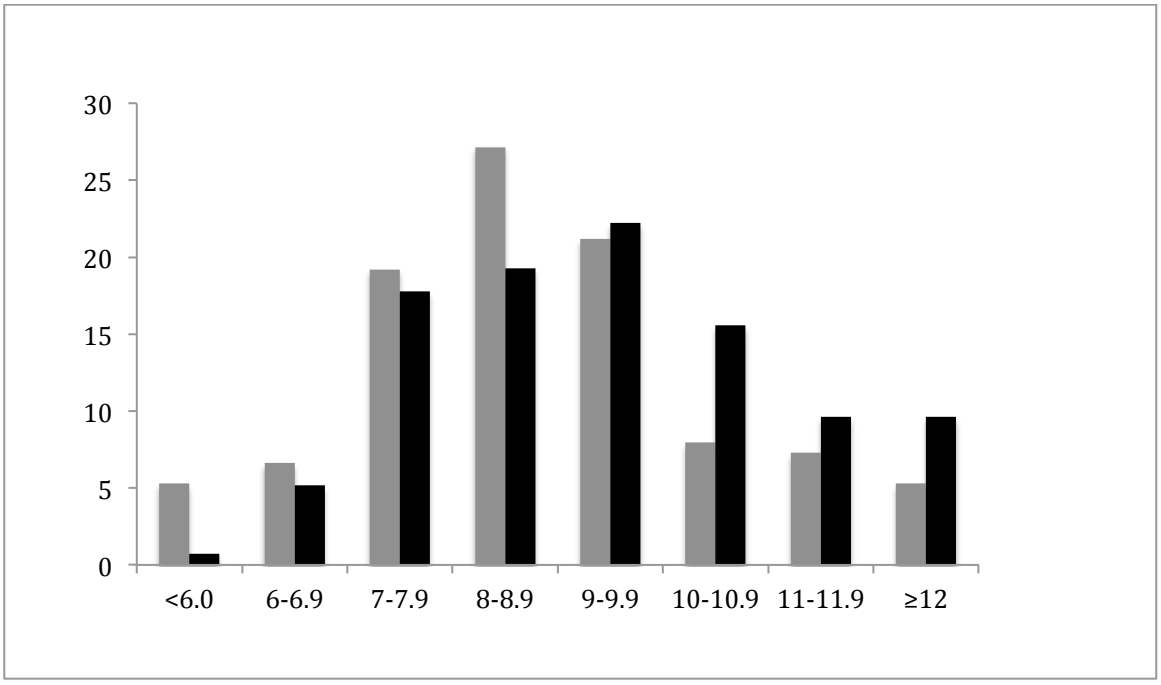
* Any depression is defined as PHQ score ≥ 5. Moderate or severe depression is defined as PHQ score ≥ 10.

Table 3. Multivariate Models of Associations of Health Characteristics with Food Insecurity

	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted OR p-value
Depressed *	5.18 (3.11-8.62)	5.14 (2.87-9.22)	**<0.001**
Obese (BMI≥30)†	2.17 (1.34-3.51)	1.79 (1.05-3.04)	**0.03**
Moderate or Severe DM Distress *	2.41 (1.50-3.89)	2.40 (1.43-4.02)	**0.001**
Low Medication Adherence *	1.90 (1.18-3.06)	1.94 (1.14-3.29)	**0.02**
Hypoglycemic Episode in Past Year*	1.65 (1.03-2.66)	1.71 (1.00-2.94)	**0.05**

* Adjusted for sex, age, race/ethnicity, language, education, marital status and BMI
† Adjusted for sex, age, race/ethnicity, language, education, and marital status

Figure



Online Supplemental Table
Table 4. Responses to USDA's Food Security Survey

USDA Short Form Food Security Survey Module	Secure 52.6%	Insecure 47.4%
"The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more." In the last 12 months, that was…		
Often true	0	39.0
Sometimes true	8.7	50.0
Never true	91.3	11.0
"(I/we) couldn't afford to eat balanced meals." In the last 12 months, that was…		
Often true	3.3	40.4
Sometimes true	9.3	50.7
Never true	87.4	8.8
In the last 12 months, did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?		
Yes	0	53.3
No	100	46.7
[If YES above] How often did this happen?		
Almost every month		50.0
Some months but not every month		38.9
In only 1 or 2 months?	n/a	11.1
In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?		
Yes	1.3	58.8
No	98.7	41.2
In the last 12 months, were you every hungry but didn't eat because there wasn't enough money for food?		
Yes	0.7	41.9
No	99.3	58.1

Responses of "often" or "sometimes" (questions 1-2), "yes" (questions 3, 5 and 6) and "almost every month" or "some months but not every month" (question 4) were coded as affirmative and given 1 point. Those with a summed score of 0 or 1 were classified as food-secure; those with a summed score of 2 or greater were classified as food-insecure. Food insecurity was further divided into "low" (score 2 to 4) and "very low" (score 5 or 6).

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