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RESEARCH ARTICLE

Healthcare and Nonhealthcare Costs: Youth With Diabetes and Food Insecurity

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Introduction: This study prospectively evaluated the association of household food insecurity with acute care costs and productivity loss in youth and young adults with Type 1 and Type 2 diabetes.

Methods: This observational cohort study included 1,256 youth and young adults with Type 1 and Type 2 diabetes from the SEARCH for Diabetes in Youth Food Security Study, with data collected at 3 time points between 2015 and 2022. Both household food insecurity (measured using the U.S. Household Food Security Survey Module) and costs (measured using survey responses on utilization and productivity losses) were self-reported by young adult participants or the caregivers of adolescents. The relationship between household food insecurity and costs was analyzed using generalized adjusted linear regression. The authors also analyzed the moderating role of continuous health insurance coverage.

Results: Each additional 1-point increase in the household food insecurity score was associated with a $1,077 (95% CI=663; 1,491) increase in measured 12-month costs. Costs were $4,384 (95% CI=2,635; 6,133) higher in households that were experiencing household food insecurity than in those that were not. Youth and young adults with continuous health insurance coverage saw smaller increases in costs ($864, 95% CI=461; 1,267) than those without continuous coverage ($1,820; 95% CI=379; 3,261).

Conclusions: This study found a positive association between household food insecurity and costs for youth and young adults with diabetes, and this relationship was modified by continuous health insurance coverage. Future work should use linked claims and electronic health record data to better inform efforts aimed at reducing household food insecurity burden and improving the continuity of insurance coverage for this population.

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INTRODUCTION

Household food insecurity (HFI), "limited or uncertain unavailability of nutritionally adequate and safe foods,"[1] is prevalent among youth and young adults (YYAs) with diabetes. Between 2016 and 2019, fully 1 in 3 YYAs with Type 2 diabetes and 1 in 6 YYAs with Type 1 diabetes experienced HFI in the last year.[2] The American Diabetes Association Standards explicitly recommend assessing HFI because of its central role in influencing the 3 pillars of optimal glycemic control: nutrition therapy, physical activity, and monitoring and selfmanagement of glucose levels.[3]

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HFI can negatively influence mental and physical health.[4,5] Food-insecure adults with chronic diseases must often choose between paying for care and paying for food.[6–11] Food insecurity among adults with diabetes is associated with fourfold higher cost-related medication underuse,[12] and food insecurity among children is associated with an almost 180% increase in foregone health care.[5] Individuals experiencing HFI generally have higher healthcare utilization and expenditures and more missed work time than the food-secure individuals, independent of other social determinants of health, especially among individuals with chronic conditions.[13–20] In a national U.S. study, children with HFI and a chronic condition had a 1.9 higher incidence rate ratio of emergency department utilization than children without HFI and/or without chronic conditions.[21] Among individuals with diabetes, the consequences of HFI include higher HbA1c levels, greater fear of hypoglycemia and episodes of severe hypoglycemia, and higher frequency of hospitalization.[11,12,22–27] In another study, HFI was associated with 3.5-fold higher odds of hospitalization among Canadian youth with insulin-dependent diabetes.[23]

Although much is known about the relationship between HFI and healthcare utilization generally, little is known about this relationship for YYAs with diabetes and even less about how it relates to healthcare costs. Moreover, the nonhealthcare sector costs related to healthcare use are rarely assessed. These costs are particularly relevant for YYAs, a working-age population in need of childcare alternatives. In a pilot study using a subsample from SEARCH (2013–2015), participants with HFI had 3 times higher prevalence rates of emergency department visits than food-secure participants, but utilization was not monetized, and emergency department utilization and hospitalizations were assessed separately.[27] This study builds on this prior literature by assessing the association between HFI, healthcare utilization, acute care costs, and productivity losses among YYAs with diabetes. The authors hypothesized that households experiencing food insecurity would have higher costs than households without food insecurity and that these associations would be moderated by continuous health insurance coverage.[28]

METHODS

Study Sample

This study used data from the SEARCH Food Security (SFS) study, an observational cohort study without intervention among YYA patients aged 10–35 years with provider-diagnosed diabetes that recruited participants from the fourth phase (2015–2019) of the parent SEARCH study (i.e., SEARCH 4).[29] SEARCH was a multicenter study conducted to improve the understanding of childhood diabetes in the U.S. Participants from 3 of the 5 SEARCH sites (Colorado, South Carolina, and Washington) were eligible to participate in the SFS study (n=1,890). This study was approved by the IRBs of each site (Seattle Children's Hospital, University of Colorado Denver - Anschutz Medical Campus, and University of South Carolina). Adult participants and parents/guardians of participants aged <18 years provided informed consent, and participants aged 8–17 years provided assent to participate in the study. The SFS study collected data from eligible participants at 2 time points (SFS Surveys 1 and 2) between 2018 and 2022, following the completion of SEARCH 4. There were 1,256 individuals who participated in at least 1 SFS survey. This study uses data from SEARCH 4, SFS Survey 1, and SFS Survey 2, and the unit of observation is person wave. Data were available from all 3 data collection points for 71.0% (n=892) of the sample, 21.4% (n=269) of participants had data for the first and second data collection points (SEARCH 4 and SFS Survey 1), and 7.6% (n=95) had data for the first and last data collection points (SEARCH 4 and SFS Survey 2) (Appendix Figure 1, available online).

Measures

The primary cost measure in analyses included formal healthcare sector and nonhealthcare sector costs. Formal healthcare costs included medical costs for several types of healthcare utilization, such as urgent care (UC) visits, emergency room (ER) visits, and inpatient hospital stays more than 24 hours. Participants reported the number of each visit type in the past 12 months, if any (Appendix Table 1, available online). All-cause UC visits, ER visits, and inpatient hospital stays were calculated for each participant. Data from the 2016 to 2020 Medical Expenditure Panel Survey (MEPS) were used to estimate average costs, including reimbursements and out-of-pocket costs, for similar utilization measures (office-based medical provider visits, ER visits, and hospital inpatient stays) for individuals with diabetes[30] (Appendix Table 2, available online). Formal healthcare costs were calculated for each patient by multiplying each utilization measure (UC, ER, and inpatient visits) by the respective estimated average cost from MEPS and summing.

Nonhealthcare sector costs to account for childcare costs and productivity losses from time away from work were estimated using microcosting.[31] Adults reported how many times they had to make childcare arrangements to attend medical appointments in the last 12 months, if any. Childcare costs were calculated by multiplying the number of hours childcare was required by the mean hourly wage for childcare workers ($14.22 U.S.

Dollars 2022) from the 2022 Occupational Employment Statistics Survey.[32,33] Adults were also asked how many hours of work they, a family member, or friend missed for typical diabetes appointments. The total missed hours of work were multiplied by the Bureau of Labor Statistics average hourly earnings of all employees seasonally adjusted ($32.25 U.S. Dollars 2022), a 9.9% tax rate,[34] and 30% fringe, following expert recommendations.[35] Nonhealthcare sector costs per participant were taken as the sum of childcare and missed work costs. Appendix Table 1 (available online) contains all survey questions used to construct costs, and Appendix Table 3 (available online) provides the impact inventory for all considered factors.

HFI was measured using the 18-item U.S. Household Food Security Survey Module.[36] At each survey data collection time point, parents/guardians of participants aged <18 years and participants aged ≥18 years provided responses to 10 items about having enough food that pertain to all household members and an additional 8 items specific to any children in households. The U.S. Household Food Security Survey Module (HFSSM) has been extensively used with strong reliability.[1,36–39] A continuous, scaled score was used as the primary HFSSM measure. A higher score is worse, indicating a higher degree of HFI. A dichotomous measure of food insecurity was created, equal to 1 if a respondent endorsed 3 or more items on the module as food insecure and 0 otherwise.

Statistical Analysis

Cohort data from all time points were used to assess the relationship between HFI and costs using generalized linear regression with a gamma distribution and a power 0.5 link function owing to the skew nature of cost data, assessed using the Modified Park Test.[40] Analyses regressed a continuous HFI score on total costs to assess the amount of costs associated with a unit increase in the HFSSM score. Analyses also regressed the dichotomous classification of food security on costs to estimate the costs associated with a food-insecure status compared with a food-secure status. All regressions adjusted for observable individual-level disease characteristics (diabetes type, diabetes duration), socioeconomic characteristics (continuous insurance coverage; insurance type; at least 1 college-educated parent; household income below $50,000), and the study site (Colorado, South Carolina, and Washington). SEs were clustered at the individual level to account for within-individual correlation. All analyses were complete case analyses.[41] Regarding the second hypothesis, analyses assessed whether and how continuous health insurance coverage moderated the relationship between food insecurity and formal healthcare sector costs using a regression with an interaction term of the HFSSM score with an indicator for continuous health insurance coverage.

An important confounder, HbA1c, was only collected from a subset of participants at baseline (during SEARCH 4) and in SFS Survey 2 by design. Glycemic control likely confounds the relationship between food insecurity and costs, biasing associations in the primary analyses. Achieving low HbA1c levels requires ample resources. Using household resources to manage diabetes may diminish the household resources available for food, contributing to food insecurity. Simultaneously, low HbA1c levels help to reduce diabetes-related complication risks, healthcare utilization, and costs. Therefore, analyses assessed whether findings were robust when accounting for HbA1c (measurement details are described in the Appendix, available online) using only data from these 2 time points. This study also assessed the robustness of the study findings by examining only formal healthcare sector costs because (1) they comprise a large share of costs where the authors expected to observe the largest associations and (2) the authors have the most reliable data for these costs because responses were missing more often for non healthcare sector costs. In addition, the authors conducted a sensitivity analysis using alternative formal healthcare sector cost estimates (Appendix Table 4, available online) from larger samples but with less granularity than MEPS, described in more detail in the Appendix (available online).

Finally, the primary analysis also did account for costs related to school absenteeism for children, a common non healthcare sector cost for YYAs with diabetes. To assess the sensitivity of findings to this potential underestimation of costs, data on how many times participants aged <18 years missed school for typical medical appointments for diabetes were added. Two different cost estimates from prior research were used to account for school absenteeism: (1) a Dutch estimate of the cost to the educational system per school absenteeism day (€27 in 2018 prices)[42,43] and (2) a Washington State–based estimate of the cost of programmatic, small group tutoring by certified teachers ($39.40 an hour in 2018 dollars).[44] Both values were inflation adjusted to 2022 U.S. Dollars using the consumer price index
(37.17 U.S. Dollars per day and 45.92 U.S. Dollars per hour, respectively) and summed with the aforementioned nonhealthcare sector costs for this sensitivity analysis.

RESULTS

Descriptive characteristics of the sample with HFI data from SEARCH 4 (n=1,219) can be found in Table 1.

Table 1. Descriptive Information by Food Security Status at Baseline

Variable	Food secure[a] (*n*=969)[b]		Food insecure[a] (*n*=250)[b]		All participants (*n*=1,219)	
	Mean	SD	Mean	SD	Mean	SD
Total costs (2022 USD)	4,104.4	14,212.6	9,963.8	24,224.9	5,243.5	16,731.2
Total formal healthcare costs (2022 USD)	3,700.1	13,861.9	8,052.0	19,054.0	4,566.7	15,107.4
Total non-healthcare sector costs (2022 USD)	556.1	3,034.7	2,840.4	16,902.3	956.9	7,656.9
HFSSM score	0.2	0.6	4.5	1.5	1.1	1.9
Study site, *n* (%)						
1	344	35.5	111	44.4	468	37.3
2	425	43.9	90	36.0	525	41.8
3	200	20.6	49	19.6	263	20.9
HbA1c[c]	8.8	2.4	9.5	2.4	8.9	2.1
Continuous insurance coverage,[a] *n* (%)						
No	67	6.9	45	18.0	113	9.0
Yes	888	91.6	204	81.6	1,109	88.3
Missing	14	1.4	1	0.4	34	2.7
Insurance type,[a] *n* (%)						
None	36	3.7	22	8.8	59	4.7
Medicaid/Medicare	149	15.4	70	28.0	221	17.6
Private	729	75.2	142	56.8	884	70.4
Other	46	4.8	14	5.6	61	4.9
Missing	9	0.9	2	0.8	31	2.5
Highest education level either parent,[a] *n* (%)						
Less than high-school graduate	32	3.3	16	6.4	48	3.8
High-school graduate or equivalent	127	13.1	56	22.4	184	14.7
Some college or Associate degree	239	24.7	87	34.8	329	26.2
Bachelor's degree or more	550	56.8	80	32.0	633	50.4
Missing	21	2.2	11	4.4	62	4.9
Income,[a] *n* (%)						
<$25,000	128	13.2	84	33.6	213	17.0
$25,000—$49,999	153	15.8	74	29.6	228	18.2
$50,000—$74,999	114	11.8	31	12.4	146	11.6
≥$75,000	328	33.8	16	6.4	347	27.6
Missing	246	25.4	45	18.0	322	25.6
Age at follow-up	22.8	5.2	23.6	5.1	22.9	5.2
Sex, *n* (%)						
Female	552	57.0	161	64.6	732	58.3
Male	417	43.0	89	35.6	524	41.7
Race/ethnicity, *n* (%)						
Asian or Pacific Islander	12	1.2	3	1.2	16	1.3
Black	139	14.3	58	23.2	203	16.2
Hispanic	114	11.8	29	11.6	148	11.8
Multiracial	32	3.3	12	4.8	47	3.7
Native American or Alaska Native	3	0.3	2	0.8	5	0.4
White	667	68.8	145	58.0	834	66.4
Missing	2	0.2	1	0.4	3	0.2
Diabetes type, *n* (%)						
Type 1	860	88.7	191	76.4	1,085	86.4
Type 2	109	11.3	59	23.6	171	13.6
Diabetes duration[a]	12.9	3.5	12.7	3.6	12.8	3.5

[a]Denotes the reported descriptive information calculated using data from baseline only.
[b]Food security status missing for *n*=37 participants at baseline, but these respondents still contribute data in subsequent follow-up surveys.
[c]HbA1c was only collected from a subset of participants at baseline (SEARCH 4) and during the second SFS collection point (Follow-Up 2).
HFSSM, Household Food Security Survey Module; SFS, SEARCH Food Security; USD, U.S. Dollars.

Table 2. Association Between Household Food Insecurity and Costs

Dependent variable: total costs	HFSSM score (*n*=1,101)		HFSSM status (*n*=1,101)	
Variable	Estimate	95% CI	Estimate	95% CI
HFSSM score	1,077.0	662.9; 1,491.1	—	—
HFSSM status				
Food secure (ref)	—	—	—	—
Food insecure	—	—	4,384.0	2,635.1; 6,132.9

Note: The cost outcome includes formal healthcare sector costs, productivity losses, and childcare costs described in the impact inventory in the Appendix (available online). Estimates using the continuous HFSSM measure are marginal changes in 2022 USD. Estimates using the dichotomized HFSSM measure are discrete changes in 2022 USD. All regressions were adjusted for individual-level disease characteristics (diabetes type, diabetes duration), socioeconomic characteristics (continuous insurance coverage; insurance type; at least 1 parent with college education or more; income below $50,000) as well as the study site location, and SEs were clustered at the individual level. A total of 155 participants were excluded owing to missing data on 1 or more measures.
HFSSM, Household Food Security Survey Module; USD, U.S. Dollars.

Most were young adults (mean age=22.9 years) with a mean diabetes duration of 12.8 years (SD=3.5) and a diagnosis of Type I diabetes (86.4%). About 1 in 5 participants (20.5%; *n*=250) were classified as food insecure. HbA1c was a mean of 8.9% (SD=2.1). Those experiencing food insecurity had a higher HbA1c of 9.5% (SD=2.4) than their food-secure counterparts with a mean HbA1c of 8.8% (SD=2.4). On average, 88.3% of respondents had continuous health insurance coverage, although that proportion was higher for those not experiencing food insecurity (91.6%) than for those in food-insecure households (81.6%). A larger proportion of participants from food-secure households (33.8%) were in the highest income category ($75,000 or more) than participants from food-insecure households (16%). Income data were missing for 25.6% of respondents at baseline; other rates of missingness at each data collection point are detailed in Appendix Table 5 (available online).

Regarding the relationship between HFI and costs, each additional 1-point increase in the HFI score was associated with a $1,077 (95% CI=663; 1,491; $p<0.01$) increase in total costs (Table 2). In analyses that dichotomized HFI, compared with food-secure households, food-insecure households had an additional $4,384 (95% CI=2,635; 6,133; $p<0.01$) in costs. This relationship was moderated by continuous health insurance coverage. Each additional 1-point increase in the HFI score was associated with a $1,820 (95% CI=379; 3,261; $p=0.013$) increase in acute care costs without continuous coverage compared with a much smaller increase, $864 (95% CI=461; 1,267; $p<0.01$), among participants with continuous coverage (Table 3).

Overall, sensitivity analyses showed that HFI is associated with increased healthcare costs, consistent with the initial finding that a 1-point increase in HFSSM score was associated with $1,077 (95% CI=662.9; 1,491) in additional costs, but there were changes in the magnitude of the association. Omitting HbA1c from base case specifications likely biased estimates upward, although not substantially so. After adjusting for HbA1c, the association of a 1-point increase in HFSSM score on costs decreased to $902 (95% CI=350; 1,454). Similarly, for analyses of the relationship between dichotomized HFI, after adjusting for HbA1c, having food insecurity was associated with an estimated $3,327 (95% CI=820; 5,834) in additional costs compared with $4,384 (95% CI=2,635; 6,133) in additional costs without HbA1c adjustment. The association of a 1-point increase in HFSSM score with costs ($1,077) was reduced relative to the primary estimate when considering only formal healthcare costs ($923; 95% CI=448.9; 1,397.2) and when using alternative cost estimates ($721; 95% CI=490.39, 950.85). Estimates were larger in sensitivity

Table 3. Association Between Household Food Insecurity and Formal Healthcare Sector Costs: Moderation by Continuous Insurance Coverage

Dependent variable: formal healthcare sector costs only	HFSSM score (*n*=1,094)	
Variable	Estimate	95% CI
HFSSM score without continuous coverage	1,819.7	378.6; 3,260.8
HFSSM score with continuous coverage	864.0	461.2; 1,266.9

Note: Cost includes formal healthcare sector costs only described in the impact inventory in the Appendix (available online). Estimates using the continuous HFSSM measure are marginal changes in 2022 USD. Estimates using the dichotomized HFSSM measure are discrete changes in 2022 USD. All regressions were adjusted for individual-level disease characteristics (diabetes type, diabetes duration) and socioeconomic characteristics (continuous insurance coverage; insurance type; at least 1 parent with college education or more; income below $50,000), and SEs were clustered at the individual level. A total of 162 participants were excluded owing to missing data on 1 or more measures.
HFSSM, Household Food Security Survey Module; USD, U.S. Dollars.

analyses adding costs related to school absences, analyses omitting childcare costs, and analyses excluding outliers. For example, each 1-point increase in HFSSM score was associated with an additional $1,124 (95% CI=677; 1,570) in costs using Washington State Institute for Public Policy estimates and an additional $1,087 (95% CI=642; 1,530) in costs using Dutch estimates. Additional details are provided in Appendix Tables 6 and 7, avalable online.

DISCUSSION

This study is one of the first to assess the relationship between HFI and costs for YYAs with Type 1 diabetes and Type 2 diabetes using multiple responses from participants and one of the first to include both healthcare sector and nonhealthcare sector costs. The key findings were that HFI had a positive relationship with costs. Moreover, discrete healthcare insurance moderated this relationship. Analyses were sensitive to controlling for HbA1c levels but not to including costs such as missed school time. Although more research is needed to understand the specific mechanisms influencing these relationships, these results suggest that addressing HFI among patients with diabetes alongside improving health insurance coverage in this population holds promise for the prevention of high acute care costs to both systems and patients.[45]

Study findings align with those of other studies that have found HFI to be associated with increased healthcare utilization and expenditures, although these other studies have largely only considered a healthcare perspective and have primarily focused on nondisease-specific adult populations, not youth with diabetes.[13–20] These findings also build on prior literature demonstrating higher healthcare utilization associated with HFI among children with chronic health conditions and limited existing findings among children and youth with diabetes.[21,23,27] These findings use a limited set of healthcare utilization types (UC visits, ER visits, and inpatient hospital stays), so further work including other utilization types (e.g., outpatient visits, prescription drugs) that adjusts for several omitted variables in these analyses is needed. Although the results of this study were not sensitive to costs attributable to missed school time, 1 study of HFI among working-age adults with diabetes found that individuals with HFI had twice the rate of healthrelated missed workdays as those without HFI.[20] An analysis that considers a broader scope of healthcare and nonhealthcare-related costs would improve on this work.

Gaps in insurance coverage have been noted as a substantial challenge during the transition from pediatric to adult care.[3] The finding that continuous health insurance coverage could reduce the burden of HFI on acute care expenditures highlights the need for education about health insurance options, how to use their health insurance efficiently, and the importance of maintaining continuous insurance coverage once they are no longer covered by their parents' health insurance,[28] as recommended by the American Diabetes Association for YYAs with diabetes.[3,46] Moreover, even among those with continuous coverage, health insurance plans differ substantially, and their match with patient needs can significantly influence utilization and out-of-pocket expenditures. As costs increasingly shift to patients through high-deductible health plans, the burden and complexity of cost sharing may lead to increased financial burden and underutilized care in adult populations.[47–49] Finally, given that children with public insurance are more likely to have gaps in coverage than children with private insurance,[50–52] states should consider policy options to reduce coverage gaps and improve the adequacy of insurance. Such policy mechanisms are currently underutilized.[52]

HFI disproportionately affects racial and ethnic minorities,[53] and it may underlie disparities in diabetes outcomes[54] and healthcare systems outcomes[55] that put minorities at disadvantage. Unfortunately, most Black and Hispanic participants in this study were concentrated in 2 sites, inhibiting the ability to meaningfully study whether the associations between HFI and costs differed among Black, Hispanic, and White participants, despite having sizeable samples from each group (Appendix Table 5, available online). There were insufficient sample sizes in other racial and ethnic groups to conduct these analyses at all. A larger and/or more dispersed sample of diverse participants would better support analyses of the association between HFI, race/ethnicity, and costs. Future work in this area could inform the identification of groups that should be prioritized for intervention.

Limitations

This study used longitudinal data from a large, population-based, multicenter cohort. Several possible sources of bias remain. Utilization was not assessed comprehensively and was assessed retrospectively, thus subject to recall bias. To improve comparability between survey waves, the survey built upon previous iterations that did not continuously measure important healthcare costs, such as outpatient visits (e.g., primary care, specialty care, mental health), prescription drugs, medical devices/supplies, laboratory tests, and others, in any study wave. Some of these costs (e.g., prescription drugs, medical devices/supplies) can be sizable for YYAs with diabetes.[56] Findings may be biased downward if these costs

are associated with food insecurity. In addition, this study included participants in a wide age range (ages 10–35 years), likely representing a large degree of heterogeneity in life and economic circumstances. Omission of several unobservable characteristics (e.g., healthcare access, comorbidities, disability, complications) may bias these findings upward. Findings may also be biased upward owing to large variability in cost estimates among patients with diabetes. Similar to many longitudinal studies, the SFS was subject to loss to follow-up. To the extent that loss to follow-up and/or item response missingness in data are not missing at random, findings may be further biased. Finally, the study was conducted during the social and economic disruption of the coronavirus disease 2019 (COVID-19) pandemic, where household food security and healthcare utilization were impacted. Given these issues, it is difficult to say with certainty which direction the findings may be biased, so further work addressing these limitations to reduce bias is recommended.

CONCLUSIONS

HFI is associated with increased expenditures among YYAs with diabetes, especially for those without continuous health insurance coverage. A more detailed future assessment of utilization and proxy measures of nonadherence to medication and self-management (e.g., HbA1c) is needed. A further elucidation of the role of HFI in adherence to recommended diabetes care will inform intervention and policy design to improve utilization of high-value health care.

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SUPPLEMENTAL MATERIAL

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