Food Insecurity and Diabetes Self-Management among Youth and Young Adults with Type 1 Diabetes

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Abstract

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Background: Household food insecurity (FI) is associated with measures of diabetes self-management among older adults with diabetes. To our knowledge, there is no existing literature assessing this association among youth and young adults (YYA) with type 1 diabetes (T1D).

Objective: To examine the association between FI and diabetes self-management, as measured by frequency of blood glucose monitoring and missed diabetes medication, among YYA with T1D.

Methods: This is a cross-sectional study using data collected from 210 participants with T1D in South Carolina and Washington through the SEARCH for Diabetes in Youth study. FI was measured using the Household Food Security Survey Module and was scored 0-10 based on a

continuous linear scale. Diabetes self-management was determined using two variables, frequency of glucose monitoring and missed medications, which were measured via health questionnaires.

Results: We found that FI is significantly associated with frequency of missed diabetes medications, but not frequency of blood glucose monitoring. A one-unit increase in the standardized FI score was associated with a 24% increase in the odds of missing diabetes medication at least once per month (OR=1.24, 95% CI 1.02, 1.50, p=0.027). Socioeconomic status was significantly associated with frequency of blood glucose monitoring (OR=2.39, 95% CI 1.25, 4.56, p=0.008).

Conclusion: These results suggest that FI is negatively associated with diabetes self-management as demonstrated by an increase in missed diabetes medication. Future studies are necessary to illuminate the relationship between FI and other self-management behaviors and examine the mechanisms through which FI may impact self-management.

Table of Contents

Abbreviations

Food insecurity (FI)

Household Food Security Survey Module (HFSSM)

SEARCH for Diabetes in Youth Study (SEARCH)

Socioeconomic status (SES)

Type 1 diabetes (T1D)

Type 2 diabetes (T2D)

United States Department of Agriculture (USDA)

Youth and young adults (YYA)

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Introduction

In 2016, 41.2 million people in the United States, including 12.9 million children, were estimated to be food insecure.[1] Food security is defined as "access by all people at all times to enough food for an active, healthy life" and is a necessary condition for a healthy population.[1] Food insecurity (FI) is the absence of this condition and ranges in severity. Individuals with a chronic disease, such as diabetes,[2] and households with children[1] are more likely to be food insecure. Families of children with type 1 diabetes (T1D) are consequently more vulnerable to FI. This relationship has been confirmed in samples of households with children with T1D or insulin dependent type 2 diabetes (T2D) in Canada and households with children with T1D the United States, the only two studies to date examining FI among youth with diabetes; higher rates of food insecurity were reported among households with a child with diabetes,[3,4] despite a higher than average income.[3]

Among older adults with type 2 diabetes (T2D), FI is associated with poor glycemic control.[5-8] Research examining FI among youth and young adults (YYA) with diabetes is more limited, however FI has been linked to poor glycemic control and higher health care utilization. Mendoza and colleagues reported that YYA from food insecure households had 2.37 higher odds HbA1c above 9% compared to those in food secure households.[4] In the same study, YYA in food insecure households were found to have higher rates of emergency department visits.[4] Similarly, Marjerrison and colleagues reported that youth with diabetes from food insecure households were almost 3.7 times more likely to be hospitalized in the past year.[3]

Self-management behaviors, such as glucose monitoring and medication adherence, may be one mechanism through which FI interacts with diabetes-related outcomes. These behaviors are key components of maintaining good glycemic control,[9-12] and have been previously

associated with food insecurity.[13] Diabetes is a chronic stressor, and self-management represents a time and financial burden on families.[14] Food insecurity adds to that chronic stress and to the burden of diabetes management, and can represent a competing financial demand.[15,16] The association between FI and diabetes medication non-adherence, including cost related non-adherence and delays in filling prescriptions, has been particularly well studied in older adults with T2D or with self-reported diabetes diagnosis (either type 1 or type 2).[6,16-22]

Youth and young adults (YYA) with T1D face unique challenges related to diabetes self-management. Changes in physiology and social factors, including increased insulin resistance, the transition from pediatric to adult medical care, a decline in parental involvement, and a decrease in self-care behavior can lead to poor glycemic control.[23-25] YYA may therefore be particularly susceptible to negative impacts of FI on diabetes management.

To date, research related to FI and diabetes self-management has primarily focused on the older adult population with T2D. To our knowledge, there is no existing literature that investigates the association between FI and diabetes self-management among YYA with T1D in the United States. Therefore, this study aims to examine the relationship between FI and diabetes self-management as measured through self-reported frequency of missed diabetes medication and glucose monitoring among YYA with T1D in the United States. Our hypothesis is that FI will be associated with more frequent missed diabetes medications and less frequent blood glucose monitoring.

Methods

Study Sample

The SEARCH for Diabetes in Youth (SEARCH) study is an observational study that was initiated in 2000 to monitor and identify trends of diabetes prevalence and incidence among youth (< 20 years old) through five research centers across the United States. Details related to the SEARCH methods have been published elsewhere.[26] The third funding cycle of SEARCH (SEARCH 3) was conducted from 2010 to 2015 and included questionnaires, physical examinations, and laboratory measures as part of the registry visit. In 2012, SEARCH began enrolling YYA that had been identified as incident cases and who had a minimum of five years diabetes duration to participate in a cohort study that would include prospective follow up.[27] From 2013 to 2015, a food insecurity (FI) pilot study was conducted at two of the five SEARCH sites: South Carolina, which enrolled participants from the entire state, and Washington, which enrolled participants from five counties surrounding Seattle. This analysis uses data available through the SEARCH 3 cohort study and the FI pilot study. These studies were approved by the local institutional review boards. Participants provided informed consent (if ≥18 years old) or assent (if <18 years old) along with parental consent before data collection.

Main Exposure

Household food insecurity over the previous 12 months was measured using the Household Food Security Survey Module (HFSSM), an 18-question survey developed by the United States Department of Agriculture (USDA).[28] For participants less than 18 years old, the parent or legal guardian was asked to complete the HFSSM. Using the survey, households with children respond to all 18 questions, and those without children respond to only 10 questions.

Responses were assigned values of 0–10 using the USDA's Household Food Security Scale, which allows for comparisons between households with and without children. On this linear, continuous scale, the value of 0 represents a fully food secure household, and values approaching 10 represent severe food insecurity.[28] Responses to the HFSSM were also dichotomized based on the USDA's categorizations of "food insecure" (including low and very low food security) and "food secure" (including high and marginal food security) for descriptive purposes.

Outcome Variables

We used reported frequency of glucose monitoring and frequency of missed diabetes medications as measures of diabetes self-management. Both outcome variables were determined based on responses to questions in a written health survey. For the outcome of frequency of glucose monitoring, the survey question stated, "How often is your blood sugar checked with a glucose meter (glucometer)?" with the following response choices: "Less than once a week," "Less than once a day," "1-2 times a day," "3 times a day," "4-6 times a day," "7 or more times a day," and "Only when you are sick." Frequency of missed diabetes medication was measured using the question "How often do you miss your diabetes medicine including insulin?" with the following response choices: "Don't take diabetes medicine," "Never," "1-3 times a month," "1-5 times a week," "1 time a day," and "More than 1 time a day." As with the HFSSM, the parent or guardian was asked to complete the health questionnaire for any participant <18 years old, and participants ≥18 years old completed the questionnaire themselves.

Data related to the outcomes were dichotomously grouped based on the desired behavior. Frequency of missed diabetes medication was divided among those who reported never missing their medication and those who reported missing their medication at least once per month.

Participants that reported not taking diabetes medicine were excluded from this analysis. The threshold for desirable glucose monitoring was set at least four times per day (or more) based on previous evidence that adolescents' self-report of blood glucose monitoring was significantly correlated with lower HbA_{1c}, and this inverse relationship peaked at four to five blood glucose checks per day.[29] Furthermore, the majority (69%) of SEARCH participants reported receiving the recommendation to perform at least four blood glucose checks daily from their health care provider.[30] Participants that reported checking their blood sugar only when sick were grouped with those that reported checking blood glucose less than 4 times per day.

Covariates

SEARCH collected data via questionnaires related to age, sex, health insurance status, diabetes duration, parental education, household income, and race and ethnicity. The previously described health survey also collected information related to current diabetes regimen, asking participants "How do you currently treat your diabetes? Do you use: Diabetes tables (pills); Insulin shots, pump, or pen; Diet (meal plan); Exercise; Other (what?)" with the option to mark "Yes" or "No" for each option except for "Other," which provided a space for participants to write in a unique response. Consistent with other variables, participants ages ≥18 years responded to these questions themselves and the parent or guardian responded for participants <18 years old.

For our analyses, we created a dichotomous composite variable of socioeconomic status (SES) combining parental education and household income. Low SES was defined as household income <$50,000/year, as an approximation of the median household income in the US.[31] If income data was missing, participants with parent education less than a bachelor's degree were

also considered low SES. Any participant with household income of ≥$50,000/year, or parental education of a bachelor's degree of higher when income data was missing, was categorized as high SES.

Statistical Analysis

T tests, chi square, and Fisher's exact analyses were used to compare food secure households to food insecure households using the categorical measure of food insecurity. Separate logistic regression analyses were used to measure the association between household food insecurity and desired frequency of glucose monitoring and missed medications. For these analyses, we used the continuous measure of household food insecurity. Our initial models included age, sex, race/ethnicity, insurance status, SES, time since diabetes diagnosis, and SEARCH study site as covariates. Current use of oral diabetes medication and current use of insulin were not included as covariates due to the lack of variability in the study sample. Backward elimination of nonsignificant ($p>0.05$) covariates identified predictors of each outcome. All statistical analyses were completed using Stata 14.1 (StataCorp LLC, College Station, Texas).

Results

Our final analytic sample included the 210 participants who had responded to the HFSSM and at least one of the questions related to the primary outcomes: frequency of glucose monitoring (n=203), or frequency of missed diabetes medication (n=191), the latter excluded those that reported not taking diabetes medication (n=6).

The mean age of participants was 17 years with an average duration of diabetes of 99 months, or approximately 8.25 years (Table 1). The majority of the participants (62%) were enrolled through the Washington SEARCH site. There were slightly more female participants (55%) than male participants. Most of the cohort (75%) self-identified as white non-Hispanic. The participants were evenly distributed by socioeconomic status (SES), with 49% classified as low SES and 51% as high SES. The majority (58%) of the cohort used private health insurance, 31% used state or federal funded health insurance including Medicare or Medicaid, 6% did not have insurance, and 5% reported their insurance status as "other." Almost all (99%) participants reported using insulin, but only a small minority (3%) reported using pills to manage their diabetes. Most participants (62%) reported checking their blood glucose levels four times per day or more and 42% of participants reported never missing diabetes medication.

Based on the responses to the HFSSM, 40 participants (19%) were considered food insecure. Participants that were food insecure were significantly more likely to be categorized as low SES and use federal or state funded health insurance (Table 1). A greater percentage of food insecure participants reported monitoring blood glucose less than 4 times per day (65% of food insecure participants compared to 61% of food secure participants) and missing diabetes medication at least once per month (75% of food insecure participants compared to 55% of food secure participants), but these differences were not statistically significant.

Table 1: Characteristics of the participants overall and by household food security status

	All participants (n=210)	**Food secure** (n=170)	**Food insecure** (n=40)	***p***
Age (in years), *mean (sd)*	17.3 (4.9)	17.3 (5.0)	17.3 (4.7)	0.985
Time since diabetes diagnosis (months), *mean (sd)*	99.4 (27.3)	99.5 (27.3)	99.2 (27.7)	0.956
SEARCH study site, *n (%)*				0.241
South Carolina	80 (38)	68 (40)	12 (30)	
Washington	130 (62)	102 (60)	28 (70)	
Gender, *n (%)*				0.168
Female	115 (55)	97 (57)	18 (45)	
Male	95 (45)	73 (43)	22 (55)	
Race/Ethnicity, *n (%)*				0.656
White Non-Hispanic	158 (75)	129 (76)	29 (73)	
Other race/ethnicity	52 (25)	41 (24)	11 (28)	
Socioeconomic status, *n (%)*				<0.001
Low	100 (49)	68 (41)	32 (82)	
High	105 (51)	98 (59)	7 (18)	
Health insurance status, *n (%)*				0.001
Public (federal or state)	64 (31)	42 (25)	22 (55)	
Private	121 (58)	108 (64)	13 (33)	
Other	11 (5)	9 (5)	2 (5)	
None	12 (6)	9 (5)	3 (8)	
Frequency of use of glucometer, *n (%)*				0.649
Less than 4 times a day	78 (38)	65 (39)	13 (35)	
4 times a day or more	125 (62)	101 (61)	24 (65)	
Frequency of missed medications, *n (%)*				0.071
Never	80 (42)	69 (45)	11 (29)	
Once a month or more	111 (58)	84 (55)	27 (71)	
Insulin use, *n (%)*				1.000
Yes	208 (99)	168 (99)	40 (100)	
No	2 (1)	2 (1)	0 (0)	
Oral diabetes medication use, *n (%)*				1.000
Yes	6 (3)	5 (3)	1 (3)	
No	198 (97)	160 (97)	38 (97)	

Age, sex, race/ethnicity, insurance status, SES, time since diabetes diagnosis, and SEARCH study site were included as covariates in the initial logistic regression model for the outcome of frequency of blood glucose monitoring (Table 2). Using the backward elimination of non-significant covariates at $p>0.05$, only age and frequency of insulin remained in the model for this outcome. In that model, FI was not significantly associated with frequency of glucose monitoring (OR=0.88, 95% CI 0.72, 1.08, p=0.226). Age and SES, however, remained as significant predictors of frequency of glucose monitoring. With each increase in age of one year, the odds of monitoring blood glucose less than 4 times per day increased by 11% (OR=1.11, 95% CI 1.04, 1.18, p=0.005). Participants categorized as low SES were 2.39 times as likely to report checking blood glucose levels less than four times per day (OR=2.39, 95% CI 1.25, 4.56, p=0.008) as participants with high SES.

Table 2: Odds ratios for glucose monitoring less than four times per day

	Model 1: Includes all a priori covariates (n=196)			**Model 2: Following backwards deletion at p>0.05 (n=198)**		
	Odds Ratio	95% CI	*p*	Odds Ratio	95% CI	*p*
Household food insecurity (continuous)	0.88	0.71, 1.09	0.239	0.88	0.72, 1.08	0.226
Age	1.11	1.03, 1.20	0.006	1.11	1.04, 1.18	0.002
Duration of diabetes	0.99	0.98, 1.01	0.229			
SEARCH study site (Reference: South Carolina)						
Washington	1.15	0.60, 2.23	0.673			
Gender (Reference: Female)						
Male	1.10	0.58, 2.07	0.779			
Minority (Reference: Non-Hispanic White)						
Other race/ethnicity	1.24	0.59, 2.61	0.573			
Insurance type (Reference: Public)						
Private	1.46	0.65, 3.24	0.357			
Other	4.12	0.84, 20.20	0.081			
None	3.32	0.69, 16.02	0.134			
Socioeconomic status (Reference: High SES)						
Low SES	2.62	1.22, 5.60	0.013	2.39	1.25, 4.56	0.008

We used the same covariates in the initial logistic regression model for the outcome of missed diabetes medication (Table 3). Following the backwards elimination of nonsignificant covariates at p>0.05, sex was the only covariate retained. In this model, FI was significantly associated with a higher odds of missed diabetes medication (OR=1.24, 95% CI 1.02, 1.50, p=0.027). A one unit increase in the standardized FI score was associated with a 24% increase in the odds of missing diabetes medication at least once per month. Sex also remained a significant predictor; males were about half as likely to report missing medication at least once per month compared to females (OR=0.51, 95% CI 0.28, 0.93, p=0.027).

Table 3: Odds ratios for missing medication at least once per month

	Model 1: Includes all a priori covariates (n=185)			**Model 2: Following backwards deletion at p>0.05 (n=191)**		
	Odds Ratio	95% CI	*p*	Odds Ratio	95% CI	*p*
Household food insecurity (continuous)	1.12	0.90, 1.38	0.307	1.24	1.02, 1.50	0.027
Age	1.03	0.96, 1.11	0.412			
Duration of diabetes	0.99	0.98, 1.01	0.364			
SEARCH study site (Reference: South Carolina)						
Washington	1.87	0.98, 3.56	0.058			
Gender (Reference: Female)						
Male	0.49	0.26, 0.94	0.03	0.51	0.28, 0.93	0.027
Minority (Reference: Non-Hispanic White)						
Other race/ethnicity	0.78	0.37, 1.65	0.521			
Insurance type (Reference: Public)						
Private	0.62	0.27, 1.41	0.252			
Other	0.60	0.14, 2.62	0.496			
None	1.28	0.26, 6.37	0.767			
Socioeconomic Status (Reference: High SES)						
Low SES	1.48	0.70, 3.13	0.301			

Discussion

Our analyses suggest that among YYA with T1D, higher FI is associated with greater medication non-adherence. Although FI was not associated with frequency of blood glucose monitoring, lower SES was significantly associated with this outcome, altogether suggesting that social determinants of health may still play a role in this aspect of diabetes self-management.

Our results are consistent with previous research that has identified an association between FI and medication non-adherence among older adults with T2D. We found that each one unit increase in FI score is associated with a 23% increase in the odds of missing a diabetes medication at least once per month. As previously described, the USDA's Household Food Security Scale ranges from 0–10, and a higher score represents an increase in the quantity and typically in the severity of indications of food insecurity that the participant reported.[28] Therefore, participants from households that reported more affirmations of food insecurity-indicative experiences on the HFSSM are more likely to miss diabetes medication at least once per month.

This association could be due to the consequences of FI, such as increased stress among YYA with diabetes and their parents or caregivers, or shared causes, such as fewer financial resources for food and diabetes medication. Previous research has identified a significant association between FI and depression, diabetes-related distress, and low medication adherence among low-income adults with poorly controlled diabetes. Furthermore, there is evidence that these three factors partially mediate the relationship between FI and glycemic control.[16] With regards to YYA with T1D, food insecurity may increase feelings of stress and anxiety among their parents, which consequently negatively impacts parenting methods and lead to poor diabetes management.[32] One study examining parental distress among parents of youth with T1D

found that increased parental distress is linked to lower parental self-efficacy, which is directly related to decreased youth adherence and higher HbA1c levels.[33]

For households experiencing food insecurity, the cost of food may represent a competing demand with the costs of diabetes medications and other supplies. One study of low income adults with diabetes found that 44% of food insecure individuals reported putting off buying diabetes testing supplies and 38% reporting putting off buying diabetes related medications in order to buy food, compared to 5% and 9% of food secure individuals, respectively.[34] Similar results have been reported among families with children with T1D or insulin dependent T2D. Marjerrison and colleagues reported that almost half of food insecure families reported purchasing cheaper food so that more money would be available for diabetes supplies, and a small number of families reported reusing needles and/or checking blood glucose less frequently than recommended due to the cost of diabetes supplies.[3]

We also found that males were about half as likely to report missing diabetes medication at least once per month. This is consistent with previous reports that gender influences diabetes management in adolescents. Forsander and colleagues report that female adolescents with diabetes report significantly higher levels of distress, even when controlling for various factors that could contribute to distress.[35] While this study did not examine the relationship with self-management behaviors, they did note that female adolescents were significantly more likely to report not feeling motivated to keep up with diabetes related care.[35]

Contrary to our hypothesis, FI was not significantly associated with frequency of blood glucose monitoring. We did, however, find that lower SES and increase in age were significant predictors of monitoring blood glucose less than four times per day. As previously described, our analyses used a composite variable for SES that relied primarily on reported income, and

secondarily on parental education for participants that did not report income level. The association between these variables and frequency of glucose monitoring in this population has been described in greater detail by Yi-Frazier and colleagues, but overall our findings are consistent with their reports that younger children in this sample were more likely to comply with provider recommendations related to frequency of blood glucose monitoring and that families with higher incomes were more likely to report more frequent monitoring.[30]

There are some limitations to this study. These analyses use cross-sectional data, so it is not possible to infer causation. The primary exposure and outcome variables rely on self-reported information, and participants may feel shame surrounding their household food security status or their lack of adherence to diabetes self-management guidelines. Therefore, there is a possibility of underreporting of the exposure and outcome variables.

Despite these limitations, this study has some considerable strengths. As previously described, the results of this study on YYA are consistent with existing research on older adults. The primary exposure variable, household food insecurity, was measured using the gold standard developed by the USDA. Moreover, the study sample was larger than previous studies examining the FI among YYA with diabetes, and, to our knowledge, the first to address FI and diabetes self-management among this population in the United States.

Future studies that are able to reach a greater number of YYA with T1D who are experiencing food insecurity may better illuminate the associations between FI and diabetes self-management behavior. Although the sample size was larger than previous studies, only 40 participants were considered food insecure. A study population with a greater number of food insecure participants would provide greater statistical power to better identify trends between food insecurity and diabetes self-management variables.

Future research is also needed to examine the mechanism through which FI interacts with diabetes self-management. As previously described, both FI and diabetes self-management are sources of stress, and the financial cost of diabetes supplies may exacerbate already strained budgets in food insecure households. The inclusion of measures of stress or cost-related non-adherence may shed light on those interactions. It is also important to note that the measure of FI used in these analyses reflects the household's status as a whole, but often children and adolescents are shielded from the most direct and severe effects of FI such as the lack of food.[3,28] Future exploration of the interaction of child perceptions of food insecurity utilizing a child focused scale may contribute to a better understanding of the implications food insecurity on diabetes self-management behaviors among YYA with T1D.

This study has important implications for clinical practice and public health policy. Identifying and addressing food insecurity in YYA with T1D may be an important step in promoting medication adherence. Our findings further support the need for food insecurity screening by primary care providers, as recommended by the American Diabetes Association for all patients with diabetes[36] and by the American Academy of Pediatric for all children and their families.[37] Primary care providers should make adjustments to the treatment plan if necessary and refer patients that are food insecure to community resources that can support the patients' needs. From a policy perspective, our results add to the existing evidence that socioeconomic factors influence health through a wide range of mechanisms throughout the life course and support the need for large scale interventions to address food insecurity and other socioeconomic inequalities affecting our population's health.

Conclusion

The results of our study suggest that food insecurity is associated with diabetes medication adherence among YYA with T1D. We found a significant association between food insecurity and frequency of missed diabetes medications, but not frequency of blood glucose monitoring. Low frequency of blood glucose monitoring was, however, associated with low socioeconomic status, suggesting that socioeconomic factors do in fact contribute to frequency of blood glucose monitoring. Future studies are necessary to assess whether alleviating FI improves diabetes medication adherence and examine the mechanisms through which food insecurity might influence medication non-adherence and other self-management behaviors.

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