

# Food Insecurity Is an Independent Risk Factor for Depressive Symptoms in Survivors of Digestive Cancers

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## ABSTRACT

**Background:** Colorectal and other digestive cancer survivors are at increased risk of depression, which can negatively affect health outcomes. Food insecurity (FI), the lack of consistent access to enough food, can also contribute to these health complications. The objective of this study was to determine the relationship between FI and depressive symptoms within this population.

**Methods:** We conducted a cross-sectional analysis of data from the 2007–2016 National Health and Nutrition Examination Survey. We included all adults (≥20 years) with a self-reported history of a digestive cancer (including colorectal, esophageal, stomach, liver, and pancreas cancer). Our primary exposure was household FI, and our outcome of interest was depressive symptoms, as measured by the validated 9-item Patient Health Questionnaire. We used multivariable ordinal logistic regression to test the association between

FI and depressive symptoms, controlling for demographic and clinical covariates.

**Results:** We included 229 adult digestive cancer survivors (weighted  $N = 1,510,579$ ). The majority of the study sample was female and non-Hispanic White with mean of 11.0 years since cancer diagnosis; 14.3% reported FI. In multivariable models controlling for demographic and clinical covariates, we found that food insecure digestive cancer survivors had significantly higher odds of depressive symptoms than food secure digestive cancer survivors (OR: 3.25; 95% confidence interval: 1.24–8.55;  $P = 0.02$ ).

**Conclusions:** Among a nationally representative sample of colorectal cancer and other digestive cancer survivors, FI was associated with increased odds of depressive symptoms.

**Impact:** This study adds further evidence to the negative impact FI may have on survivors' physical and mental health.

## Introduction

An estimated 1.7 million people are diagnosed with cancer in the United States annually, and colorectal cancer is one of the most commonly diagnosed malignancies with approximately 140,000 incident cases each year (1, 2). Fortunately, because of the greater use of early detection measures and advances in treatment, the overall mortality rate from colorectal cancer has been decreasing and there are an estimated 1.4 million colorectal cancer survivors in the United States (1–3). However, colorectal cancer and other digestive cancer survivors continue to face ongoing physical and mental health challenges that impact morbidity and mortality, and survivors are at higher risk of increased cardiovascular disease (CVD) risk and worse psychosocial function (4–8). Indeed, one in five colorectal cancer survivors report symptoms of depression, which has been associated with increased morbidity and mortality and reduced quality of life in this population (5, 9–11). Also, some studies have found that patients with

colorectal cancer and other digestive cancer may have higher rates of depression than other cancer types (9–12).

Despite this burden, there are limited data on potential factors associated with the development of depressive symptoms in survivors (5, 11, 13). Cancer is one of the most costly medical conditions to treat (14). As many insurers in the United States are shifting more medical costs to patients, even patients with commercial insurance are at risk of the detrimental financial impact of cancer care (15). Because of the high out-of-pocket expenses of cancer treatment and follow-up care, cancer survivors are at higher risk of financial hardship and having unmet health-related social needs, such as food insecurity (FI; refs. 16–19). FI, the lack of consistent access to enough food for an active and healthy life, is prevalent among cancer survivors (20–25). In prior studies, FI has been associated with worse diet quality, difficulty with being able to afford prescribed medications, and higher smoking rates among cancer survivors (26–28). Although FI has been associated with higher rates of anxiety and depression in other populations (29, 30), it is not established whether FI is associated with depressive symptoms in digestive cancer survivors.

The objective of this study was to fill an important gap in the literature by evaluating the relationship between FI and depressive symptoms in digestive cancer survivors. Specifically, we aimed to determine the association between FI and depressive symptoms in a nationally representative sample of colorectal cancer and other digestive cancer survivors. We hypothesized that adult digestive cancer survivors who were food insecure would be more likely to report depressive symptoms than food secure survivors.

## Materials and Methods

### Study design and data source

We conducted a cross-sectional analysis of data from the 2007–2016 National Health and Nutrition Examination Survey (NHANES; ref. 31). NHANES is conducted by the National Center for Health Statistics for the Centers for Disease Control and Prevention as a series

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**Note:** Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (<http://cebp.aacrjournals.org/>).

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of large, cross-sectional surveys collected every 2 years. The data obtained in NHANES include responses to an in-home interview (in English or Spanish), findings from a physical examination conducted at a mobile examination center, and laboratory measurements. All NHANES participants provide written informed consent at the time of the in-home interview and prior to the physical exam. We combined data from the 2007–2008, 2009–2010, 2011–2012, 2013–2014, and 2015–2016 waves of NHANES. Further details of the study design and procedures have been published previously (<https://www.cdc.gov/nchs/nhanes/index.htm>; ref. 31).

### Study sample

Because of the potential increased rates of depressive symptoms in digestive cancer survivors, we included all adults ( $\geq 20$  years) with a self-reported history of a digestive cancer. All participants in NHANES who are 20 years of age and older are asked whether a doctor or other health professional had ever told her or him if she or he had cancer or a malignancy of any kind. Participants who reported yes were then asked what kind, and we included all adults who reported a history of colon, rectal, esophageal, stomach, liver, or pancreas cancers. Participants who were missing FI data ( $N = 7$ ) and data from the Patient Health Questionnaire-9 (PHQ-9;  $N = 45$ ) were excluded for a total unweighted sample of 229.

### Exposure

Our exposure of interest was household FI, which was measured using the U.S. Department of Agriculture (USDA) 10-item Adult Food Security Survey Module (<https://www.ers.usda.gov/media/8279/ad2012.pdf>; ref. 21). This validated questionnaire was developed by the USDA to measure household FI over the prior 12 months. NHANES administers the Food Security Survey Module in accordance with the USDA recommendations and uses the established scoring system for responses to the items to categorize household food security. Using the standard USDA scoring recommendations, we analyzed FI as a binary variable: food secure (0–2 affirmative responses) or food insecure ( $\geq 3$  affirmative responses; refs. 21, 22, 32–35).

### Outcomes

Our outcome of interest was depressive symptoms as measured by the validated PHQ-9 (36). The PHQ-9 consists of nine items that assess the frequency of depressive symptoms over the prior 2 weeks. Questions include how often over the last 2 weeks have you felt down or depressed and how often have you had thoughts that you would be better off dead or hurting yourself in some way. Responses include “not at all,” “several days,” “more than half the days,” and “nearly every day” and are given a point ranging from 0 to 3. Using the standard scoring, we evaluated depression as a continuous variable based on the total sum of the item responses (0–27) and a categorical variable: minimal (1–4), mild (5–9), moderate (10–14), moderately severe (15–19), and severe (20–27; ref. 36). As a sensitivity analysis, we also analyzed depressive symptoms combining the moderate, moderately-severe, and severe categories and found similar results to our main analyses (see Supplementary Tables S1 and S2).

### Covariates

Covariates included demographic and clinical characteristics that have been associated with FI and/or depression. Covariates included self-reported gender and self-reported race/ethnicity (non-Hispanic White; non-Hispanic Black; Hispanic/other). We also included marital status (married or living with a partner; divorced, widowed, separated or never married), highest educational level achieved (high school

graduate or less; greater than high school graduate), household income-to-poverty ratio, and smoking status (current or never/former). Household income-to-poverty ratio is calculated by dividing the total household income by the poverty guidelines, based on family size, year, and state. We also included time since cancer diagnosis, which was determined by self-reported age when cancer was first diagnosed subtracted from age at the time of the NHANES interview.

As prior studies have noted an association between FI and CVD and CVD risk factors and some studies have also noted an association between CVD and depressive symptoms (33, 37–42), we also included if a participant had obesity, diabetes, or CVD (yes or no). Obesity was defined as a body-mass index (BMI)  $\geq 30$  kg/m<sup>2</sup>. BMI was based on each participants' measured height and weight from the NHANES examination. Diabetes was defined as having any of the following: self-report of diabetes, glycated hemoglobin  $>6.5\%$ , fasting glucose  $>126$ , or taking a diabetes medication including a sulfonylurea, insulin, or an incretin mimetic. CVD was determined by a self-reported history of coronary artery disease, angina, myocardial infarction, stroke, or congestive heart failure. In addition, we included whether a participant reported having seen a mental health provider in the prior 12 months (yes or no).

### Statistical analysis

Participant characteristics were presented as mean (SEs) for continuous variables or  $N$  (percent) for categorical variables. We performed bivariate analyses testing the association between FI, depressive symptoms, and all covariates using  $\chi^2$  tests or  $t$  tests. We used multivariable ordinal logistic regression to test the association between FI and depression severity and estimated ORs with 95% confidence intervals (CI). We also analyzed depressive symptoms as a continuous variable, and we used generalized linear models to test the association between FI and total PHQ-9 score, controlling for all covariates. On the basis of prior studies (29, 30), we hypothesized, a priori, that there would be significant differences in the association between FI and PHQ-9 scores based on participant characteristics (gender, race/ethnicity, marital status, and highest education level achieved), and we evaluated for significant interactions between patients characteristics and FI. For participant characteristics with a potentially significant interaction ( $P < 0.2$ ), we used predictive margins to determine the adjusted mean PHQ-9 score. In addition, we attempted to evaluate the association between FI and illicit drug use (self-report of cocaine, heroin, or methamphetamine use) and FI and alcohol abuse (greater than four drinks daily) in survivors, but there were a limited number of participants who reported either illicit drug use or alcohol abuse in the dataset. All analyses accounted for the complex survey design of NHANES by applying appropriate sample weights, clustering, and the primary sampling unit. Sample weights for the differential probabilities of selection for the sampling domains, survey nonresponse, and the target population distribution, so estimates are representative of the noninstitutionalized U.S. civilian population. We used multiple imputation to account for missing data for the household income-to-poverty ratio (7.0% missing). We used a two-sided hypothesis test and considered a  $P < 0.05$  statistically significant. All analyses were conducted using Stata 15.1 (StataCorp). The Wake Forest School of Medicine Institutional Review Board deemed this study of publicly available, deidentified data exempt from human subjects' research.

## Results

The study population included 229 adult digestive cancer survivors (176 colorectal cancer, 14 esophageal, 17 stomach, 14 liver, and

8 pancreas) for a weighted sample size of 1,510,579. The majority of the study population was female, non-Hispanic White, and had greater than a high school education (Table 1). The mean income-to-poverty ratio was 2.78 (95% CI: 2.5–3.1), and mean time from cancer diagnosis was 11.0 years (95% CI: 8.8–13.3). Of the study population, 14.3% reported living in a food insecure household. Seventy percent of the study population reported having some depressive symptoms with 18.7% reporting mild, 6.5% reporting moderate, 3.7% reporting moderately severe, and 2.3% reporting severe symptoms. The mean PHQ-9 total score was 3.84 (95% CI: 3.05–4.64).

In bivariate analysis, participants who reported FI were significantly more likely to be non-Hispanic Black, to not be married/living with a partner, graduated high school or less, and have lower household income-to-poverty ratio. Participants who reported FI were also more likely to be current smokers (38.0% vs. 9.2%,  $P = 0.001$ ). Participants who lived in a food insecure household were significantly more likely to report depressive symptoms ( $P = 0.02$ )

and have a higher PHQ-9 total score [6.31 (95% CI: 4.08–8.55) vs. 3.43 (95% CI: 2.61–4.26),  $P = 0.02$ ].

#### FI and depressive symptoms

In multivariable models controlling for all demographic and clinical covariates, food insecure digestive cancer survivors had a significantly higher odds of reporting depressive symptoms (OR: 3.25; 95% CI: 1.24–8.55;  $P = 0.02$ ) than survivors who were food secure (Table 2). In multivariable generalized linear models, FI was associated with a higher PHQ-9 total score in survivors ( $\beta = 2.57$ ; 95% CI: 0.05–5.08;  $P < 0.05$ ; Table 3).

#### FI and depressive symptoms by participant characteristics

We found a potential interaction ( $P < 0.2$ ) between FI and gender and FI and highest education level achieved (Table 4). Females who were food secure had a mean PHQ-9 total score of 3.77 (95% CI: 2.63–4.91) and food insecure females had a mean score

**Table 1.** Prevalence of FI by participant characteristics: NHANES 2007–2016.

		Total sample: % (95% CI)	Food secure: % (95% CI)	Food insecure: % (95% CI)	<i>P</i>
Total population	Weighted $N = 1,510,579$		85.7 (78.7–90.7)	14.3 (9.3–21.3)	
Time since cancer diagnosis	Mean (95% CI) years	11.0 (8.8–13.3)	11.5 (8.9–14.1)	8.4 (5.7–11.1)	0.12
NHANES survey year	2007–2008	16.1 (11.5–22.2)	86.2 (66.1–95.3)	13.8 (4.7–33.9)	<b>0.007</b>
	2009–2010	19.5 (12.4–29.2)	92.4 (79.6–97.4)	7.6 (2.6–20.5)	
	2011–2012	24.3 (17.2–33.2)	86.5 (75.7–93.0)	13.5 (7.0–24.4)	
	2013–2014	21.1 (14.2–30.3)	95.1 (84.8–98.5)	4.9 (1.5–15.2)	
	2015–2016	19.0 (12.8–27.3)	67.0 (45.9–83.0)	33.0 (17.0–54.1)	
Gender					0.36
	Male	43.2 (35.6–51.1)	89.1 (77.5–95.1)	11.0 (5.0–22.5)	
	Female	56.8 (48.9–64.4)	83.2 (72.9–90.1)	16.8 (8.9–27.1)	
Race/ethnicity					<b>0.001</b>
	Non-Hispanic, White	83.2 (78.0–87.3)	88.2 (80.1–93.3)	11.8 (6.7–19.9)	
	Non-Hispanic, Black	11.0 (7.5–15.8)	65.6 (50.3–78.2)	34.4 (21.8–49.7)	
	Hispanic or other	5.8 (3.9–8.8)	88.6 (75.1–95.2)	11.4 (4.8–24.9)	
Marital status					<b>0.04</b>
	Married/living with partner	54.3 (45.2–63.2)	90.6 (81.4–95.6)	9.4 (4.5–18.6)	
	Divorced/widowed/separated/never married	45.7 (36.8–54.8)	79.8 (69.5–87.3)	20.2 (12.7–30.5)	
Education level					<b>0.01</b>
	High school graduate or less	34.9 (27.9–42.5)	75.0 (61.8–84.8)	25.0 (15.2–38.3)	
	Greater than high school	65.2 (57.5–72.1)	91.5 (82.7–96.0)	8.5 (4.0–17.3)	
Smoking					<b>0.001</b>
	Never/former	82.4 (76.6–87.1)	90.8 (84.2–94.8)	9.2 (5.2–15.8)	
	Current	17.6 (12.9–23.5)	62.0 (39.3–80.4)	38.0 (19.6–60.7)	
Income-to-poverty ratio	Mean (95% CI)	2.78 (2.5–3.1)	3.0 (2.7–3.3)	1.3 (1.0–1.6)	<b>&lt;0.0001</b>
CVD risk factors					0.74
	No	43.3 (35.6–51.4)	86.8 (75.0–93.5)	13.2 (6.5–25.0)	
	Yes	56.7 (48.7–64.4)	84.9 (75.9–90.9)	15.1 (9.1–24.1)	
MHP					0.83
	No	90.8 (84.2–94.8)	85.8 (78.0–91.2)	14.2 (8.8–22.0)	
	Yes	9.2 (5.2–15.8)	84.6 (71.8–92.2)	15.4 (7.8–28.2)	
Depression severity					<b>0.02</b>
	None	29.1 (22.0–37.2)	94.7 (87.8–97.8)	5.3 (2.3–12.2)	
	Minimal	39.8 (31.8–48.5)	83.2 (67.8–92.1)	16.8 (7.9–32.3)	
	Mild	18.7 (13.4–25.5)	88.8 (74.4–95.6)	11.2 (4.5–25.6)	
	Moderate	6.5 (3.6–11.4)	79.4 (52.6–93.1)	20.6 (7.0–47.4)	
	Moderately severe	3.7 (1.9–6.9)	49.8 (21.4–78.4)	50.2 (21.6–78.6)	
	Severe	2.3 (0.9–5.4)	66.7 (18.7–94.6)	33.3 (5.4–81.3)	

Note: CVD risk factors included if a participant had obesity, diabetes, or CVD (yes or no). Values in bold are statistically significant ( $P < 0.05$ ).

Abbreviations: CI, confidence interval; CVD, cardiovascular disease; MHP, seen a mental health provider in the prior 12 months; NHANES, National Health and Nutrition Examination Survey.

**Table 2.** Association between participant characteristics and severity of depressive symptoms.

		OR	95% CI	P
Food security	Secure	Ref		
	Insecure	3.25	1.24–8.55	<b>0.02</b>
Time since cancer diagnosis		1.01	0.99–1.03	0.22
NHANES survey year	2007–2008	Ref		
	2009–2010	0.77	0.25–2.42	0.66
	2011–2012	0.39	0.14–1.11	0.07
	2013–2014	0.58	0.21–1.58	0.28
	2015–2016	0.33	0.14–0.78	<b>0.01</b>
Gender	Male	Ref		
	Female	1.58	0.79–3.15	0.19
Race/ethnicity	Non-Hispanic, White	Ref		
	Non-Hispanic, Black	0.60	0.25–1.45	0.25
	Hispanic or Other	1.75	0.60–5.13	0.30
Marital status	Married/living with partner	Ref		
	Divorced/widowed/separated/never married	1.29	0.63–2.64	0.47
Education level	High school graduate or less	0.66	0.32–1.38	0.27
	Greater than high school	Ref		
Smoking	Never/former	Ref		
	Current	1.79	0.62–5.19	0.28
Income-to-poverty ratio		0.97	0.71–1.33	0.84
CVD risk factors	Yes	1.75	0.82–3.73	0.14
MHP	Yes	3.94	1.33–11.66	<b>0.01</b>

Note: We used multivariable ordinal logistics regression to test the association between FI and depression severity in individuals with a history of a digestive cancer, controlling for all variables listed in the table above. CVD risk factors included if a participant had obesity, diabetes, or CVD (yes or no). Values in bold are statistically significant ( $P < 0.05$ ).

Abbreviations: CI, confidence interval; CVD, cardiovascular disease; MHP, seen a mental health provider in the prior 12 months; NHANES, National Health and Nutrition Examination Survey; OR, odds ratio.

of 7.18 (95% CI: 4.56–9.80). FI was associated with an adjusted difference of 3.41 (95% CI: 0.69–6.13,  $P = 0.02$ ) in the total PHQ-9 score among female participants. Food secure participants who had greater than a high school education had a mean total score of 3.61 (95% CI: 2.51–4.72) and food insecure participants who had greater than a high school education had a mean total score of 8.21 (95% CI: 3.88–12.53). FI was associated with an adjusted difference of 4.60 (95% CI: 0.02–9.18;  $P < 0.05$ ) in mean total PHQ-9 scores among participants with greater than a high school education.

## Discussion

Among a nationally representative sample, we found that digestive cancer survivors who were living in a food insecure household had significantly higher odds of depressive symptoms than survivors living in a food secure household. Because of advances in care and early detection measures, the number of colorectal cancer and digestive cancer survivors has been growing, but cancer survivors continue to face ongoing health challenges. Many national organizations recommend that providers develop cancer survivorship plans with patients that outline personal health maintenance goals (e.g., healthy diet and exercise) and a follow-up care plan to detect early concerns (e.g., cancer recurrence). Social and economic factors, however, can impact patients' health and ability to engage in these behaviors, and this study adds further evidence to the impact FI may have on cancer survivors' health.

Although our study is the first, to our knowledge, to evaluate the association between FI and depressive symptoms in digestive cancer survivors, our findings are consistent with prior studies showing FI to be associated with increased depressive symptoms in other populations. Two recent systematic reviews found that FI was associated with

increased risk of depression across multiple populations (e.g., mothers) and chronic conditions (e.g., people living with HIV/AIDS, individuals with type 2 diabetes; refs. 29, 30, 43–45). Our study adds to this growing body of literature by specifically showing this relationship among colorectal cancer and other digestive cancer survivors. Similar to our results, studies have found that the association of FI and depression is stronger among women, particularly single mothers, compared with men (46, 47). Although the exact mechanism by which FI could lead to depressive symptoms or other poor health outcomes is unclear, it is possible that FI could lead to increased stress and depressive symptoms because individuals, particularly parents, are concerned about providing enough food to children or other household members (29). Interestingly, we also found a potential interaction between FI and education level. It is plausible that digestive cancer survivors with greater than a high school education may have not expected to be food insecure possibly leading to increased depressive symptoms. Further research is needed, however, to evaluate these results and confirm our findings.

Although FI may lead to depressive symptoms because of concerns about having enough food, this relationship is likely bidirectional. It is possible depression may lead to FI by reducing an individual's ability to work or work productivity, which could lead to diminished earning potential, fewer resources for health care spending, and further limiting expenditures for food (29). Depression is known to be associated with increased morbidity/mortality and reduced quality of life in colorectal cancer survivors (4, 5). Depression can occur early in the treatment course of colorectal cancer and persist years after treatment has been completed (13). Depression has been shown to worsen outcomes, with prior studies showing patients with colorectal cancer and other digestive cancer have higher rates of depressive symptoms when compared with

**Table 3.** Association between participant characteristics and total Patient Health Questionnaire-9 sum score.

		$\beta$	95% CI	P
Food security	Secure	Ref		
	Insecure	2.57	0.05–5.08	<0.05
Time since cancer diagnosis		0.00	–0.03 to 0.03	0.96
NHANES survey year	2007–2008	Ref		
	2009–2010	–0.38	–3.01 to 2.25	0.77
	2011–2012	–2.20	–4.35 to –0.05	<0.05
	2013–2014	–1.45	–3.78 to 0.88	0.22
	2015–2016	–2.57	–4.49 to –0.65	0.01
Gender	Male	Ref		
	Female	0.81	–0.73 to 2.35	0.30
Race/ethnicity	Non-Hispanic, White	Ref		
	Non-Hispanic, Black	–0.15	–2.31 to 2.00	0.89
	Hispanic or Other	2.39	–0.23 to 5.02	0.07
Marital status	Married/living with partner	Ref		
	Divorced/widowed/separated/never married	0.28	–1.13 to 1.68	0.70
Education level	High school graduate or less	–1.12	–2.84 to 0.61	0.20
	Greater than high school	Ref		
Smoking	Never/former	Ref		
	Current	1.76	–0.68 to 4.20	0.16
Income-to-poverty ratio		–0.19	–0.69 to 0.31	0.44
CVD risk factors	Yes	1.18	–0.10 to 2.46	0.07
MHP	Yes	2.87	–1.27 to 7.01	0.17

Note: We used multivariable general linear models to test the association between FI and total patient health questionnaire (PHQ-9) total score in individuals with a history of a digestive cancer, controlling for all variables listed in the table above. CVD risk factors included if a participant had obesity, diabetes, or CVD (yes or no). Values in bold are statistically significant ( $P < 0.05$ ).

Abbreviations: CI, confidence interval; CVD, cardiovascular disease; MHP, seen a mental health provider in the prior 12 months; NHANES, National Health and Nutrition Examination Survey.

other cancer types, whether at the time of cancer diagnosis or later in their disease course (10–13, 48). Therefore, early recognition and treatment of depression, and potential risk factors associated with depressive symptoms, may improve both the quality of life of patients and reduce health disparities (4).

FI is prevalent in the United States and a strong mediator of disparities in cancer mortality (49). Although many patients will be food insecure prior to their diagnosis of a digestive cancer, cancer is financially costly to treat and could place individuals at risk of becoming food insecure (14, 20). Even patients with commercial insurance are at risk of the detrimental financial impact of cancer care due to increasing out-of-pocket costs (15). The additional burden of cancer care (e.g., treatment costs, missed days of work) can lead many survivors vulnerable to developing unmet health-related social needs, such as FI. (20, 22). Also, individuals living in food insecure

households are more likely to consume low-cost, high-calorie dense foods, smoke, and delay preventative care (49). Epidemiologic data propose that potentially modifiable lifestyle factors such as diet are more strongly associated with the initial, as well as recurrent risk for developing colorectal cancer, than any other cancers (3, 50). These health risk behaviors may put individuals living in food insecure households at higher risk of developing incident or recurrent colorectal cancer or other digestive cancers (51).

The impact of FI and other unmet social needs on patients' health has led to growing interest among national health care organizations, such as the National Academy of Medicine and the Centers for Medicare and Medicaid, to address FI and other unmet social needs as a routine part of clinical care (52–55). There has been a growing body of literature developing strategies to address FI and other unmet social needs in clinical care settings. These strategies include

**Table 4.** Differences in depressive symptoms by participant characteristics.

		Predicted mean PHQ-9 total (95% CI)	Adjusted difference (95% CI)	P
Males	Food secure	3.10 (1.85–4.34)	Ref	
	Food insecure	3.96 (0.68–7.24)	0.86 (–2.72 to 4.45)	0.63
Females	Food secure	3.77 (2.63–4.91)	Ref	
	Food insecure	7.18 (4.56–9.80)	3.41 (0.69–6.13)	0.02
High school graduate or less	Food secure	3.25 (1.88–4.63)	Ref	
	Food insecure	4.34 (2.42–6.27)	1.09 (–1.22 to 3.40)	0.35
Greater than high school	Food secure	3.61 (2.51–4.72)	Ref	
	Food insecure	8.21 (3.88–12.53)	4.60 (0.02–9.18)	<0.05

Note: Values in bold are statistically significant ( $P < 0.05$ ).

connecting food insecure patients to government-based resources, such as the Supplemental Nutrition Assistance Program, or directly or indirectly providing resources from local community organizations, such as food pantries. Although the data are still limited on if these interventions improve health outcomes, these studies have shown that addressing FI in clinical care settings can improve the resources patients receive (52). Addressing FI as a routine part of care may have significant benefits for digestive cancer survivors (2). Developing interventions for oncology clinics and other clinics caring for survivors that address the psychosocial factors that lead to poor health outcomes could be an important next step to reduce health disparities among digestive cancer survivors.

There are several limitations to our study that should be acknowledged. First, we analyzed cross-sectional data, so causation cannot be determined. Whether FI causes depression in digestive cancer survivors or increased depressive symptoms lead survivors to become food insecure is unclear. NHANES does not include data on if participants were food insecure before or after their cancer diagnosis. As we are unable to determine temporal trends in these cross-sectional data, further longitudinal analyses will be necessary to determine causation. Nonetheless, our study used a nationally representative sample to provide accurate results regarding FI. Second, a clinical diagnosis of depression, ascertained by a standard clinical interview, was not available and the study relied on self-reported symptoms of depression rather than a diagnosis. While this could lead to misclassification, the PHQ-9 is a well-validated tool that has been used in numerous prior studies and in clinical practice (36). Third, based on the data available in NHANES, we were only able to evaluate the relationship between FI and depressive symptoms. We were planning to also evaluate the relationship between FI and illicit drug use and alcohol abuse, but were unable to given the limited number of participants who reported drug use and alcohol abuse in the dataset. Further research is needed to evaluate FI and other mental health conditions in cancer survivors. Fourth, NHANES does not include data on other unmet social needs (e.g., housing instability or financial strain) that often cluster with FI. As a result, it is unclear if FI is a marker for some of these unmet social needs or on the causal pathway in developing depressive symptoms in cancer survivors. Fifth, NHANES does not include if participants had sufficient geographic access to healthy food (e.g., living in a food desert), which could limit individuals' access to food and be a future area for study. Sixth,

although we applied the appropriate sample weights included in NHANES, the weighted sample is based on data from 229 digestive cancer survivors. We did follow the recommendations provided in the NHANES analytic guide (<https://www.cdc.gov/nchs/nhanes/tutorials/module5.aspx>; <https://www.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-guidelines.pdf>) that recommends determining an effective sample size based on the unweighted sample size divided by the design effect though.

### Conclusion

In this nationally representative cohort, we found that digestive cancer survivors who lived in food insecure households were significantly more likely to have depressive symptoms than food secure survivors. Our study is the first to investigate the association between depressive symptoms and FI among digestive cancer survivors. Further longitudinal studies and programs to support at-risk adults are needed to better understand directionality and potentially attenuate worsened health outcomes in survivors.

### Authors' Disclosures

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### Authors' Contributions

**K.E. Madigan:** Conceptualization, writing—original draft. **D.A. Leiman:** Conceptualization, writing—review and editing. **D. Palakshappa:** Conceptualization, formal analysis, supervision, writing—review and editing.

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