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Food Insecurity Is Associated with Poor Sleep Outcomes among US Adults[1–3]

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Abstract

Background: Although food insecure (FI) adults are at risk of chronic conditions, little research attention is given to their health behaviors, such as sleep.

Objective: We examined the associations between adult food security status and sleep duration, sleep latency, and sleep complaints reported to a health care professional.

Methods: Our population-based sample included 5637 men and 5264 women (≥22 y) who participated in the NHANES 2005–2010. Food security status was assessed with USDA's 10-item adult Food Security Survey Module. Self-reported information about sleep duration, sleep latency, and sleep complaints to a health care professional were used as sleep outcomes. Multiple linear, stratified by sex, and logistic regression models were used to estimate the association between food security status and the 3 sleep outcomes.

Results: Very low food secure (FS) women reported significantly shorter sleep duration than fully FS women (difference: -30 ± 5.2 min; $P < 0.01$); however, no relation to sleep duration was observed among men. Among men, participants who were marginally FS (4 ± 1.1 min), low FS (4 ± 1.7 min), and very low FS (5 ± 1.8 min) reported significantly longer sleep latency than fully FS men ($P < 0.05$), but no association with sleep latency was observed among women. The divergent patterns in sleep duration and latency were likely because of our reference groups reporting undesirable sleep outcomes; fully FS men reported inadequate sleep and fully FS women reported long sleep latency. Among both men and women, marginally FS (OR: 1.64; 95% CI: 1.24, 2.16), low FS (OR: 1.63; 95% CI: 1.16, 2.30), and very low FS (OR: 1.99; 95% CI: 1.36, 2.92) participants were more likely to report sleep complaints than their fully FS counterparts ($P < 0.05$).

Conclusions: Poor sleep quantity and quality may predispose FI adults to adverse health outcomes. *J Nutr* 2015;145:615–21.

Keywords: food insecurity, sleep, sex, hunger, low income, adults, NHANES

Introduction

Findings from the 2012 Current Population Survey indicate that in the United States, 14.1% of adults are food insecure (FI),[8] and of those, 5.3% are characterized as very low food secure (FS) (1). Food insecurity is widely recognized as a serious public health problem because numerous studies that focus on US adult populations have shown that food insecurity is associated with obesity (2), diabetes (3, 4), hypertension (5), hyperlipidemia (5, 6), and heart disease (5). FI adults are also more likely to experience poorer mental health (7, 8) and depression (5, 9) than their FS counterparts. Although FI adults are recognized as a vulnerable population, the intricate causal mechanisms by which food insecurity predisposes one to adverse health outcomes have not been adequately identified.

Modifiable, lifestyle-related health behaviors, such as poor diet quality, smoking, physical inactivity, and inadequate sleep, are identified as risk factors for many chronic conditions and for premature mortality (10). Researchers have hypothesized that shifts in dietary quantity and quality associated with food insecurity (8, 11) may promote an inflammatory state in the body and an increased susceptibility to infection (12). Few studies have assessed the lifestyle-related behaviors, other than dietary, of FI populations (13).

Sleep is an ancestral and primitive behavior for almost everyone on a daily basis (14). Because of longer working hours, more shift work, and the 24/7 availability of food and recreational activities, the average number of hours of sleep has declined over the past century (15, 16). Buysse et al. (17)

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[3] Supplemental Tables 1–6 are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.

[8] Abbreviations used: FI, food insecure; FS, food secure; PIR, poverty income ratio; SES, socioeconomic status; SNAP, Supplemental Nutrition Assistance Program.

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have suggested that complaints about sleep quality have become common and that a considerable proportion of adults experience sleep quality disturbances, such as difficulty initiating asleep. Difficulty initiating sleep is suggested as a mechanism to link the consequences of stress with immune suppression that in turn leads to chronic inflammation and progression to chronic disease states (18). Because sleep is recognized as an important determinant of health and well-being, sleep hygiene recommendations were developed by several health organizations (19–21).

As with FI, sleep is linked to chronic conditions such as obesity (22, 23), diabetes (14, 24–26), heart disease (27), and hypertension (28, 29). Although the chronic conditions associated with food insecurity and inadequate sleep are similar, we are not aware of any reports that have examined the relation between food insecurity and any measure of sleep. Accordingly, our purpose was to estimate the association between food insecurity and several sleep outcomes. We hypothesized that FI adults have poorer sleep outcomes than FS adults.

With the use of a nationally representative sample, we evaluated the relation between food security status and the following: sleep duration, sleep latency (length of time to transition from full wakefulness to sleep), and sleep complaints reported to a health care professional. The association between food security status and health outcomes is shown to vary by sex (2, 4, 11). For example, food insecurity is linked to obesity and overweight among adult women but not among men. Therefore, the possibility that the relation between food security status and the 3 sleep outcomes is moderated by sex was also examined. Investigating the association between food insecurity and sleep quantity and quality may expand our understanding of the potential pathways through which food insecurity is associated with adverse health outcomes.

Methods

Sample. The NHANES of the National Center for Health Statistics are cross-sectional, nationally representative health and nutrition surveys of the noninstitutionalized US civilian population. The NHANES are complex multistage probability samples, and details about the recruitment and survey design of these samples are published elsewhere (30). We combined data from the 2005–2006, 2007–2008, and 2009–2010 waves of NHANES (men: n = 15,401; women: n = 15,633).

Adults aged ≥22 y (n = 15,961) were included in the analytic sample so we could compare population-adjusted means to age-based Healthy People 2020 recommendations (31). We excluded pregnant (n = 417) and breastfeeding women (n = 93) because they were likely to have disrupted sleep patterns. We excluded participants who reported taking medication for insomnia, sleep apnea, sleep automatism, sleep walking disorder, and shift work sleep disorder (n = 1194). Participants who did not have complete information on food security status (n = 152) and sleep outcomes (n = 20) were excluded. We further excluded participants (n = 953) who reported being diagnosed with a sleep disorder. Our analytic sample then included participants with complete information on age, poverty income ratio (PIR) (missing: n = 1061), BMI; missing: n = 591), mental health (missing: n = 511), household size, race/ethnicity, education level (missing: n = 9), marital status (missing: n = 7), work schedule (missing: n = 3), general health condition (missing: n = 4), smoking status (missing: n = 5), alcohol consumption (missing: n = 20), and menopause status (only for women) (missing: n = 20). The analytic sample included 5637 men and 5264 women from the analysis of sleep duration and sleep complaints. The analysis of sleep latency was based on the 2005–2006 and 2007–2008 waves of NHANES because the 2009–2010 wave did not include this item. The analytic sample for sleep latency was 3617 men and 3363 women.

Details about NHANES participants' consents are published elsewhere (32). The protocol for this study was approved by the Institutional Review Board, Office of Human Subjects Research, Auburn University.

Food security status. NHANES 2005–2010 included the Food Security Survey Module, which is a well-validated questionnaire that measures the presence of food insecurity at the household level during the past 12 mo (33). We used participants' responses to the 10 household adult items in the 18-item scale, because the remaining 8 items were specific for children (34). Thus, we considered a participant to be fully FS if 0 items in the scale were answered affirmatively and marginally FS if 1–2 items were affirmative. We further classified FI participants as low FS if 3–5 items were affirmative and very low FS if 6–10 items were affirmative. Low and very low food security classifications were referred to as food insecurity (33).

Sleep outcomes. Questions on sleep were asked during the household interview with the use of the Computer-Assisted Personal Interview system (34). We used questions about self-reported sleep duration, sleep latency, and sleep complaints as outcome variables. Participants were asked how many hours of sleep they usually got at night on weekdays or workdays. Participants' answers ranged from 1 to 11 h, and participants who reported ≥12 h were coded as 12 h (34). Inadequate sleep was classified as participants reporting <7 h of sleep per night (31).

Evidence supports an association between both short and long duration of habitual sleep with several chronic conditions and premature mortality (35). Our analyses on long sleep duration (≥9 h) were limited by sample size (marginal FS men: n = 35; low FS men: n = 36; very low FS men: n = 26; marginal FS women: n = 35; low FS women: n = 33; very low FS women: n = 23). Thus, we excluded participants who had long sleep duration in the prevalence of inadequate sleep estimates and the analyses of sleep duration. We also estimated all our associations with participants who reported long sleep duration, and we observed similar results.

In the 2005–2008 NHANES, participants were asked how long it usually took to fall asleep at bedtime (sleep latency). Answers ranged from 0 to 59 min, and participants who reported ≥60 min were coded as 60 min (34). In the 2005–2010 NHANES, participants also reported whether they had ever told a doctor or health care professional that they were having trouble sleeping (sleep complaints).

Control variables. We used participants' age at the time of their screening interview, household family PIR, measured BMI, and household size as continuous control variables in our analyses. Other variables were used as indicator control variables, including race/ethnicity, education level, marital status, work schedule, mental health, general health condition, smoking status, alcohol consumption, and menopause status (only for women). Mental health was assessed by participants' response to the item: "for how many days during the past 30 d was your mental health not good." We classified mental health into 2 categories: 0 d and ≥1 d. We grouped race/ethnicity as non-Hispanic white, non-Hispanic black, Mexican-American, and other races, including other Hispanic and multiracial. Education levels were collapsed into 2 categories: <high school and ≥high school degree (or equivalent). Marital status was classified into 2 categories: living with partner (participants who were married or were living with a partner) and living without partner (participants who were widowed, divorced, separated, or never married). Work schedule was grouped into 3 categories: regular daytime schedule, shift schedules (including evening, night, and rotating shift), and not working. Self-reported general health condition had 2 levels: excellent to good and fair to poor. Smoking status was classified into 3 categories: nonsmoker, former smoker, and current smoker. Alcohol consumption was classified on the basis of the average number of alcoholic drinks consumed per day; nondrinker, moderate drinker (up to 1 drink per day for women and 2 drinks per day for men), and heavy drinker (>1 drink per day for women and <2 drinks per day for men) (36). We also considered menopause status in our analyses of women. This variable was dichotomized to menopause/hysterectomy/ medical treatments and having menstrual period in the past 12 mo.

Statistical analysis. As indicated by the National Center for Health Statistics (30), the sampling weights and sample design variables from the 3 survey rounds (2 rounds for sleep latency) were used to account for the stratification and clustering of observations in the NHANES. All values were considered significant at $P \leq 0.05$. Associations across levels of food security were tested by χ-square tests of independence for categorical variables and linear regression models for continuous variables.

We used multiple linear regression models to examine the association between food security status and self-reported hours for sleep duration and minutes for sleep latency, whereas we used logistic regression models to examine the association between food security status and sleep complaints. Several model specifications, such as age alone, age and socioeconomic status (SES) variables, and a full model of age, SES, and health variables, were used in our regression analyses. Because our results were robust for controlling SES and for controlling SES with health variables, we present 2 model specifications: model 1 controlled for age and model 2 included all control variables. Continuous variables were age, PIR, BMI, and household size. Indicator variables included race/ethnicity, education level, marital status, work schedule, poor mental health, general health condition, smoking status, alcohol consumption, and menopause status (only for women). Reference groups for each variable used in our multiple linear and logistic regression models are indicated in **Supplemental Table 1**.

Analyses were stratified by sex because we found significant interaction terms (sex and food security status) in the full model analyses of sleep duration and sleep latency ($P < 0.05$). In our stratified analysis for women, fully FS women were considered the referent group, whereas in our stratified analysis, for men, fully FS men were the referent group. For sleep duration, we examined a model in which fully FS women were the common referent for all sex and food security categories. We also examined a model in which fully FS men were the common referent for sleep latency. With the use of a common referent analysis, we statistically tested whether our reference groups were reporting short sleep duration and long sleep latency. Reference groups reporting poor outcomes could be an underlining reason for finding no association. To account for possible confounding by income, we conducted additional analyses and restricted the sample to low-income participants. A 185% PIR was used as the cut-off value for low income, because it is the upper bound for several Food and Nutrition Service programs and is often used in analyses (37).

Results

Differences across levels of food security for men and women were found for every characteristic: age, PIR, BMI, household size, race/ethnicity, education level, marital status, work schedule, poor mental health, general health condition, smoking status, and alcohol consumption and menopause status among women (Supplemental Table 1). The prevalence of inadequate sleep duration is presented by food security status for men and women in **Figure 1**. Among men, participants reporting inadequate sleep were 38% (95% CI: 37%, 40%) in fully FS, 41% (95% CI: 36%, 47%) in marginally FS, 45% (95% CI: 39%, 50%) in low FS, and 52% (95% CI: 44%, 60%) in very low FS. Among women, the findings were 33% (95% CI: 31%, 36%) in fully FS, 42% (95% CI: 37%, 47%) in marginally FS, 47% (95% CI: 41%, 54%) in low FS, and 61% (95% CI: 56%, 67%) in very low FS. In a bivariate analysis, inadequate sleep was not independent of food security status ($P < 0.05$).

The adjusted mean values for sleep duration are presented in **Table 1**. Very low FS women reported significantly shorter sleep duration than fully FS women in both model specifications ($P < 0.01$). On average, very low FS women reported sleeping half an hour less than fully FS women (-30 ± 5.2 min; $P < 0.01$), while controlling for all variables. Marginally FS and low FS women also reported shorter sleep duration than fully FS women in model 1, but the association was attenuated and no longer significant after further adjustment. Among men, differences in sleep duration were not observed after adjustment for all variables. With the common referent analysis, fully FS men, very low FS men, low FS women, and very low FS women reported shorter sleep duration than fully FS women (**Supplemental Table 2**).

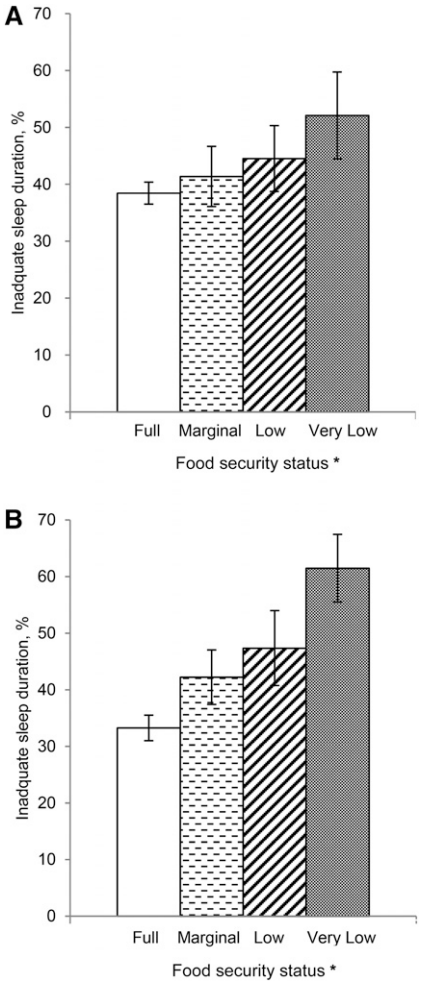

FIGURE 1 Prevalence of inadequate sleep duration among men (A) ($n = 5283$; fully FS: $n = 3987$; marginally FS: $n = 544$; low FS: $n = 452$; very low FS: $n = 300$) and women (B) ($n = 4854$; fully FS: $n = 3575$; marginally FS: $n = 573$; low FS: $n = 444$; very low FS: $n = 262$) by food security status. NHANES 2005–2010 were used in the analysis. Inadequate sleep (<7 h of sleep per night) was based on Healthy People 2020 sleep recommendations (15). Participants who had long sleep duration (≥9 h) were excluded in this analysis. All values were weighted, and design corrections were applied to the analysis as directed by the National Center for Health Statistics (30). Inadequate sleep was not independent of food security status (chi-square tests of independence). *$P < 0.05$. FS, food secure.

The adjusted mean values for sleep latency are presented in **Table 2**. Among men, participants who were marginally, low, and very low FS reported significantly longer sleep latency than fully FS men in both model specifications ($P < 0.05$). On average, marginally, low, and very low FS men reported 4–5 min more than fully FS men, while controlling for all variables. Among women, participants who were marginally FS, low FS, and very low FS reported longer sleep latency than fully FS women in model 1, but the association was attenuated and no longer significant after further adjustment. With the common referent

TABLE 1 Predicted and average differences in sleep duration across food security status among adults[1]

	Model 1			Model 2		
Food security status	Predicted sleep, h	β ± SE, min	*P*	Predicted sleep, h	β ± SE, min	*P*
Men (*n* = 5283)						
Full (*n* = 3987)	6.7	Reference	—	6.7	Reference	—
Marginal (*n* = 544)	6.6	−4 ± 3.6	0.29	6.7	0 ± 3.9	1.0
Low (*n* = 452)	6.6	−8 ± 5.2	0.10	6.6	−4 ± 5.5	0.43
Very low (*n* = 300)	6.4	−20 ± 6.9	<0.01	6.5	−12 ± 7.3	0.11
Women (*n* = 4854)						
Full (*n* = 3575)	6.8	Reference	—	6.7	Reference	—
Marginal (*n* = 573)	6.6	−13 ± 3.9	<0.01	6.7	−3 ± 3.6	0.39
Low (*n* = 444)	6.4	−24 ± 5.3	<0.01	6.6	−10 ± 5.2	0.06
Very low (*n* = 262)	6.0	−48 ± 4.9	<0.01	6.2	−30 ± 5.2	<0.01

[1] NHANES 2005–2010 were used in the analysis. Predicted sleep duration in hours and β coefficients in minutes were from linear regression models adjusted for different control variables in the 2 models. Participants who had long sleep duration (≥9 h) were excluded in this analysis. Model 1 was adjusted for age, and model 2 included age and was further adjusted for poverty income ratio, body mass index, household size, race/ethnicity, education level, marital status, work schedule, poor mental health, general health condition, smoking status, alcohol consumption, and menopause status (only for women). All values were weighted, and design corrections were applied to the analysis as directed by the National Center for Health Statistics (30).

analysis, marginally FS, low FS, and very low FS men and fully FS, marginally FS, low FS, and very low FS women reported longer sleep latency than fully FS men (**Supplemental Table 3**).

The adjusted ORs for sleep complaints are presented in **Table 3**. Compared with fully FS adults, marginally FS and low FS adults were ~60% more likely and very low FS adults were twice as likely to report sleep complaints ($P < 0.05$).

When the sample was restricted to participants with PIR < 185%, similar results for sleep duration, sleep latency, and sleep complaints were found in both model specifications (**Supplemental Tables 4–6**). Our results were again robust in that excluding participants with sleep disorders did not change any of our reported findings.

Discussion

To our knowledge, our study is the first to demonstrate a link between food insecurity and habitual short sleep duration and long sleep latency and for frequent sleep complaints to a health care professional. Although the presence of a relation depended on participants' sex, 2 different conclusions were reached about the relations between food insecurity and sleep duration and latency. Among women, participants who were very low FS were associated with sleeping less; however, no relation was found among men. Conversely, among men food insecurity was associated with prolonged sleep latency, yet among women no association was observed. On the basis of the common referent analysis, these divergent patterns were likely because of our reference groups that reported undesirable sleep outcomes; fully FS men reported inadequate sleep and fully FS women reported long sleep latency. Although the results for sleep duration and latency were divergent, we found both men and women in FI households were more likely to report sleep complaints to a health care professional.

Comparisons between the results of our study and previous studies are difficult because no other studies have examined the relation between food insecurity and sleep. However, there is a large body of literature about the relation between income and sleep outcomes, including sleep duration, sleep latency, and sleep complaints. Researchers found that low income was linked to short sleep duration (38) and more frequent sleep complaints

TABLE 2 Predicted and average differences in sleep latency across food security status among adults [1]

	Model 1			Model 2		
Food security status	Predicted sleep latency, min	β ± SE, min	*P*	Predicted sleep latency, min	β ± SE, min	*P*
Men (*n* = 3617)						
Full (*n* = 2814)	18	Reference	—	19	Reference	—
Marginal (*n* = 345)	24	6 ± 1.0	<0.01	24	4 ± 1.1	<0.01
Low (*n* = 296)	25	7 ± 1.7	<0.01	24	4 ± 1.7	0.03
Very low (*n* = 162)	28	10 ± 2.0	<0.01	25	5 ± 1.8	<0.01
Women (*n* = 3363)						
Full (*n* = 2562)	21	Reference	—	23	Reference	—
Marginal (*n* = 377)	25	3 ± 1.5	0.03	23	0 ± 1.7	0.99
Low (*n* = 289)	27	6 ± 1.7	<0.01	25	1 ± 1.6	0.37
Very low (*n* = 135)	31	9 ± 2.3	<0.01	27	4 ± 2.4	0.14

[1] NHANES 2005–2008 were used in the analysis. Predicted sleep latency and β coefficients in minutes were from linear regression models adjusted for different control variables in the 2 models. Model 1 was adjusted for age, and model 2 included age and was further adjusted for poverty income ratio, body mass index, household size, race/ethnicity, education level, marital status, work schedule, poor mental health, general health condition, smoking status, alcohol consumption, and menopause status (only for women). All values were weighted, and design corrections were applied to the analysis as directed by the National Center for Health Statistics (30).

TABLE 3 Association between food security status and sleep complaints among adults[1]

	Adjusted OR (95% CI)	
Food security status	Model 1	Model 2
Men and women (n = 10,901)		
Full (n = 8138)	Reference	Reference
Marginal (n = 1187)	1.56 (1.25, 1.96)	1.64 (1.24, 2.16)
Low (n = 965)	1.47 (1.11, 1.94)	1.63 (1.16, 2.30)
Very low (n = 611)	2.03 (1.57, 2.63)	1.99 (1.36, 2.92)

[1] NHANES 2005–2010 were used in the analysis. Adjusted ORs were from logistic regression models adjusted for different control variables in the 2 models. Model 1 was adjusted for age, and model 2 included age and was further adjusted for poverty income ratio, body mass index, household size, race/ethnicity, education level, marital status, work schedule, poor mental health, general health condition, smoking status, alcohol consumption, and menopause status (only for women). All values were weighted, and design corrections were applied to the analysis as directed by the National Center for Health Statistics (30).

(39). Higher income was related to better sleep quality (40), greater sleep efficiency, and shorter sleep latency (40, 41). All of the SES studies support our results that FI, caused primarily by a lack of resources, may have an effect on adults' quality and quantity of sleep. Although these studies support this relation, it is still imperative to examine the relation between food insecurity and sleep because there is not a one-to-one correspondence between income and food security status (42). Even after we controlled for PIR and restricted the data to only participants who had low income in our models, the associations between food security status and the 3 sleep outcomes remained.

The mechanisms that underlie the relation between food security status and sleep are not established; however, there are several possibilities. One possibility is that food insecurity may work through poor mental health (8). Studies have linked food insecurity to depression (43–46), anxiety (44), and stress (8, 45, 47, 48). With the use of a longitudinal design, researchers observed that changes in food insufficiency status are associated with changes in depression status among women (43). In rural Tanzania, Hadley and Patil (44) found that food insecurity increases the risk of anxiety and depression. Whitaker and colleagues (9) found a relation between higher levels of food insecurity and higher levels of maternal anxiety. Several groups have linked food insecurity to both acute and chronic stress (8, 47, 48). Researchers have reported an association between depression, stress, and sleep (16, 18, 49). Although we included mental health status in our analyses, it is possible that mental health problems in marginally FS, low FS, and very low FS adults could still potentially result in poor sleep outcomes. Because mental and physical health might in fact be intermediaries in the associations between food insecurity and poor sleep outcomes, this might represent statistical overadjustment. Another possible mechanism might be that FI adults may have diets deficient in nutrients, such as vitamin B-12 or folic acid (50), which could influence mood and immune functions (51, 52) and that in turn may have an effect on their sleep.

Our results provide insights about the potential health benefits of participating in food and nutrition assistance programs. The largest and best-known federal food assistance program is the Supplemental Nutrition Assistance Program (SNAP), formerly the Food Stamp Program, which has a well-established framework aimed at reducing food insecurity in the United States (5, 53, 54). Although analyzing the impact of SNAP on household food security is complicated by self-selection problems, where food insecurity is a primary driver of families seeking assistance, receipt of SNAP benefits is shown to lower the prevalence and severity of food insecurity (53–56). Future studies should examine the potential impact of SNAP on sleep hygiene.

The relations between food insecurity and sleep duration we observed among women were expected because other studies found sex differentials in the health consequences of food insecurity (2, 4, 6). Prinz et al. (57) demonstrated that in women, but not men, higher cortisol (a marker of physiologic stress) was associated with earlier time of arising. A high concentration of cortisol is also linked to partial sleep deprivation and insomnia (58). We know of no studies that detail the mechanisms for observing differences in our food insecurity and sleep latency relations for men and women.

The finding about complaints to a health care professional was expected among women. Women have more contact with the medical system, receive more physician time, and get more detailed answers to their medical questions than men (59). Other researchers have suggested that men are less likely to recognize signs and symptoms and delay seeking medical help because they perceive less vulnerability than women (60). For example, FI men were less aware than FI women of their health risk of diabetes (4). Our results suggest that among men food insecurity may not prevent them from seeking medical attention about sleep concerns.

There were some limitations to our study methods. First, sleep duration and latency were measured according to participants' self-report, which was potentially subject to recall bias. Objective sleep recording with the use of wrist actigraphy may provide more accurate measurements than self-reported sleep measurement. However, self-reported and measured sleep duration are shown to be moderately correlated. Although actigraphy provides an adequately accurate measure of duration, Lauderdale et al. (61) suggested that it leaves important sleep characteristics unmeasured. Second, self-reported sleep duration and latency were based on participants' responses of usual sleep without a specific time period, whereas food security status was assessed for the past 12 mo. Third, the item about sleep complaints was measured by one general question without further details, such as whether the complaint was for insomnia or waking up during the night. Fourth, although we controlled for demographic, socioeconomic, and health-related variables in our analyses, there remains several environmental factors, such as noise and light level in participants' sleep environment, that we could not include. Fifth, we used regression models to estimate the association between food security status and our 3 sleep outcomes. When using regression models, we assume food insecurity is exogenous and not correlated with the error term in the regression model. Although, there might be bias because of this assumption, Gundersen and Kreider (62) stated that results about the impact of food insecurity on health are more likely to be underestimated than overestimated. Finally, the study is limited by the cross-sectional nature of NHANES, which does not allow us to determine the causal relation between food insecurity and the 3 sleep outcomes. Reverse causation is possible in that sleep problems may lead to lower job performance and lower income and these in turn may lead to food insecurity.

In conclusion, results from this study suggest that poor sleep quantity and quality may predispose FI adults to adverse health outcomes. Participation in food and nutrition assistance programs may alleviate FI, which in turn may have the potential to improve diet quality and sleep hygiene. In addition to encouraging participation in food and nutrition assistance

programs, health promotion efforts for FI populations should incorporate advice about sleep hygiene.

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MD and CAZ designed and conducted the study, analyzed the plan, interpreted data, and drafted the manuscript; MD analyzed data; MKK analyzed the plan; KBG designed and conducted the study; MD, MKK, KBG, PAD, and CAZ critically revised the manuscript. All authors read and approved the final manuscript.

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