



# Household Food Insecurity and Fear of Hypoglycemia in Adolescents and Young Adults With Diabetes and Parents of Youth With Diabetes

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## OBJECTIVE

To evaluate the relation between household food insecurity (HFI) and fear of hypoglycemia among young adults with type 1 and type 2 diabetes and adolescents with type 1 diabetes and their parents.

## RESEARCH DESIGN AND METHODS

We analyzed cross-sectional data of 1,676 young adults with youth-onset diabetes (84% type 1, 16% type 2) and 568 adolescents (<18 years old; mean age 15.1 years) with type 1 diabetes from the SEARCH for Diabetes in Youth study. Adult participants and parents of adolescent participants completed the U.S. Household Food Security Survey Module. Adults, adolescents, and parents of adolescents completed the Hypoglycemia Fear Survey, where answers range from 1 to 4. The outcomes were mean score for fear of hypoglycemia and the behavior and worry subscale scores. Linear regression models identified associations between HFI and fear of hypoglycemia scores.

## RESULTS

Adults with type 1 diabetes experiencing HFI had higher fear of hypoglycemia scores (0.22 units higher for behavior, 0.55 units for worry, 0.40 units for total; all  $P < 0.0001$ ) than those without HFI. No differences by HFI status were found for adolescents with type 1 diabetes. Parents of adolescents reporting HFI had a 0.18 unit higher worry score than those not reporting HFI ( $P < 0.05$ ). Adults with type 2 diabetes experiencing HFI had higher fear of hypoglycemia scores (0.19 units higher for behavior, 0.35 units for worry, 0.28 units for total; all  $P < 0.05$ ) than those in food secure households.

## CONCLUSIONS

Screening for HFI and fear of hypoglycemia among people with diabetes can help providers tailor diabetes education for those who have HFI and therefore fear hypoglycemia.

In 2019, 10.5% of U.S. households (6.5% of households with children) experienced household food insecurity (HFI), the “limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods

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in socially acceptable ways" (1,2). HFI is even more prevalent among adults with cardiometabolic diseases (3) and families with a child who has diabetes (4), as it affects 20% of Americans with diabetes (3). Epidemiologic research specific to food insecurity among adolescents and young adults with diabetes is limited (4). However, we recently reported that 18% of youth and young adults with type 1 diabetes and 31% with type 2 diabetes experienced HFI in the previous year (5). This research suggests that food insecurity is a considerable problem, particularly among adolescents and young adults with diabetes.

Hypoglycemia is a common acute complication of diabetes and is characterized by abnormally low blood glucose levels that can trigger sweating, shaking, heart palpitations, dizziness, lethargy, slurred speech, and mental confusion (6). Severe hypoglycemia can be life-threatening due to loss of consciousness, seizure, accidents, physical injury, and in the most severe cases, death (7). Consequently, many people with diabetes attempt to avoid hypoglycemia by treating early signs and ingesting fast-acting carbohydrate-rich snacks (8,9). Although some level of concern is normal, individuals with diabetes or parents may develop a more significant, anxiety-like fear of hypoglycemia that negatively impacts quality of life and diabetes management (7,10). This more severe fear of hypoglycemia is typically expressed as worrying about hypoglycemia or through avoidant behaviors (10).

For individuals with diabetes experiencing HFI, the uncertain availability of food may increase fear of hypoglycemia. Fast-acting carbohydrate foods may be insufficient in quantity or unhealthy (11), compromising the ability to treat early signs of hypoglycemia. Food may also be completely unavailable. There is research to support that people with diabetes who have HFI must sometimes choose between food, medication, and living expenses (11,12). Among people with diabetes who use community food resources such as food banks or kitchens, at least one in three opt to purchase medication before food (12).

To our knowledge, there are no studies with exploration of a relation between HFI and fear of hypoglycemia among people with diabetes. If such a relation exists, providers may be encouraged

to screen for HFI and fear of hypoglycemia, as well as modify conversations about fear of hypoglycemia if a patient experiences HFI. Therefore, the purpose of this study was to evaluate the relation between HFI and fear of hypoglycemia in young adults with youth-onset type 1 or type 2 diabetes as well as among adolescents with youth-onset type 1 diabetes and their parents. We hypothesized that people who experience HFI would have more fear of hypoglycemia than those in food secure households.

## RESEARCH DESIGN AND METHODS

The SEARCH for Diabetes in Youth (SEARCH) study is a multicenter observational study with assessment of incidence and prevalence of youth-onset diabetes. The overarching goal of SEARCH is to advance the understanding of the epidemiology of nongestational diabetes among youth and young adults diagnosed with diabetes before age 20 years. Initially designed as a surveillance effort, SEARCH has expanded into a multicenter cohort study (13,14). Data collection sites include CA, CO, OH, SC, and WA (14). Institutional review board approval to conduct this study was granted at each of the participating funded centers. Participants provided informed consent (if  $\geq 18$  years old) or assent (if  $< 18$  years old) and parents provided consent before data collection began. Methods for SEARCH have previously been described (14).

In this study, we used cross-sectional data collected during the SEARCH phase 4 cohort study in years 2015–2019.

## HFI

HFI was assessed with the 18-item U.S. Household Food Security Survey Module, which includes queries about the previous 12 months. Parents/guardians of SEARCH participants under age 18 years and young adults  $\geq 18$  years of age completed the survey. The first 10 questions pertain to all households (with or without minors), and the last 8 questions are specific to households with children ages 0–17 years (1). Both households with and households without children were classified as food insecure if three or more food insecure conditions or behaviors were affirmed and as food secure otherwise (2). For the purpose of assessing the prevalence of HFI among

U.S. households, the U.S. Household Food Security Survey Module has been shown to be a stable, robust, valid, and reliable measurement tool (1).

## Fear of Hypoglycemia

The Hypoglycemia Fear Survey-II (HFS-II) contains two question sets for people with diabetes: one on behaviors to avoid or mitigate hypoglycemia and its consequences and another on worries concerning hypoglycemia (15). These two question sets can be combined to produce an overall fear of hypoglycemia score.

The adult behavior subscale includes assessment of 15 behaviors (e.g., keeping blood glucose levels  $> 150$  mg/dL, making sure other people are around, and limiting exercise or physical activity) and the worry subscale addresses 18 concerns about experiencing hypoglycemia (e.g., being alone, episodes occurring during sleep, or having an accident) (15). In the current study, adult participants (ages 18–35 years) completed this survey. For each item, a participant indicated his/her response on a Likert scale of 0–4 as never, rarely, sometimes, often, or almost always. We used an average score for each subscale and an average score for the full survey (16). Therefore, scores of the subscales and full survey ranged from 0 to 4. A 0.5-unit change in the score indicates movement from one response to the midpoint of another response. Findings of a large study among adults with type 1 diabetes (mean age 41.9 years) showed that the HFS-II had good validity and reliability, demonstrated by positive correlations between the survey and other measures of distress (15).

The Hypoglycemia Fear Survey for Children (HFS-C) and the Hypoglycemia Fear Survey for Parents (HFS-P) are adapted from the original adult version to be appropriate for children with type 1 diabetes and their parents (17,18). In our study, adolescent participants ages 10–17 years completed the HFS-C and their parents completed the HFS-P. The HFS-C was created for youth ages 6–18 years and has demonstrated adequate internal consistency and reliability (18,19). Additionally, the HFS-P has been well validated among parents of youth with type 1 diabetes (20).

The parent and adolescent versions of the survey include 10 behavior subscale questions and 15 worry subscale questions

that vary slightly from the adult version in wording and do not have questions that would not pertain to adolescents. As with the adult survey, adolescents and parents answered questions on a Likert scale of 0–4. An average score was calculated for the behavior subscale, the worry subscale, and the full survey so that scores ranged from 0 to 4.

### Covariates

Continuous variables used for this analysis include the participant's age and diabetes duration at the cohort visit. Categorical variables included sex (female/male), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), SEARCH clinic site (CA, CO, OH, SC, WA), highest parental education (less than high school graduate, high school graduate, some college/associate degree, bachelor's degree or higher), household income (<\$25,000, \$25,000–49,000, \$50,000–75,000, ≥\$75,000), insurance type (state/federal, private, other/unknown, none), diabetes medication regimen (insulin pump, long-acting and rapid-acting insulin, 3+ injections per day, any other combo of insulin injections, oral hypoglycemic medication, no pharmacological treatment), and continuous glucose monitoring use (yes/no).

### Statistical Analysis

Cohort visits were completed for 2,669 participants (699 adolescents <18 years old and 1,970 young adults). Because this sample had been part of a longitudinal study with three to six prior data collection points, missing demographic characteristics (household income, parent education, and insurance type) were obtained from the most recent data collection time point for 89 adolescents and 447 young adults. Among 1,970 young adults, 1,892 completed the HFS-II. Young adults missing a single question ( $n = 20$ ) were included in the analysis. Of people who completed the HFS-II, 16 did not have household food security information. After restriction of the data set to those with all covariates, 1,676 were left in the sample. Young adults were divided into groups of those with type 1 diabetes ( $n = 1,401$ ) and type 2 diabetes ( $n = 275$ ) for the analyses.

The sample of 676 adolescents with type 1 diabetes was restricted to those

for whom there was both an HFS-C and HFS-P ( $n = 623$ ). Adolescents missing a single question from the survey ( $n = 4$  adolescents,  $n = 3$  parents) were included in the analysis. Four additional adolescents were excluded because they did not have household food security data. Using only complete data sets limited the analysis to 568 adolescents with type 1 diabetes and their parents. Due to the mean age at type 2 diabetes diagnosis and the minimum diabetes duration of 5 years to be eligible for a cohort visit, there was only a small number of adolescents with type 2 diabetes ( $n = 23$ ), and this group was excluded because it was too small for statistical analysis.

All analyses were conducted separately for young adults with type 1 diabetes and type 2 diabetes and adolescents with type 1 diabetes and parents of these adolescents. We examined the association between HFI and fear of hypoglycemia using linear regression analysis. A partially adjusted model included adjustment for the participant's age, diabetes duration, sex, race/ethnicity, and SEARCH clinic site. The fully adjusted model additionally included parent education, household income, health insurance type, diabetes medication regimen, and continuous glucose monitoring use, as these variables are modifiable.

The mean fear of hypoglycemia score, behavior subscale score, and worry subscale score showed slightly skewed distributions. We repeated the linear regression analyses after a square root transformation of the mean scores. This yielded similar results and is not reported.

For adults with type 2 diabetes, risk of hypoglycemia is higher for those who include insulin in their medication regimen than for those who do not (21,22). Therefore, we repeated the analysis for adults with type 2 diabetes with stratification by those who use any form of insulin and those who do not. All analyses were completed with SAS 9.4.

### RESULTS

The study sample was comprised of 568 adolescents <18 years old with type 1 diabetes (mean  $\pm$  SD age  $15.1 \pm 2.1$  years [range 10.0–17.9]), 1,401 young adults with type 1 diabetes ( $23.6 \pm 3.7$  years [18.1–35.9]), and 275 young adults with type 2 diabetes ( $25.8 \pm 3.8$  years

[range 18.2–35.6]). Of these participants, 16%, 19%, and 35%, respectively, were from food insecure households. Additional descriptive information is provided in Table 1.

The mean fear of hypoglycemia scores overall and stratified by food security status are presented in Table 1 for each group. Fear of hypoglycemia scores were highest for parents of adolescents with type 1 diabetes and were lowest for young adults with type 1 diabetes. Unadjusted models for assessment of the association between HFI and fear of hypoglycemia scores are presented in Tables 2 and 3. HFS-II scores were significantly higher for young adults with type 1 diabetes and type 2 diabetes experiencing HFI compared with their counterparts who lived in food secure households. There was no difference in HFS-C and HFS-P scores between food secure and food insecure households of adolescents with type 1 diabetes and parents.

Young adults with type 1 diabetes from food insecure households had significantly higher HFS-II scores, behavior subscale scores, and worry subscale scores than those without HFI, independent of age, diabetes duration, sex, race, and clinic (Table 2). These associations remained significant after additional adjustment for demographic and clinical covariates. Specifically, young adults with type 1 diabetes experiencing HFI had mean  $\pm$  SD HFS-II score  $0.40 \pm 0.046$  units higher than those from food secure homes ( $P < 0.0001$ ). They also had a behavior subscale score  $0.22 \pm 0.040$  units higher ( $P < 0.0001$ ) and a worry subscale score  $0.55 \pm 0.061$  units higher ( $P < 0.0001$ ) than those without HFI.

For adolescents with type 1 diabetes and their parents, no differences in the self-reported fear of hypoglycemia scores were observed between adolescents living in food secure households and those in food insecure households (Table 2). Among parents of adolescents with type 1 diabetes, parents' average worry subscale scores were 0.18 units higher ( $P < 0.05$ ) among those experiencing HFI compared with parents in food secure households in the fully adjusted model.

Among young adults with type 2 diabetes, HFI was associated with HFS-II score, the worry subscale score, and the behavior subscale score (Table 3). These associations remained in the fully adjusted models, in which food insecurity

**Table 1—Demographic and clinical characteristics of adults participating in SEARCH for Diabetes in Youth study (2015–2019), by household food security status**

	Adolescents with type 1 diabetes (n = 568)				Young adults with type 1 diabetes (n = 1401)				Young adults with type 2 diabetes (n = 275)			
	Household food security status		Household food security status		Household food security status		Household food security status		Household food security status		Household food security status	
	Total	Food secure (n = 477)	Food insecure (n = 91)	Total	Food secure (n = 1,141)	Food insecure (n = 260)	Total	Food secure (n = 180)	Food insecure (n = 95)	Total	Food secure (n = 180)	Food insecure (n = 95)
Age	15.1 ± 2.1	15.1 ± 2.1	15.0 ± 2.1	23.6 ± 3.7	23.5 ± 3.7	24.1 ± 3.5	25.8 ± 3.8	25.7 ± 3.9	26.1 ± 3.7			
Sex												
Female	50.2	48.6	58.2	54.3	53.8	56.2	66.5	65.6	68.4			
Male	49.8	51.4	41.8	45.8	46.2	43.9	33.5	34.3	31.6			
Race/ethnicity												
NH White	71.1	74.4	53.9	74.6	75.6	70.4	22.2	18.3	29.5			
NH Black	11.8	9.0	26.4	10.6	9.0	17.3	43.3	43.9	42.1			
Hispanic	13.4	13.0	15.4	12.4	13.0	10.0	23.6	26.7	17.9			
Other	3.7	3.6	4.4	2.4	2.5	2.3	10.9	11.1	10.5			
Household income												
<\$25,000	10.0	7.3	24.2	21.2	16.7	40.8	50.9	45.6	61.1			
\$25,000–49,999	18.3	15.5	33.0	23.4	21.2	33.1	33.5	32.2	35.8			
\$50,000–74,999	17.3	14.5	31.9	17.1	17.4	15.8	7.6	10.6	2.1			
≥\$75,000	54.4	62.7	11.0	38.3	44.7	10.4	8.0	11.7	1.1			
Clinic												
SC and NC	19.9	18.5	27.5	18.8	17.8	23.5	34.6	32.8	37.9			
OH	14.8	15.5	11.0	19.8	20.7	16.2	20.0	20.6	19.0			
CO	37.5	37.7	36.3	33.9	33.9	33.9	20.0	18.9	22.1			
CA	10.7	11.5	6.6	12.5	12.9	10.8	19.6	23.9	11.6			
WA	17.1	16.8	18.7	14.9	14.7	15.8	5.8	3.9	9.5			
Parent education												
<HS graduate	2.1	2.1	2.2	4.4	4.2	5.0	12.0	12.2	11.6			
HS graduate	9.0	7.6	16.5	15.3	13.7	22.3	33.1	35.6	28.4			
Some Col./Asso.	32.0	28.9	48.4	26.0	23.8	35.4	37.8	36.1	41.1			
≥Bachelor's degree	56.9	61.4	33.0	54.4	58.3	37.3	17.1	16.1	19.0			
Insurance status												
State/federal	23.4	18.0	51.7	12.4	9.8	23.9	37.5	35.0	42.1			
Private	75.0	80.3	47.3	81.4	84.5	68.1	44.4	47.2	39.0			
Other/unknown	0.9	0.8	1.1	2.2	2.5	1.2	2.9	3.3	2.1			
None	0.7	0.8	0.0	3.9	3.2	6.9	15.3	14.4	16.8			
Diabetes duration, months	116.8 ± 36.9	117.1 ± 37.2	115.2 ± 34.9	148.2 ± 33.9	148.0 ± 33.7	148.9 ± 34.9	135.2 ± 39.5	136.1 ± 38.1	133.3 ± 42.3			
Diabetes regimen												
Insulin pump	75.0	76.5	67.0	55.0	57.9	42.3	3.6	3.9	3.2			
Long-acting and rapid-acting insulin, 3+ injections per day	22.2	20.8	29.7	38.5	36.4	47.7	16.4	13.3	22.1			
Any other combination of insulin injections	2.8	2.7	3.3	5.4	4.8	7.7	34.6	37.2	29.5			

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Table 1—Continued

	Adolescents with type 1 diabetes (n = 568)			Young adults with type 1 diabetes (n = 1401)			Young adults with type 2 diabetes (n = 275)		
	Household food security status			Household food security status			Household food security status		
	Total	Food secure (n = 477)	Food insecure (n = 91)	Total	Food secure (n = 1,141)	Food insecure (n = 260)	Total	Food secure (n = 180)	Food insecure (n = 95)
Oral hypoglycemic medication									
No treatment	0.0	0.0	0.0	0.6	0.4	1.5	16.7	15.6	19.0
	0.0	0.0	0.0	0.6	0.5	0.8	28.7	30.0	26.3
CGM2 use, %	49.3	51.4	38.5	34.9	38.7	18.5	16.7	15.0	20.0
Participant fear scores									
HFS score*	1.3 ± 0.5	1.3 ± 0.5	1.3 ± 0.5	1.1 ± 0.7	1.0 ± 0.6	1.4 ± 0.7	0.7 ± 0.6	0.6 ± 0.6	0.9 ± 0.7
Behavior subscale	1.8 ± 0.6	1.8 ± 0.6	1.8 ± 0.6	1.0 ± 0.6	1.0 ± 0.5	1.2 ± 0.6	0.7 ± 0.6	0.6 ± 0.6	0.9 ± 0.7
Worry subscale	1.0 ± 0.6	0.9 ± 0.6	1.0 ± 0.7	1.1 ± 0.9	1.0 ± 0.8	1.5 ± 1.0	0.7 ± 0.8	0.5 ± 0.8	0.9 ± 0.9
Parent fear scores†									
HFS score	1.6 ± 0.6	1.5 ± 0.6	1.6 ± 0.6						
Behavior subscale	2.0 ± 0.6	2.0 ± 0.6	1.9 ± 0.6						
Worry subscale	1.3 ± 0.7	1.3 ± 0.7	1.4 ± 0.8						

Data are means ± SD or % Asso., associates; CGM, continuous glucose monitoring; Col., college; HS, high school; NH, non-Hispanic. \*Including the HFS-C and the HFS-P. †HFS score range 0–4, behavior subscale range 0–4, worry subscale range 0–4.

was associated with the average fear of hypoglycemia score (0.28 units higher;  $P < 0.05$ ), the behavior subscale score (0.19 units higher;  $P < 0.05$ ), and the worry subscale score (0.35 units higher;  $P < 0.05$ ). Of the 275 individuals in our study with type 2 diabetes, 150 (55%) used insulin in their medication regimen. In analyses stratified by insulin use, HFI was significantly associated with the HFS-II score and worry subscale score in both groups. However, the magnitude of the associations was higher among those who use insulin. For the behavior subscale score, those who did not use insulin had no association between food insecurity and hypoglycemia fear after adjustment for covariates. Those who used insulin had a higher behavior subscale score (0.28 units higher;  $P < 0.05$ ) if they were food insecure compared with those who were food secure. The results of the stratified analysis can be found in Table 4.

## CONCLUSIONS

The results of this study demonstrated that HFI in the past year was associated with increased fear of hypoglycemia, expressed as both engaging in behaviors to avoid hypoglycemia and worries of experiencing hypoglycemia in people with type 1 and type 2 diabetes. The nature of the food insecurity experience makes it likely that people with diabetes in food insecure households are keenly aware that preventing and overcoming hypoglycemia may be difficult for them because they do not always have immediate access to food because of monetary constraints. This is consistent with other research where investigators found that higher income was associated with less fear of hypoglycemia (23).

Parents with HFI worried about their child with type 1 diabetes experiencing hypoglycemia more than parents whose households were food secure. Parental concern about the child's hypoglycemia is well documented (17,18,24–26), with mothers reporting greater fear than fathers (24,25). In our study we extend this research by differentiating by household food security status. Parents who are experiencing food insecurity may be more aware of the dangers of not having enough food and therefore more inclined to worry about the child having a hypoglycemic episode. Literature also

**Table 2—Association of household food security with hypoglycemia fear scores and subscales among young adults, adolescents, and the parents of adolescents with type 1 diabetes: SEARCH for Diabetes in Youth study**

Outcomes	Model 1*		Model 2†		Model 3‡		Adjusted mean		Mean difference
	β ± SE	P	β ± SE	P	β ± SE	P	FS	FI	
Young adults (n = 1,401)									
HFS-II score	0.39 ± 0.04	<0.05	0.37 ± 0.04	<0.05	0.40 ± 0.05	<0.05	0.75	1.15	0.40
Behavior subscale score	0.21 ± 0.04	<0.05	0.20 ± 0.04	<0.05	0.22 ± 0.04	<0.05	0.85	1.07	0.22
Worry subscale score	0.53 ± 0.06	<0.05	0.51 ± 0.06	<0.05	0.55 ± 0.06	<0.05	0.67	1.22	0.55
Adolescents (n = 568)									
HFS-C score	0.05 ± 0.06	>0.05	0.04 ± 0.06	>0.05	0.05 ± 0.06	>0.05	0.98	1.03	0.05
Behavior subscale score	−0.02 ± 0.06	>0.05	0.00 ± 0.07	>0.05	0.01 ± 0.07	>0.05	1.44	1.46	0.02
Worry subscale score	0.10 ± 0.07	>0.05	0.07 ± 0.07	>0.05	0.07 ± 0.08	>0.05	0.67	0.75	0.08
Parents of adolescents (n = 568)									
HFS-P score	0.05 ± 0.06	>0.05	0.05 ± 0.07	>0.05	0.11 ± 0.07	>0.05	1.42	1.54	0.12
Behavior subscale score	−0.04 ± 0.07	>0.05	−0.04 ± 0.07	>0.05	0.01 ± 0.07	>0.05	1.64	1.65	0.01
Worry subscale score	0.11 ± 0.08	>0.05	0.11 ± 0.08	>0.05	0.18 ± 0.09	<0.05	1.28	1.46	0.18

Food secure is the reference level. FI, food insecure; FS, food secure. \*Model 1: unadjusted association between household food security and hypoglycemia fear scores and subscales. †Model 2: adjustment for age, diabetes duration, sex, race/ethnicity, and clinic. ‡Model 3: model 2 adjustments plus parent education, household income, insurance type, medication regimen, and continuous glucose monitoring use.

**Table 3—Association of household food security with hypoglycemia fear scores and subscales among young adults with type 2 diabetes: SEARCH for Diabetes in Youth study**

Outcomes in young adults (N = 275)	Model 1*		Model 2†		Model 3‡		Adjusted mean		Mean difference
	$\beta \pm SE$	P	$\beta \pm SE$	P	$\beta \pm SE$	P	FS	FI	
HFS-II score	0.32 $\pm$ 0.08	<0.05	0.37 $\pm$ 0.08	<0.05	0.28 $\pm$ 0.08	<0.05	0.61	0.88	0.27
Behavior subscale score	0.24 $\pm$ 0.08	<0.05	0.29 $\pm$ 0.08	<0.05	0.19 $\pm$ 0.08	<0.05	0.66	0.85	0.19
Worry subscale score	0.39 $\pm$ 0.10	<0.05	0.43 $\pm$ 0.10	<0.05	0.35 $\pm$ 0.10	<0.05	0.56	0.91	0.35

Food secure is the reference level. FI, food insecure; FS, food secure. \*Model 1: unadjusted association between household food security and hypoglycemia fear scores and subscales. †Model 2: adjustment for age, diabetes duration, sex, race/ethnicity, clinic. ‡Model 3: model 2 adjustments plus parent education, household income, insurance type, medication regimen, and continuous glucose monitoring use.

**Table 4—Association of household food security with hypoglycemia fear scores and subscales among young adults with type 2 diabetes, stratified by insulin use: SEARCH for Diabetes in Youth study (n = 275)**

Outcomes	No insulin use, n = 125		Insulin use, n = 150	
	$\beta \pm SE$	P	$\beta \pm SE$	P
HFS-II score	0.24 $\pm$ 0.09	0.01	0.35 $\pm$ 0.14	0.01
Behavior subscale score	0.10 $\pm$ 0.10	0.32	0.28 $\pm$ 1.12	0.03
Worry subscale score	0.35 $\pm$ 0.13	0.01	0.41 $\pm$ 0.17	0.02

Food secure is the reference level. Models adjusted for age, diabetes duration, sex, race/ethnicity, clinic, parent education, household income, insurance type, and continuous glucose monitoring use.

documents that very worried mothers of adolescents with type 1 diabetes may accept elevated glucose levels to reduce risk of hypoglycemia (26). Long-term, glucose levels higher than the recommendations (hyperglycemia) can have serious negative health consequences such as poor cognitive function (27), cardiac

autoimmunity leading to increased risk of cardiovascular disease later in life, and chronic diabetes complications (9). In future research investigators should focus on parents who fear hypoglycemia for their children and explore how to help those in food insecure households manage the child's diabetes.

Among adolescent participants with type 1 diabetes, we did not observe an association between HFI and self-reported fear of hypoglycemia. This lack of association may be because children are often shielded from HFI as parents try to maintain a near-normal diet for their children even if they themselves are not able to eat (28). In 2019, only 0.6% of U.S. households with youth experienced food insecurity so severe that caregivers reported there was not enough money for food so that their children experienced hunger, could not eat all daily meals, or did not eat for 24 h (2). Parents have also reported that if their children experience food insecurity, they are usually older (2,28).

Young adults with type 1 diabetes or type 2 diabetes who lived in households with food insecurity experienced more worry, engaged in more avoidant behaviors, and overall had higher



fear of hypoglycemia scores than those living in food secure households. By and large, the most common predictor of fear of hypoglycemia is the experience of previous hypoglycemic episodes (10,16,18,29–31). Reports document consistently that adults with HFI have a higher prevalence and increased risk of experiencing hypoglycemia (32,33). Adults who fear hypoglycemia oftentimes consume excessive carbohydrates and simple sugars to prevent a hypoglycemic episode (34,35). The latter is problematic for two reasons. First, long-term consequences of hyperglycemia result in chronic complications of diabetes (36–38).

Second, fearing hypoglycemia may further exacerbate the difficult task of balancing food and diabetes medicine in a stretched budget, as overeating carbohydrates requires administration of more medication to counter elevated blood glucose levels, which in turn requires purchasing of more medication. People who have diabetes and HFI struggle to balance acquiring food, medicine, and supplies for diabetes, along with their day-to-day expenses (12). Consequently, integrating fear of hypoglycemia screening as well as food security screening into diabetes clinical visits will provide relevant information for tailored diabetes education. Tailored education is needed for households that are food insecure, as innovative rather than conventional strategies to maintain glycemic control are necessary for people with diabetes and HFI (11). This conclusion is in line with the American Diabetes Association's recommendation to screen for food insecurity in all patients with diabetes (9).

For adults with type 2 diabetes, the magnitude of the associations of HFI, HFS-II score, and worry subscale score was higher for those using insulin than for those who do not use insulin. Additionally, adults with type 2 diabetes using insulin had a higher behavior subscale score if they were food insecure compared with those who were food secure. This association was not significant for those who do not use insulin, which is what we expected to observe. The belief that hypoglycemia is uncommon in people with Type 2 diabetes is a myth. In a systematic review, Alwafi et al. (22) found that the prevalence of hypoglycemia

among people with type 2 diabetes is as high as 73.0%, and the risk is highest among those using insulin-based therapy. Diabetes providers should pay special attention to patients with type 2 diabetes using insulin, especially since the prevalence of HFI is typically higher in those with type 2 diabetes than in those with type 1 diabetes (5). In our study, 35% of adults with type 2 diabetes experienced HFI compared with 19% of adults with type 1 diabetes and 16% of adolescents with type 1 diabetes.

A strength of this study is the use of validated and widely accepted instruments to measure HFI and fear of hypoglycemia, which allow for comparison and future replication in other populations (1,16–18). Moreover, our study included a large diverse set of perspectives of adolescents with type 1 diabetes, parents of adolescents with type 1 diabetes, and young adults with type 1 and type 2 diabetes, whereas most previous work examining fear of hypoglycemia focused on either adults or adolescents with type 1 diabetes and parents of adolescents with type 1 diabetes (7,10,18,24,25,39). A weakness of this study is the sample size of adolescents with type 2 diabetes.

In conclusion, young adults with type 1 diabetes and type 2 diabetes who lived in households with food insecurity experienced more fear of hypoglycemia than those living in food secure households. Parents of adolescents with type 1 diabetes living in food insecure households experienced more worry about hypoglycemia than parents in food secure households. More research is needed that explores how to help young adults manage fear of hypoglycemia and manage glucose levels in the presence of HFI. Additionally, providers should consider tailored strategies that take into account social determinants of health such as HFI status in discussing how to manage low blood glucose levels and fear of hypoglycemia with patients. Innovations are clearly needed because conventional methods to prevent or overcome hypoglycemia, such as carrying snacks, is problematic for people who are food insecure.

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