Exploration of the Relationship Between Household Food Insecurity and Diabetes in Canada

ENZA GUCCIARDI, MHSC, PHD[1,2]
JANET A. VOGT, PHD[3]
MARGARET DEMELO, RD, CDE[3]
DONNA E. STEWART, MD, FRCP(C)[4]

OBJECTIVE — To determine the household food insecurity (HFI) prevalence in Canadians with diabetes and its relationship with diabetes management, self-care practices, and health status.

RESEARCH DESIGN AND METHODS — We analyzed data from Canadians with diabetes aged ≥12 years (n = 6,237) from cycle 3.1 of the Canadian Community Health Survey, a population-based cross-sectional survey conducted in 2005. The HFI prevalence in Canadians with diabetes was compared with that in those without diabetes. The relationships between HFI and management services, self-care practices, and health status were examined for Ontarians with diabetes (n = 2,523).

RESULTS — HFI was more prevalent among individuals with diabetes (9.3% [8.2–10.4]) than among those without diabetes (6.8% [6.5–7.0]) and was not associated with diabetes management services but was associated with physical inactivity (odds ratio 1.54 [95% CI 1.10–2.17]), lower fruit and vegetable consumption (0.52 [0.33–0.81]), current smoking (1.71 [1.09–2.69]), unmet health care needs (2.71 [1.74–4.23]), having been an overnight patient (2.08 [1.43–3.04]), having a mood disorder (2.18 [1.54–3.08]), having effects from a stroke (2.39 [1.32–4.32]), lower satisfaction with life (0.28 [0.18–0.43]), self-rated general (0.37 [0.21–0.66]) and mental (0.17 [0.10–0.29]) health, and higher self-perceived stress (2.04 [1.30–3.20]). The odds of HFI were higher for an individual in whom diabetes was diagnosed at age <40 years (3.08 [1.96–4.84]).

CONCLUSIONS — HFI prevalence is higher among Canadians with diabetes and is associated with an increased likelihood of unhealthy behaviors, psychological distress, and poorer physical health.

Diabetes Care **32:2218–2224, 2009**

More than 2 million Canadians have diabetes, and the rising prevalence is alarming (1). In 2003, the economic burden of treating diabetes and its complications and the subsequent loss of productivity and life were estimated to be 9 billion dollars (2). Evidence supports the benefits of aggressive glycemic control to reduce the risk of the development and progression of diabetes complications (3,4). Self-management, including nutrition therapy, is very challenging for individuals with diabetes.

Food security, an important determinant of health, "exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (5). In 2004, 9.2% of Canadian households, an estimated 1.1 million households, were food insecure (6). Among adults, household food insecurity (HFI) is associated with lower nutrient intakes and consumption of a less healthy diet (7). A healthy diet is important for both the prevention and treatment of diabetes.

Our objectives were to determine the prevalence of HFI and its associated factors in Canadians with diabetes and to examine the relationship between HFI and diabetes management. The findings have potential policy implications for delivery of health care and social services.

RESEARCH DESIGN AND METHODS

Data sources

We analyzed data from the Canadian Community Health Survey (CCHS), cycle 3.1 (2005), a cross-sectional general health survey of 132,947 individuals aged ≥12 years residing in private dwellings. Residents of Indian Reserves or Crown lands, full-time members of the Canadian Armed Forces, and individuals residing in institutions or certain remote areas were excluded. The overall combined response rate was 79% at the national level and 77% for Ontario (for references and more information about the CCHS 3.1, see supplemental Appendix A, available at http://care.diabetesjournals.org/cgi/content/full/dc09-0823/DC1).

We limited the sample to respondents who were not missing data for diabetes and HFI. The "food security," "diabetes care," and "fruit and vegetable consumption" modules were optional. British Columbia, Alberta, Ontario, Quebec, Nova Scotia, Prince Edward Island, Northwest Territories, and Nunavut included the food security module. Although not all provinces participated in the food security module, ~89.3% of the Canadian population resides in the eight provinces and territories that participated (8). British Columbia, Alberta, Ontario, and Prince Edward Island included the fruit and vegetable consumption module.

Measurement of HFI

The Household Food Security Survey Module (9) used in CCHS 3.1 focuses on self-reported uncertain, insufficient, or inadequate food access, availability, and usage due to financial constraints and the subsequent compromised eating patterns. It does not assess other dimensions of food security, such as the availability of culturally preferred foods. Consequently,

From [1]Ryerson University, Toronto, Ontario, Canada; the [2]University Health Network Woman's Health Program, Toronto, Ontario, Canada; the [3]University Health Network Diabetes Education Centre, Toronto, Ontario, Canada; and the [4]Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada.
Corresponding author: Enza Gucciardi, egucciar@ryerson.ca.
Received 5 May 2009 and accepted 17 August 2009. Published ahead of print at http://care.diabetesjournals.org on 31 August 2009. DOI: 10.2337/dc09-0823.

Table 1—*Characteristics of individuals living in food-insecure households by diabetes status*

	Individuals without diabetes		Individuals with diabetes	
	Weighted population*	Proportion food insecure (95% CI)	Weighted population*	Proportion food insecure (95% CI)
Total sample	22,138,500*†	6.8 (6.5–7.0)	1,109,900*†	9.3 (8.2–10.4)‡
Male sex (by age)				
12–45 years	6,602,400	7.3 (6.9–7.7)	83,800	13.8 (8.4–19.2)§
46–55 years	1,871,200	4.6 (3.9–5.3)	102,200	9.5 (6.2–12.7)§
56–65 years	1,254,000	2.9 (2.4–3.4)	179,600	6.9 (4.4–9.4)§
>65 years	1,110,300	2.3 (1.7–2.9)	235,500	3.6 (2.1–5.1)§
Total (male sex)	10,837,900	5.8 (5.5–6.1)	601,100	7.0 (5.6–8.3)
Female sex (by age)				
12–45 years	6,533,100	9.5 (9.0–10.0)	89,700	25.0 (18.1–31.9)‡
46–55 years	1,952,200	7.0 (6.1–7.8)	79,100	14.9 (10.3–19.4)‡
56–65 years	1,326,300	5.2 (4.5–5.9)	127,300	12.1 (8.8–15.5)‡
>65 years	1,489,000	3.0 (2.5–3.5)	212,700	5.4 (3.7–7.2)§
Total (female sex)	11,300,600	7.7 (7.4–8.0)	508,800	12.0 (10.1–13.9)‡
Adjusted income ratio‖				
First decile	1,860,600	29.4 (27.9–30.9)	148,700	29.6 (25.1–34.1)
Second decile	1,859,300	14.9 (13.7–16.0)	157,800	15.4 (11.6–19.2)
Third decile and above	15,590,000	3.4 (3.2–3.6)	654,600	4.1 (3.0–5.2)
Main source of household income				
Salary/wages	14,950,000	6.0 (5.7–6.3)	433,500	8.5 (6.5–10.5)‡
Social assistance	389,200	54.9 (51.5–58.4)	38,200	60.0 (50.4–69.6)
Pension/benefits	2,912,900	4.3 (3.9–4.7)	446,400	6.6 (5.5–7.6)‡
Other	2,967,200	7.3 (6.6–8.0)	133,200	7.0 (4.0–10.0)§
Home ownership				
Yes	16,880,000	3.6 (3.4–3.8)	802,400	5.4 (4.2–6.6)‡
No	5,208,000	17.0 (16.3–17.7)	305,100	19.7 (17.2–22.2)
Employment status				
Employed	15,520,000	5.9 (5.6–6.2)	451,900	7.3 (5.5–9.0)
Unemployed	4,262,400	10.1 (9.5–10.7)	447,500	12.8 (11.1–14.5)‡
Household education level				
Less than secondary	1,462,900	12.3 (11.4–13.2)	200,900	13.4 (11.1–15.8)
Secondary graduate ± some postsecondary	3,242,300	10.6 (9.9–11.3)	184,300	8.5 (5.8–11.2)
Postsecondary graduate	15,640,000	5.3 (5.0–5.6)	648,700	7.9 (6.5–9.3)‡
Country of birth				
Canada	17,060,000	6.6 (6.4–6.8)	814,200	8.9 (7.7–10.2)‡
Not Canada	5,071,700	7.4 (6.8–8.0)	295,700	10.3 (7.7–12.9)
Primary language English				
Yes	12,230,000	6.9 (6.6–7.2)	581,700	9.9 (8.4–11.4)
No	9,898,500	6.6 (6.2–7.0)	527,900	8.7 (7.0–10.4)
First Nations status				
Yes	671,600	15.9 (14.2–17.6)	38,800	22.8 (13.3–32.3)§
No	21,070,000	6.4 (6.2–6.7)	1,054,600	8.6 (7.5–9.7)

Data are proportions (95% CI) unless otherwise stated. These analyses are based on data from individuals, aged ≥12 years, living in British Columbia, Alberta, Ontario, Quebec, Nova Scotia, Prince Edward Island, Northwest Territories, and Nunavut, provinces that incorporated the food security module in their survey. *Survey expansion weights were used with the CCHS 3.1 data to produce proportion estimates and population numbers representative at the population level. For example, the weighted population number in column 2 of this table is the estimated number of individuals without diabetes in the population who are represented by the survey respondents whose answers fell in the specific category indicated in the same row of column 1. Because of the inclusion of missing categories in the analysis for most variables, not all weighted population estimates for the various categories of each variable will add up to the same estimate as that for the total population (for which there was no missing category). The value in column 3 represents the proportion of the population (reported in column 2) that is estimated to be living in a food-insecure household. †The SAS program reports population estimates of 10,000,000 or more in scientific notation with three decimal places. Therefore, if any categories represented 10,000,000 or more respondents when the survey weights were applied, the overall population totals will not necessarily agree among variables. ‡Estimates for food-insecure individuals with diabetes versus food-insecure individuals without diabetes are significantly different, based on nonoverlapping 95% CIs. §This estimate is considered to be of marginal quality because of the high sampling variability associated with it. ‖This variable was not calculated for respondents residing in the Northwest Territories and Nunavut.

HFI in this article refers to income-related HFI. Eighteen questions assess a broad range of experiences over the previous year (e.g., worrying about running out of food). Ten questions are specific to the experiences of adults or the household in general and eight are specific to children aged <18 years.

We described household food secu-

rity using two categories: *1*) food secure and *2*) food insecure, as defined by Health Canada (6). Person-level survey weights supplied by Statistics Canada were used to estimate the number of individuals living in food-insecure households, as opposed to the number of food-insecure households themselves.

Diabetes status

Survey respondents were asked whether their diabetes had been diagnosed by a health professional. No distinction was made between type 1 and type 2 diabetes in this survey. Although a new algorithm based on cycle 1.1 of the CCHS has been developed to classify respondents according to whether they have type 1, type 2, or gestational diabetes, it requires further development and validation (for reference, see supplemental Appendix A).

Only Ontario and Prince Edward Island participated in both the food security and the diabetes care modules. The Prince Edward Island sample comprised ~5% of the combined sample and was not large enough to allow subanalysis by province, so we restricted our analysis to the province of Ontario.

Statistical analysis

Survey expansion weights were used to provide prevalence estimates representative of the population. A bootstrap variance estimation method and bootstrap weights, provided by Statistics Canada, were used to calculate 95% CI and coefficients of variation (CVs). Proportions are significantly different if their 95% CIs do not overlap. Odds ratios (ORs) are significantly different if their 95% CIs do not include the value 1. Estimates with a CV between 16.6 and 33.3% are considered to be of marginal quality because of high sampling variability and are indicated in the tables. Estimates with a CV >33.3% are considered unacceptable and are therefore not reported (supplemental Appendix B). Responses of "not applicable" were excluded from the analysis, whereas responses of "not stated," "don't know," and "refusal" were combined to create a "missing" category. When the CVs for the missing categories did not exceed 33.3%, these estimates were compared for "food secure" versus "food insecure," and no significant differences were found. Estimates for missing categories are not reported.

For individuals with diabetes, we used a multivariate approach to exam-

Table 2—*Clinical and lifestyle characteristics of individuals with diabetes by household food security status*

	Food secure*†	Food insecure*‡
At what age was diabetes first diagnosed?		
≤39 years	18.2 (16.6–19.7)	36.0 (29.5–42.5)§
≥40 years	81.0 (79.4–82.6)	63.5 (57.0–70.0)§
Do you have a regular medical doctor?		
Yes	96.4 (95.8–97.1)	93.5 (90.9–96.1)
No	3.6 (2.9–4.2)	6.5 (3.9–9.1)‖
Self-perceived unmet health care needs		
Yes	9.7 (8.6–10.9)	25.2 (19.4–30.9)§
No	90.1 (88.9–91.3)	74.7 (68.9–80.5)§
Overnight patient during past 12 months		
Yes	13.7 (12.5–14.9)	27.6 (21.6–33.6)§
No	86.3 (85.1–87.4)	71.7 (65.7–77.7)§
Length of overnight stay (nights)		
Mean (nights)	15.5 (12.3–18.8)	9.0 (6.6–11.4)§
Currently takes insulin		
Yes	19.7 (18.1–21.3)	24.8 (19.4–30.2)
No	80.2 (78.6–81.8)	74.9 (69.6–80.3)
Takes pills to control blood glucose		
Yes	68.8 (66.9–70.6)	65.9 (59.8–71.9)
No	31.1 (29.3–32.9)	33.9 (27.9–40.0)
Heart disease		
Yes	20.2 (18.6–21.8)	20.9 (16.3–25.6)
No	79.4 (77.8–81.0)	78.5 (73.8–83.2)
High blood pressure		
Yes	52.3 (50.3–54.3)	46.5 (40.2–52.8)
No	47.5 (45.4–49.5)	52.8 (46.4–59.2)
Glaucoma (aged ≥18 years)		
Yes	5.3 (4.5–6.2)	6.1 (3.3–8.9)‖
No	94.5 (93.7–95.4)	93.8 (91.1–96.6)
Stroke		
Yes	4.9 (4.1–5.7)	11.2 (6.7–15.6)§‖
No	95.0 (94.1–95.8)	88.3 (83.8–92.7)§
Mood disorder		
Yes	7.5 (6.6–8.4)	21.1 (17.1–25.1)§
No	92.5 (91.6–93.4)	78.6 (74.6–82.6)§
Daily servings of fruits and vegetables¶		
<5 times/servings per day	49.3 (46.7–51.9)	63.9 (55.7–72.1)
≥5 times/servings per day	43.5 (40.8–46.1)	25.6 (19.2–32.0)
Smoking status		
Current (includes daily and occasional)	16.1 (14.7–17.5)	32.1 (26.3–38.0)§
Former	53.5 (51.5–55.4)	38.9 (32.8–45.0)§
Never	30.3 (28.6–32.1)	28.8 (22.4–35.3)
Physical activity index		
Inactive	56.9 (54.9–58.9)	63.7 (57.6–69.8)
Moderate to active	38.7 (36.8–40.7)	29.2 (23.8–34.7)§
BMI: self-reported		
Obese	35.0 (33.2–36.9)	40.3 (34.4–46.3)
Overweight	36.2 (34.4–38.1)	29.8 (23.6–36.0)
Neither overweight nor obese	26.4 (24.7–28.0)	22.4 (17.1–27.7)
Average daily alcohol consumption		
≥1 drink	27.2 (24.9–29.5)	14.8 (9.0–20.7)§‖
Never	70.7 (68.3–73.0)	84.7 (78.9–90.5)
Satisfaction with life in general		
Negative(dissatisfied, very dissatisfied)	4.5 (3.7–5.3)	20.5 (16.0–25.0)§
Neither satisfied nor dissatisfied	5.8 (4.9–6.6)	14.5 (10.8–18.2)§
Positive (very satisfied, satisfied)	85.0 (83.6–86.4)	57.8 (51.7–63.9)§

Table 2—*Continued*

	Food secure	Food insecure
Self-perceived health		
Poor to fair	36.4 (34.6–38.2)	61.6 (55.5–67.7)§
Good	41.8 (39.9–43.8)	28.9 (23.3–34.5)§
Very good to excellent	21.5 (19.8–23.3)	9.5 (5.3–13.6)§
Self-perceived mental health		
Poor to fair ("poor," "fair")	6.1 (5.3–7.0)	23.6 (18.2–29.0)§
Good	23.7 (22.0–25.4)	31.0 (25.5–36.5)§
Very good	32.5 (30.8–34.3)	25.2 (19.1–31.3)
Excellent	33.2 (31.3–35.0)	13.2 (9.6–16.8)§
Self-perceived stress (aged ≥15 years)		
Quite a bit or extremely stressful	18.3 (16.8–19.9)	40.3 (34.0–46.5)§
A bit stressful	37.0 (35.1–38.8)	30.4 (24.9–35.9)
Not at all or not very stressful	44.2 (42.2–46.2)	28.3 (22.2–34.3)§

Data are proportions (95% CI). These analyses are based on data from individuals with diabetes, aged ≥12 years, living in British Columbia, Alberta, Ontario, Quebec, Nova Scotia, Prince Edward Island, Northwest Territories, and Nunavut provinces that incorporated the food security module in their survey. *Survey expansion weights were used with the CCHS 3.1 data to produce proportion estimates and population numbers representative at the population level. In this table, the proportions apply to the weighted population number reported at the top of the column. †Weighted total food-secure population, n = 1,006,700. ‡Weighted total food-insecure population, n = 103,200. §Estimates for food-insecure individuals with diabetes versus food-secure individuals with diabetes are significantly different, based on nonoverlapping 95% CIs. ‖This estimate is considered to be of marginal quality because of the high sampling variability associated with it. ¶This variable was only available for respondents residing in British Columbia, Alberta, Ontario, and Prince Edward Island and is representative of a weighted population of ~674,100 individuals living in food-secure households and ~69,400 living in food-insecure households in these combined provinces.

ine the relationship between HFI and variables that were statistically significant, based on the bivariate analyses. We recategorized many of the CCHS 3.1 variables to increase cell sizes and produce more robust estimates (supplemental Appendix C). We used a bootstrapped binary logistic regression to assess the association between HFI and the following dependent variables: self-perceived unmet health care needs, having an overnight hospitalization in the past year, daily fruit and vegetable consumption, having a mood disorder, having had the effects of a stroke, physical activity index, and age at diagnosis. We also used this model to examine the relationship between age of diagnosis (as the key explanatory variable) and HFI. We performed ordinal logistic regression using the survey logistic procedure in SAS 9.1 to assess the association between HFI and the following dependent variables: satisfaction with life, self-rated physical and mental health, and self-perceived stress. Adjusted ORs were generated from a model that included age, sex, diabetes duration, insulin status, having a regular medical doctor, having had the effects of a stroke, adjusted income ratio, household education level, First Nations status, smoking status, and physical activity level. These covariates were chosen either because they were significantly associated at the bivariate level with HFI in this dataset or because they were considered potential confounders.

RESULTS — Table 1 presents weighted distributions of sample characteristics for the population living in food-insecure households by diabetes status. The overall rate of HFI was higher among those with diabetes than among those without diabetes. Compared with females without diabetes, the rate of HFI was significantly higher among females with diabetes, peaking at 25.0% for those aged 12–45 years. Unemployed individuals with diabetes had higher rates of HFI than those without diabetes. Regardless of diabetes status, tenancy and reliance on social assistance were both associated with higher rates of HFI and as the adjusted income ratio of a household increased, the HFI rate decreased.

Table 2 shows clinical and lifestyle characteristics of individuals with diabetes, by household food security status. A higher proportion of individuals with diabetes living in food-insecure households reported having the diagnosis of diabetes at age <40, having unmet health care needs, being hospitalized overnight during the last year, being current smokers, having had the effects of a stroke, and having a mood disorder. Among those who were hospitalized overnight, the mean length of stay was shorter for those living in food-insecure households. A lower proportion of individuals living in food insecure households reported consuming five or more daily servings of fruit and vegetables, being former smokers, having one or more drinks per day, and being moderately active or active. Higher proportions of individuals with diabetes living in food-insecure households rated their general health, mental health, satisfaction with life, and self-perceived stress in negative or neutral terms. When diabetes medical management services were examined using the diabetes care module in Ontario, there were no significant differences based on household food security status (Table 3).

After multivariate adjustment, an individual with the diagnosis of diabetes at ≤40 years was more likely to live in a food-insecure household than an individual with a later diagnosis. For each year younger an individual was at diagnosis, the odds of HFI were 4% higher (1.04 [95% CI 1.02–1.05]). Among individuals with diabetes, HFI was highly correlated with reporting unmet health care needs, being hospitalized overnight, being a current smoker, having a mood disorder, having had the effects of stroke, being physically inactive, and consuming less fruits and vegetables (Table 4). Individual with diabetes living in a food-insecure compared with a food-secure household were less likely to rate their satisfaction with life as positive, their health as good or very good to excellent, or their mental health as good, very good, or excellent and were more likely to perceive themselves as quite a bit or extremely stressed.

CONCLUSIONS — We found significantly higher rates of HFI among Canadians with diabetes (9.3%), compared with those without diabetes (6.8%). Data from the 1999–2002 U.S. National Health and Nutrition Examination Survey (NHANES) also revealed an association between food insecurity and diabetes, but a direct comparison of rates is difficult because of differences in methodology (10). Our work extended the NHANES analyses by assessing relationships between HFI and diabetes medical management, self-care practices and health

Table 3—*Characteristics of diabetes medical management among Ontarians with diabetes, by household food security status.*

	Food secure*†	Food insecure*‡
Tested for A1C		
Yes	77.5 (74.9–80.1)	74.8 (66.2–83.5)
No	19.2 (16.7–21.8)	20.5 (12.7–28.3)§
Tested for A1C (no. times in past 12 months)		
≤3	55.1 (51.6–58.7)	45.9 (33.5–58.3)
≥4	38.4 (35.0–41.8)	45.3 (32.8–57.8)
Urine tested for protein in past 12 months		
Yes	70.5 (67.6–73.3)	72.9 (63.7–82.0)
No	25.2 (22.5–27.8)	25.3 (16.3–34.4)§
Ever had an eye examination with pupils dilated?		
Yes	70.9 (68.0–73.7)	68.0 (57.1–78.9)
No	27.0 (24.3–29.8)	30.5 (19.5–41.5)§
Eye examination with pupils dilated (last time)		
<1 month	12.5 (10.2–14.9)	19.3 (7.5–31.0)§
1 month–<1 year ago	56.5 (52.9–60.1)	48.0 (36.2–59.7)
1 year–<2 years	16.9 (13.8–20.0)	19.8 (10.8–28.7)§
≥2 years	11.0 (8.6–13.5)	10.3 (3.8–16.9)§
Feet checked by health professional		
Yes	50.1 (46.8–53.3)	61.3 (51.5–71.1)
No	49.5 (46.4–52.7)	38.7 (28.9–48.5)
Feet checked by a health professional (no. times in past 12 months)		
≤3	61.0 (56.6–65.4)	56.3 (41.7–71.0)
≥4	37.0 (32.6–41.4)	42.6 (28.0–57.3)§
No. times feet checked by self, per day		
<1 time/day	59.8 (56.6–63.0)	53.4 (42.6–64.2)
≤1 times/day	38.3 (35.1–41.5)	42.3 (31.7–52.9)
No. times glucose checked per day		
<1 time/day	47.6 (44.4–50.8)	39.8 (29.2–50.4)
≤1 times/day‖	51.2 (48.0–54.5)	59.3 (48.8–69.9)
ASA (taken in past month)		
Yes	51.7 (48.3–55.1)	59.6 (48.9–70.4)
No	48.0 (44.6–51.4)	38.0 (27.5–48.5)
Cholesterol medication (taken in past month)‖		
Yes	53.8 (50.3–57.2)	49.9 (39.4–60.4)
No	45.5 (42.0–48.9)	50.1 (39.6–60.6)

Data are proportions (95% CI). *Survey expansion weights were used with the CCHS 3.1 data to produce proportion estimates and population numbers representative at the population level. In this table, the proportions apply to the weighted population number reported at the top of the column. These analyses were performed on 2,523 individuals with diabetes in Ontario, aged ≥12 years, who had no missing data for household food security status. †Weighted total food-secure population, n = 426,500. ‡Weighted total food-insecure population, n = 43,200. §This estimate is considered to be of marginal quality because of the high sampling variability associated with it. ‖Asked of respondents aged ≥35 years. ASA, acetylsalicylic acid.

status. Among Canadians with diabetes, the proportion of females residing in food-insecure households (12.0%) was much higher than that of males (7.0%) and peaked at 25.0% for females aged between 12 and 45 years. Research has shown that female lone parents have an especially high risk of food insecurity (11), but sample size limitations precluded us from pursuing this analysis. Nonetheless, it is clear that a significant number of individuals with diabetes are coping with self-management of this disease in the context of financial constraint and limited resources, and a disproportionate number are female.

Among Ontarians with diabetes, we found no association between HFI and factors specifically associated with diabetes management services. Regardless of household food security status, individuals with diabetes were equally likely to be monitored for A1C, to have urinalysis, to have their feet and retinas checked by a health professional, and to be taking acetylsalicylic acid or cholesterol medication. These findings suggest that, because of the universal provision of these services, Ontarians and probably Canadians are generally able to obtain the necessary medical services to manage their diabetes, regardless of their socioeconomic status.

Among Canadians with diabetes, HFI was significantly associated with some self-care practices. Although it is recommended that individuals with diabetes consume a variety of fruits and vegetables, those living in a food-insecure household were only half as likely to consume at least five daily servings. A Canadian study has shown that as per capita income increased by 10%, purchase of fruits and vegetables increased by 1.6% (12). Respondents living in food-insecure households were also more likely to be physically inactive. Conversely, the Ontario analysis showed that HFI had no impact on practices such as self-monitoring of blood glucose levels and foot self-examinations. The government of Ontario provides financial assistance to help with some of the costs specific to diabetes management, such as glucose testing strips.

A study in the southeastern U.S. reported that variability in A1C change was more strongly associated with patient-level factors than with physician-related factors (13). Similarly, our findings show that physician services for diabetic patients were comparable regardless of HFI status, whereas self-care activities exhibited variation across those with and without HFI. These results suggest the importance of giving attention to patient self-care strategies in diabetes education. Our results suggest that policies that improve access to necessary resources for management are important in minimizing the impact of HFI on individuals with diabetes.

Among individuals with diabetes, the proportion of current smokers was approximately twice as high for those experiencing HFI. A Canadian study found increased odds of smoking cessation associated with middle to high household income and also revealed an inverse relationship between smoking cessation and stress levels (14). In our sample, a person reporting high stress levels was twice as likely to be in a food-insecure household, compared with a person in a food-secure household, suggesting that stress might be a mediating factor in the association between HFI and smoking behavior observed in this study.

Among individuals with diabetes, those displaying lower scores on ques-

Table 4—*ORs for variables of interest associated with household food insecurity for individuals with diabetes*

	n	Unadjusted ORs (95% CI)	Adjusted ORs (95% CI)*
Unmet health care needs†	4,953	3.12 (2.24–4.35)‡	2.71 (1.74–4.23)‡
Overnight hospital patient†	4,957	2.42 (1.76–3.33)‡	2.08 (1.43–3.04)‡
Has a mood disorder†	4,954	3.33 (2.53–4.39)‡	2.18 (1.54–3.08)‡
Has had a stroke†	4,957	2.45 (1.49–4.02)‡	2.39 (1.32–4.32)‡
Physical activity index†	4,957		
Inactive vs. moderately active or active		1.48 (1.13–1.94)‡	1.54 (1.10–2.17)‡
Fruit and vegetable intake†	3,160		
≥5 vs. <5		0.46 (0.32–0.65)‡	0.52 (0.33–0.81)‡
Satisfaction with life§	4,940		
Positive vs. neutral		0.25 (0.17–0.38)‡	0.28 (0.18–0.43)‡
Negative vs. neutral		1.75 (1.08–2.83)‡	1.47 (0.86–2.50)
Self-rated health§	4,950		
Good vs. fair to poor		0.39 (0.29–0.54)‡	0.53 (0.36–0.76)‡
Very good to excellent vs. fair to poor		0.24 (0.14–0.40)‡	0.37 (0.21–0.66)‡
Self-rated mental health§	4,950		
Good vs. poor to fair		0.32 (0.22–0.47)‡	0.46 (0.28–0.73)‡
Very good vs. poor to fair		0.19 (0.13–0.30)‡	0.32 (0.19–0.55)‡
Excellent vs. poor to fair		0.10 (0.06–0.15)‡	0.17 (0.10–0.29)‡
Self-perceived stress§	4,924		
A bit stressful vs. not at all or not very stressful		1.22 (0.85–1.77)	1.01 (0.66–1.55)
Quite a bit or extremely stressful vs. not at all or not very stressful		3.18 (2.19–4.62)‡	2.04 (1.30–3.20)‡
Smoking status§	4,957		
Current vs. never		2.06 (1.42–3.00)‡	1.71 (1.09–2.69)‡
Former vs. never		0.79 (0.55–1.15)	1.06 (0.69–1.65)

Data are unadjusted ORs (95% CI). These analyses are based on data from individuals with diabetes, aged ≥12 years, living in British Columbia, Alberta, Ontario, Quebec, Nova Scotia, Prince Edward Island, Northwest Territories, and Nunavut, provinces that incorporated the food security module in their survey. *Covariates were age, sex, duration of diabetes, insulin status, whether or not an individual had a regular medical doctor, whether or not an individual had the effects of a stroke, adjusted income ratio, household education level, First Nations status, smoking status, and physical activity level. †Binary logistic regression, with survey expansion weights, modeled the effect of being food insecure compared with being food secure. *n* is the sample size for this analysis. ‡OR is statistically significant; 95% CI does not include 1. §Ordinal logistic regression, with survey expansion weights, modeled the effect of being food insecure compared with being food secure.

tions regarding general health and adverse health statuses were associated with an increased likelihood of HFI, even after adjustment for a number of factors. Individuals in these circumstances were almost three times as likely to report unmet health care needs. A study using data from the 1998–1999 Canadian National Population Health Survey reported that 13% of unmet needs were attributed to accessibility problems, 90% of which were related to cost (15). In other studies, those reporting poor general and mental health and high levels of stress (16,17) also exhibited an increased likelihood of HFI. Individuals with diabetes are already more likely to suffer from anxiety (18) and depression (19), which are associated with poorer glycemic control in this population (20,21). Thus, it would seem prudent to include identification of HFI as an essential component of diabetes care.

The strong inverse relationship between age at diagnosis and HFI is provocative, but we cannot make causal inferences because of the cross-sectional nature of the data. A "social causation" perspective suggests that HFI increases the risk of early diagnosis with diabetes (22). Conversely, the "health selection" hypothesis proposes that a decline in health status precedes and is presumably the cause of downward social mobility and a decrease in income (23). Diabetes is a progressive disease whereby longer duration of the disease predisposes an individual to a greater risk of deterioration and development of complications and may increase the likelihood of finding oneself in a food-insecure household. Our regression modeling supports the latter interpretation, suggesting that the likelihood of HFI increases by 4% for each year earlier diabetes is diagnosed. A prospective population-based study of adults in Manitoba showed that individuals with diabetes complications were twice as likely not to be in the labor force (24), and a study of physician service use among Saskatchewan adults before going on welfare suggested that poor health may precede financial difficulties (25). Clarification of the causal nature of this relationship is important, given the increasing rates of diabetes in young individuals.

Limitations

This study was able to examine various aspects of diabetes, in relation to HFI, in a large, fairly representative sample of the Canadian population but nonetheless has some limitations. All data were self-reported and potentially subject to recall bias. Respondents were not asked for their diabetes type. The prevalence and risk estimates for HFI probably underestimate the magnitude of the problem because this survey did not include two of our most marginalized groups: individuals of First Nations descent living on reserves and homeless individuals. The fact that two modules of primary interest to us, food security and diabetes care, were optional and therefore were not chosen for participation by all provinces, coupled with the relatively small proportion of the population in whom diabetes has been diagnosed, severely limited our analytical sample size. This limitation resulted in less precise estimates of ORs for some variables. For instance, we were unable to generate reliable estimates for Canadians of First Nations, Southeast Asian, Latin American, and African descent, even though their increased risk of developing type 2 diabetes makes them of particular interest.

In summary, our study demonstrates a higher prevalence of HFI among Canadians with diabetes but shows no association between HFI and an individual's ability to access medical care specific to diabetes management. Among those with diabetes, HFI is associated with lower physical activity, fruit and vegetable consumption, satisfaction with life, self-rated general and mental health, and age at diagnosis and higher rates of current smoking, reporting unmet health care needs, having an overnight hospitalization, having a mood disorder or stroke, and self-

perceived stress. The lack of association between HFI and medical management and self-monitoring of blood glucose reflects the universal and comprehensive support of Canadian health care regardless of income; however, Canadian health care does not appear to extend support effectively to other aspects of self-care. Consideration of household food security status should be an essential component of patient assessment and diabetes care plans. Furthermore, given the positive associations between HFI and behaviors such as low fruit and vegetable consumption, physical inactivity, and current smoking, there is a need for research to determine how best to support and facilitate behavioral change in individuals with diabetes who are also coping with HFI. To be successful, strategies will probably have to address the financial barriers preventing individuals from making these changes.

Acknowledgments— This study was funded by a grant to E.G., M.D., and D.E.S. from the Banting and Best Diabetes Centre, Faculty of Medicine, University of Toronto.

No potential conflicts of interest relevant to this article were reported.

We acknowledge Dr. Valerie Tarasuk's review of the manuscript before submission and our reviewers for their constructive feedback.

References

1. Ohinmaa A, Jacobs P, Simpson S, Johnson JA. The projection of prevalence and cost of diabetes in Canada: 2000 to 2016. Can J Diabetes 2004;28:116–123
2. *Diabetes in Ontario: An ICES Practice Atlas.* Toronto, ON, Canada, Institute for Clinical Evaluative Sciences, 2003
3. Gaede P, Lund-Andersen H, Parving HH, Pedersen O. Effect of a multifactorial intervention on mortality in type 2 diabetes. N Engl J Med 2008;358:580–591
4. Nathan DM, Cleary PA, Backlund JY, Genuth SM, Lachin JM, Orchard TJ, Raskin P, Zinman B. Intensive diabetes treatment and cardiovascular disease in patients with type 1 diabetes. N Engl J Med 2005; 353:2643–2653
5. Agriculture and Agri-Food Canada. *Canada's Action Plan for Food Security: A Response to the World Food Summit.* Ottawa, ON, Canada, Agriculture and Agri-Food Canada, 1998, p. 1–54
6. Health Canada. *Canadian Community Health Survey, Cycle 2.2, Nutrition (2004)-Income-Related Household Food Security in Canada.* Ottawa, ON, Canada, Office of Nutrition Policy and Promotion, Health Products and Food Branch, Health Canada, 2007 (publ. no. 4694)
7. Kirkpatrick S, Tarasuk V. Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. J Nutr 2008;138:604–612
8. Statistics Canada. *Population and Dwelling Counts, for Canada, Provinces and Territories, 2006 and 2001 Censuses.* Ottawa, ON, Canada, Statistics Canada, 2007
9. Bickel G, Nord M, Price C, Hamilton WL, Cook J. *Guide to Measuring Household Food Security.* Alexandria, VA, U.S. Department of Agriculture, Food and Nutrition Service, Office of Analysis, Nutrition and Evaluation, 2000
10. Seligman HK, Bindman AB, Vittinghoff E, Kanaya AM, Kushel MB. Food insecurity is associated with diabetes: results from the National Health Examination and Nutrition Examination Survey (NHANES) 1999–2002. J Gen Intern Med 2007;22: 1018–1023
11. Ledrou I, Gervais J. Food insecurity. Health Rep 2005;16:47–50
12. Ricciuto L, Tarasuk V, Yatchew A. Socio-demographic influences on food purchasing among Canadian households. Eur J Clin Nutr 2006;60:778–790
13. Tuerk PW, Mueller M, Egede LE. Estimating physician effects on glycemic control in the treatment of diabetes. Diabetes Care 2008;31:869–873
14. Shields M. The journey to quitting smoking. Health Rep 2005;16:19–36
15. Chen J, Hou F. Unmet needs for health care. Health Rep 2002;13:23–34
16. Vozoris N, Tarasuk V. Household food insufficiency is associated with poorer health. J Nutr 2003;133:120–126
17. Nelson K, Cunningham W, Andersen R, Harrison G, Gelberg L. Is food insufficiency associated with health status and health care utilization among adults with diabetes? J Gen Intern Med 2001;16:404–411
18. Grigsby AB, Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. Prevalence of anxiety in adults with diabetes: a systematic review. J Psychosom Res 2002;53: 1053–1060
19. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. The prevalence of comorbid depression in adults with diabetes: a meta-analysis. Diabetes Care 2001;24: 1069–1078
20. Lustman PJ, Anderson RJ, Freedland KE, de Groot M, Carney RM, Clouse RE. Depression and poor glycemic control: a meta-analytic review of the literature. Diabetes Care 2000;23:934–942
21. Anderson RJ, Grigsby AB, Freedland KE, de Groot M, McGill JB, Clouse RE, Lustman PJ. Anxiety and poor glycemic control: a meta-analytic review of the literature. Int J Psychiatry Med 2002;32: 235–247
22. Hollingshead AB, Redlich FC. Social class and mental illness: a community study. Am J Public Health 2007;97:1756–1757
23. Wender PH, Rosenthal D, Kety SS, Schulsinger F, Welner J. Social class and psychopathology in adoptees: a natural experimental method for separating the roles of genetic and experimental factors. Arch Gen Psychiatry 1973;28:318–325
24. Kraut A, Walld R, Tate R, Mustard C. Impact of diabetes on employment and income in Manitoba, Canada. Diabetes Care 2001;24:64–68
25. Morris E, Rosenbluth D, Scott D, Livingstone T, Lix L, McNutt M, Watson F. To what extent does poor health precede welfare? Can J Public Health 2005;96:201–205