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Food Insecurity and Glycemic Control Among Low-Income Patients With Type 2 Diabetes

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OBJECTIVE—To determine whether food insecurity—the inability to reliably afford safe and nutritious food—is associated with poor glycemic control and whether this association is mediated by difficulty following a healthy diet, diabetes self-efficacy, or emotional distress related to diabetes.

RESEARCH DESIGN AND METHODS—We used multivariable regression models to examine the association between food insecurity and poor glycemic control using a cross-sectional survey and chart review of 711 patients with diabetes in safety net health clinics. We then examined whether difficulty following a diabetic diet, self-efficacy, or emotional distress related to diabetes mediated the relationship between food insecurity and glycemic control.

RESULTS—The food insecurity prevalence in our sample was 46%. Food-insecure participants were significantly more likely than food-secure participants to have poor glycemic control, as defined by hemoglobin A_{1c} ≥8.5% (42 vs. 33%; adjusted odds ratio 1.48 [95% CI 1.07–2.04]). Food-insecure participants were more likely to report difficulty affording a diabetic diet (64 vs. 49%, $P < 0.001$). They also reported lower diabetes-specific self-efficacy ($P < 0.001$) and higher emotional distress related to diabetes ($P < 0.001$). Difficulty following a healthy diet and emotional distress partially mediated the association between food insecurity and glycemic control.

CONCLUSIONS—Food insecurity is an independent risk factor for poor glycemic control in the safety net setting. This risk may be partially attributable to increased difficulty following a diabetes-appropriate diet and increased emotional distress regarding capacity for successful diabetes self-management. Screening patients with diabetes for food insecurity may be appropriate, particularly in the safety net setting.

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The epidemic of type 2 diabetes has hit the poor particularly hard. Low socioeconomic status is associated with a higher prevalence of diabetes and a greater risk for diabetes complications (1–3). There are likely many specific elements of poverty that predispose adults to diabetes and poor diabetes control, but a great number of these potentially predisposing factors have not been fully investigated.

Food insecurity has been postulated as one mechanism by which poverty might predispose adults of low socioeconomic status to poor diabetes control (4). Food insecurity refers to going hungry or being at risk for going hungry because of the inability to afford food. It exists "whenever the availability of nutritionally adequate and safe foods or the ability to acquire acceptable foods in socially acceptable ways [e.g., without resorting to emergency food supplies, scavenging, stealing, or other coping strategies] is limited or uncertain" (5). In 2010, 14.5% of U.S. households were food-insecure, representing 32 million adults (6).

A recent study conducted with a nationally representative sample (National Health and Nutrition Examination Survey) of low-income adults found that among patients with a known diagnosis of diabetes, 69% of food-insecure and 49% of food-secure adults were unable to achieve a hemoglobin A_{1c} (HbA_{1c}) ≤7% (7). Studies among children with type 2 diabetes have demonstrated higher HbA_{1c} values among children living in food-insecure households compared with children living in food-secure households (8). However, the association between food insecurity and glycemic control has not been evaluated in clinical populations of adult patients with diabetes, and mechanisms for a relationship between food insecurity and glycemic control remain unclear.

Food insecurity is a multidimensional concept, encompassing reductions in food quantity and food quality. Other studies suggest that food insecurity may increase patients' difficulty following a diabetes-appropriate diet because they shift their dietary intake toward inexpensive, calorically dense foods, which generally include a high proportion of added fats, added sugars, and other refined carbohydrates, to maintain caloric needs (9). These foods generally make glycemic control more difficult to achieve. However, we hypothesized that additional mechanisms existed by which food insecurity may directly influence glycemic control. For example, food insecurity may reduce self-efficacy, defined as confidence in one's ability to successfully manage all of the things necessary to take care of one's own health, or it may increase emotional distress regarding diabetes management. Reduced self-efficacy and emotional distress related to diabetes may both interfere with patients' ability to manage their diabetes (10–13).

Our objective was to determine whether food insecurity was independently associated with poor glycemic control in a clinical population of low-income adults with

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diabetes. We hypothesized that the association between food insecurity and glycemic control would be mediated by increased difficulty following a healthy diet, decreased diabetes-specific self-efficacy, and greater emotional distress related to diabetes among the food-insecure participants.

RESEARCH DESIGN AND METHODS

We administered a cross-sectional survey to a convenience sample of 711 patients with type 2 diabetes as part of the Immigration, Culture, and Healthcare Study. All study participants were receiving care for diabetes in safety net clinics in the San Francisco Bay area or Chicago. These clinics were federally qualified health centers or affiliated with a public safety net health system. Eligible patients were recruited in consecutive order on the dates in which the research assistants were assigned to each participating clinic. Eligibility criteria included a diagnosis of type 2 diabetes confirmed in the medical record, English or Spanish fluency, age ≥18 years, and self-identification as white, African American, or Mexican/Mexican American. We excluded patients who were unable to participate in the survey, at the discretion of the research assistant, because of cognitive impairment, active substance abuse, or psychosis. The study was conducted between 2008 and 2009. The institutional review boards at each affiliated institution approved the study protocol.

Measures

Bilingual research assistants orally administered the survey to participants in their preferred language. We measured food insecurity using the U.S. Department of Agriculture's Food Security Survey Module (six-item version). The items in this module address inadequate food in the household, reduced or skipped meals, or hunger because of the inability to afford food. By established convention, we considered participants to be food-insecure if two or more responses were answered affirmatively (14). This survey appears to be a valid measure of food insecurity because it shows associations with reduced dietary variety, increased consumption of calorically dense foods, reduced intake of fruits, vegetables, and dairy, and reduced micronutrient intake (15–21), in addition to obesity (women only) and diabetes (22–24).

The primary dependent variable for our analysis was the most recent HbA_{1c} available in the electronic medical record within 1 year before the date of survey administration. The mean number of days between HbA_{1c} measurement and survey administration was 86.4 days. A priori, we defined poor glycemic control as an HbA_{1c} ≥8.5% to be consistent with expert guidelines that define poor glycemic control as >8.0% or >9.0% (25–27).

We were interested in three potential mechanisms by which food insecurity might influence the ability to achieve glycemic control: difficulty following a diabetic diet, diabetes-specific self-efficacy, and emotional distress related to diabetes. We assessed difficulty following a diabetic diet by assessing agreement with the following statement using a 5-point Likert response (agree or strongly agree vs. others): "It has been difficult following the diet (diabetic foods) the doctor ordered for me." The 2.1% of respondents who reported this question was "not applicable" (presumably because their doctor had not described to them an appropriate diet) were excluded from this analysis.

We assessed diabetes-specific self-efficacy using a scale assessing confidence in one's ability to manage numerous self-care behaviors, including diet, physical activity, and management of blood glucose (eight items) (28). Although results are inconsistent, greater diabetes-specific self-efficacy has been associated with improved performance of self-care behaviors in some previous studies (29). We generated a mean score from the 10-point Likert response options (range 1–10), with higher scores indicating greater self-efficacy. The questions included in this scale are available in the Supplementary Data.

We measured emotional distress related to diabetes using the emotional burden subscale of the Diabetes Distress Scale (five items) (30). This scale measures frustration, anger, and discouragement associated with managing a complex, demanding, and often confusing disease. Questions address, for example, the extent to which diabetes "takes up too much of my mental and physical energy," "controls my life," and makes me feel "overwhelmed by the demands of living with diabetes." In previous studies, lower scores on this scale have been associated with better self-management and glycemic control (11–13). We generated a mean score (range 1–5), with higher scores indicating more distress.

We included medication adherence as a covariate because food insecurity may decrease medication adherence due to competing financial demands. We assessed medication adherence using the Modified Morisky Scale of Medication Adherence, a four-item scale (range, 0–4 points). This scale has been validated with pharmacy claims data among patients with diabetes (31,32).

Statistical analysis

We compared baseline characteristics of food-insecure and food-secure participants using χ^2 tests for categoric variables and *t* tests for continuous variables. We used linear models for the continuous outcome of HbA_{1c} and logistic models for the dichotomous outcome of poor glycemic control. Sociodemographic covariates included age, sex, race/ethnicity, income, and education. Clinical covariates included BMI, insulin use, tobacco use, and medication adherence.

We performed a traditional mediation analysis to determine the extent to which difficulty following a diabetic diet, diabetes-specific self-efficacy, and emotional distress related to diabetes mediated the relationship between food insecurity and glycemic control. We therefore report the extent to which the association between food insecurity and glycemic control was attenuated after controlling for difficulty following a diabetic diet, diabetes-specific self-efficacy, and emotional distress related to diabetes. We formally tested these three variables as mediators using Sobel-Goodman mediation tests (33). Analyses were performed using Stata 11 software (StataCorp LP, College Station, TX).

RESULTS

Of the 782 eligible patients approached to participate in the study, 711 provided informed consent and completed interviews (91% participation rate). The prevalence of food insecurity was 46% (n = 325). Food-insecure participants were generally younger than food-secure participants, had lower household incomes, and were more likely to be white (Table 1). Food insecurity was associated with increased difficulty following a diabetic diet, lower mean self-efficacy scores, and higher emotional distress scores (all $P < 0.001$, Table 1). The internal consistency of the diabetes-specific self-efficacy and emotional distress related to diabetes scales was high (Cronbach α = 0.79 and 0.89, respectively).

Mean HbA_{1c} was 8.54% among food-insecure participants and 8.09% among food-secure participants (P = 0.007). After adjusting for age, sex, race/ethnicity, income, education, tobacco use, BMI, insulin use, and medication adherence, mean HbA_{1c} was 8.55% among food-insecure participants and 8.10% among food-secure

Table 1—*Participant characteristics* (n = *711*)

	Food security		
	Insecure *n* = 325	Secure *n* = 386	*P*
Age, mean (SD)	52.5 (10.3)	56.2 (12.5)	<0.001
Female, %	51.4	49.2	0.6
Race, %			0.03
Mexican/Mexican American	57.5	55.7	
African American	24.3	31.6	
White	18.2	12.7	
English proficient, %	68.9	74.1	0.1
Education, %			0.1
<High school degree/GED	46.2	39.1	
High school degree/GED	27.4	33.9	
>High school degree/GED	26.5	26.9	
Annual household income, %			<0.001
<$10,000	41.4	27.2	
$10,000–24,999	39.2	43.0	
≥$25,000	12.0	24.6	
Declined to state	7.4	5.2	
Household size, mean (SD)	2.38 (1.7)	2.37 (2.14)	0.9
BMI, %			0.2
Underweight	0.3	0.8	
Normal	8.7	11.9	
Overweight	24.5	27.2	
Obese	66.6	60.1	
BMI (kg/m^2), mean (SD)	33.9 (7.6)	32.7 (7.4)	0.03
Insulin use, %	48.0	50.5	
Tobacco (at least one puff in last 7 days), %	33.5	17.1	<0.001
Medication adherence score, mean (SD)*	1.08 (1.12)	0.93 (1.02)	0.06
Difficulty following a diabetic diet, %	64.3	49.0	<0.001
Self-efficacy score, mean (SD)	7.1 (1.7)	7.7 (1.6)	<0.001
Emotional distress related to diabetes score, mean (SD)	3.9 (1.5)	3.0 (1.6)	<0.001

GED, General Education Diploma. *Higher scores indicate poorer medication adherence.

participants (P = 0.06). More food-insecure participants than food-secure participants had poor glycemic control, defined as an HbA_{1c} ≥8.5% (41.9 vs. 32.8%), with an odds ratio (OR) of 1.48 (95% CI 1.07–2.04; Fig. 1). The relationship between food insecurity and poor glycemic control persisted after adjustment (OR 1.46; P = 0.05).

Difficulty following a diabetic diet, self-efficacy, and emotional distress related to diabetes were weakly correlated (correlation coefficients 0.23–0.27). Difficulty following a diabetic diet ($P < 0.001$), self-efficacy ($P < 0.001$), and emotional distress related to diabetes ($P < 0.001$) were each associated with HbA_{1c}, with higher HbA_{1c} levels observed among participants with more difficulty following a diabetic diet, lower self-efficacy scores, and greater emotional distress related to diabetes. These results were similar for the dichotomous outcome of poor glycemic control, although the association between glycemic control and self-efficacy was only marginally statistically significant (Table 2).

The relationship between food insecurity and poor glycemic control was attenuated when difficulty following a diabetic diet, self-efficacy, and emotional distress related to diabetes were added to the fully adjusted model (Table 3). However, only difficulty following a diabetic diet (P = 0.01) and emotional distress related to diabetes (P = 0.006) met formal criteria as mediators, with difficulty following a diabetic diet mediating 20% of the total effect and emotional distress related to diabetes mediating 34% of the total effect.

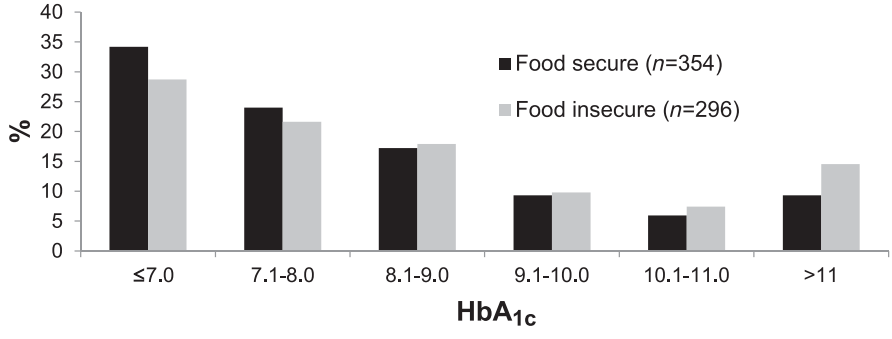

Figure 1—*Association between HbA_{1c} and food security status among patients with diabetes receiving care in safety net clinics* (n = *710*).

CONCLUSIONS—This is the first study in the clinical setting to examine in detail the relationship between food insecurity and glycemic control among low-income patients with diabetes. We found that food insecurity is an independent predictor of glycemic control and that this relationship is partially explained by difficulty following a diabetic diet and increased emotional distress related to diabetes.

There are numerous mechanisms by which food insecurity may influence glycemic control. At its most extreme, food-insecure adults are unable to meet their caloric needs and weight loss occurs. When less severe, food-insecure adults maintain their caloric needs by shifting dietary intake toward less expensive foods (34). Carbohydrate and fat-rich foods cost far less calorie-per-calorie than other foods. For example, the most cost-efficient way to consume calories is with oils and sweets, bread, pasta, and rice, and the least cost-efficient way is with fruits and vegetables (9). As food budgets become increasingly inadequate, incorporating higher-cost items, such as vegetables, becomes more difficult (35). Although it is possible to maintain a healthy diet within financial constraints, such diets may require considerably more time, motivation, planning, and knowledge than many patients have. Future research needs to explore

Table 2—*Association between poor glycemic control and food insecurity, difficulty following a diabetic diet, self-efficacy, and emotional distress related to diabetes among patients with diabetes receiving care in safety net clinics*

	Odds of poor glycemic control	
	OR (95% CI)	Adjusted OR (95% CI)*
Food insecurity	1.48 (1.07–2.04)	1.46 (1.01–2.11)
Difficulty following diabetic diet	2.00 (1.44–2.78)	1.65 (1.15–2.38)
Self-efficacy	0.92 (0.84–1.02)	0.94 (0.85–1.05)
Emotional distress related to diabetes	1.20 (1.08–1.32)	1.16 (1.04–1.30)

*Adjusted for age, sex, race/ethnicity, income, education, BMI, insulin use, tobacco, and medication adherence.

strategies for assisting food-insecure patients not only in *what* healthy foods to eat but also in *how* to afford and prepare such foods.

Our study makes clear that patients with food insecurity have increased difficulty following a diabetic diet. Qualitative studies of food-insecure patients with diabetes have highlighted this difficulty: "The end of the month, I start getting out of food... but I have to eat something, 'cause if I don't eat behind my [insulin] shot, that shot will make you so sick. I just eat anything I can find during that time just to keep me from getting sick (36)." The compensatory strategies used by patients taking diabetes medications to prevent hypoglycemia when food is scarce, such as "eating anything I can find," may increase risk of hyperglycemia. The pressure to balance the need for diabetes-appropriate foods with the realities of food costs also seems to have implications for patients' emotional response to diabetes, with food insecurity being highly associated with self-efficacy and emotional distress related to diabetes.

Food insecurity is a cyclic phenomenon, with repeated episodes of food scarcity following episodes of relative food adequacy (37). Episodes of food scarcity predispose patients with type 2 diabetes to hypoglycemia (4,38). To prevent hypoglycemia-related complications, providers taking care of patients experiencing repeated episodes of hypoglycemia often liberalize glycemic targets. This may represent an additional mechanism by which food insecurity might contribute to hyperglycemia.

In this safety net–based study, almost half of adults with diabetes were food-insecure, a finding supported by other small studies (39). Identifying food insecurity among patients with diabetes may improve clinical care. Programs that identify food-insecure patients should be implemented in the context of institutional support for linking patients to more reliable food access, including support for applying for food assistance programs, such as the Supplemental Nutrition Assistance Program (formerly Food Stamps), referrals to local food pantries or nutrition programs, or tailored nutrition education. Nutrition education for this population should focus on cost-neutral strategies for improving glycemic control, such as reducing carbohydrate portions. A simple, two-item measure has recently been validated as an appropriate diagnostic tool for food insecurity in low-income clinical samples: *1*) "Within the past 12 months we worried whether our food would run out before we got money to buy more," and *2*) "Within the past 12 months the food we bought just didn't last and we didn't have money to get more." A response of "often true" or "sometimes true" to either item carries 97% specificity and 83% sensitivity for food insecurity (40).

Because this study is cross-sectional, we are unable to determine the direction of the proposed mechanistic pathways. Participants were recruited from urban, safety net health clinics, and therefore, results may not be generalizable to other populations. In particular, the experience of food insecurity in the developing world is different from the experience of food insecurity in the developed world, and our data should not therefore be extrapolated beyond the U.S. Finally, the time frame of the food insecurity questions is wider than that of the HbA_{1c} measurement; thus, it is possible that HbA_{1c} measurements do not reflect concurrent food insecurity experiences.

There are many ways in which poverty among patients with diabetes contributes to poor glycemic control. This study shows that the inability to afford healthy foods is likely to be one of them, and food insecurity may therefore be an important contributor to inequities in diabetes-related microvascular complications. In addition to the importance of food insecurity in the clinical management of patients with diabetes, the translation of diabetes interventions into low-income communities must specifically address the financial difficulty participants may have in implementing recommended dietary changes. Policy strategies to increase access to diabetes-appropriate foods may reduce socioeconomic disparities in glycemic control.

Table 3—*Association between food insecurity and HbA_{1c} ≥8.5% among patients with diabetes receiving care in safety net health clinics**

	OR (95% CI)
Unadjusted	1.48 (1.07–2.04)
+ Demographics and socioeconomic status†	1.41 (1.00–2.01)
+ Clinical risk factors for hyperglycemia‡	1.46 (1.01–2.11)
+ Difficulty following a diabetic diet	1.40 (0.96–2.00)
+ Self-efficacy	1.37 (0.94–2.00)
+ Emotional distress related to diabetes	1.28 (0.87–1.88)

*Each row of the table indicates a separate model with covariates added sequentially to the model in the row above it. Thus, the final row of the table includes all covariates listed in the table. Demographic variables, socioeconomic status, and clinical risk factors for hyperglycemia were potential confounders. Difficulty following a diabetic diet, self-efficacy, and emotional distress related to diabetes were potential mediators. †Age, sex, race/ethnicity, income, education, and tobacco use. ‡BMI, insulin, and poor medication adherence.

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H.K.S. is the guarantor of this work. H.K.S. conceived the project idea, assisted with the parent study, conducted data analysis, and prepared the manuscript. E.A.J. obtained funding, conducted the parent study, and edited the manuscript. A.L. assisted with data analysis and manuscript preparation and edited the manuscript. J.T. assisted with study measures and data analysis and edited the manuscript. A.F. obtained funding, conducted the parent study, and edited the manuscript.

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