Each underlined sentenced has comment attached

Food Insecurity Is Associated with Increased Risk of Obesity in California Women[1,2]

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ABSTRACT Food insecurity, the limited or uncertain availability of nutritionally adequate and safe foods, may be associated with disordered eating and a poor diet, potentially increasing risk for obesity and health problems. Patterns of food insecurity in California women are described and relationships between food insecurity and obesity (body mass index ≥ 30 kg/m^2) are evaluated using data from the 1998 and 1999 California Women's Health Survey. A total of 8169 women aged ≥ 18 y were randomly selected and interviewed by telephone. Food insecurity was evaluated by use of four questions adapted from the U.S. Household Food Security Module. Logistic regression was used to examine the relationship between food insecurity and obesity, controlling for income, race/ethnicity, education, country of birth, general health status and walking. Food insecurity without hunger affected 13.9% of the population and food insecurity with hunger, 4.3%. Almost one fifth (18.8%) of the population was obese. Obesity was more prevalent in food insecure (31.0%) than in food secure women (16.2%). Food insecurity without hunger was associated with increased risk of obesity in whites [odds ratio (OR) = 1.36] and others (OR = 1.47). Food insecurity with hunger was associated with increased risk of obesity for Asians, Blacks and Hispanics (OR = 2.81) but not for non-Hispanic Whites (OR = 0.82). Food insecurity is associated with increased likelihood of obesity and risk is greatest in nonwhites. J. Nutr. 133: 1070–1074, 2003.

KEY WORDS: • *food insecurity* • *hunger* • *obesity* • *women* • *California*

Although extreme forms of hunger are uncommon in the United States, food insecurity and less severe forms of hunger have remained persistent problems (1,2). Food insecurity, which has been defined as "the limited or uncertain availability of nutritionally adequate and safe foods," can exist with or without hunger, the uneasy or painful sensation caused by lack of food (2). Not surprisingly, food insecurity has been associated with increased risk for poor nutritional status (3–5) and poor health outcomes (3,6). The presence of food insecurity and hunger seems to contrast sharply with the economic prosperity of the United States and increasing rates of obesity in this country (7,8). However, food insecurity can be associated with either overnutrition or undernutrition (3,9). In addition, economic prosperity notwithstanding, millions of Americans live in poverty (10). For many of these persons, purchasing enough nutritious foods may strain the household budget.

Dietz brought attention to the idea that the food insecure are at increased risk of obesity (11). Since then, this association has been documented in studies of rural women in New York State (4) and in a sample representative of the U.S. population (12). This relationship may not hold in all populations, however, and may vary, depending on coping strategies adopted in response to food insecurity.

Obesity has been clearly linked to numerous poor health outcomes such as high blood pressure, diabetes and heart disease, all of which increase morbidity and premature mortality (7). Over the past decade, the prevalence of obesity has increased dramatically in the United States and reduction of obesity has been identified as a national health priority (7,8). Given its potential impacts on health, understanding the relationship between obesity and food insecurity is essential. The purposes of this study were to determine the prevalence of food insecurity with and without hunger in women living in California in 1998 and 1999, and to examine the relationship between food insecurity and obesity as identified by body mass index (BMI) of ≥30 kg/m^2.

SUBJECTS AND METHODS

Study population and data collection. Data were obtained from the 1998 and 1999 California Women's Health Survey (CWHS) (13). The CWHS, an ongoing telephone survey, collects self-reported information on a variety of health-related behaviors, attitudes and outcomes in women in California. Women aged >18 y were randomly selected through random-digit dialing and interviewed anon-

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[2] Analyses, findings and conclusions described in this report are not necessarily endorsed by the California Department of Health Services or the California Women's Health Survey Group.
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ymously by telephone. There were 8169 participants, with response rates of 70% in 1998 and 81% in 1999 (13). All interviewers were trained in standard procedures for administering the CWHS (13). The survey was administered in English or Spanish, depending on participants' preferences, with most participants selecting English. The CWHS was developed in English and translated into Spanish by a native Spanish speaker. The survey included ~200 questions and took about 30 min to administer in English. This study was determined to be exempt from review by the Committee for the Protection of Human Subjects at the Centers for Disease Control and Prevention.

Assessment of food insecurity. In both survey years, food insecurity was evaluated using a subset of four questions (**Table 1**) adapted from the U.S. Household Food Security Module (HHFSM) (2). Classification was by the number of questions answered affirmatively ("often" or "sometimes" to questions 1 and 2, and "yes" to questions 3 and 4). Women with zero or one affirmative response were classified as food secure, those with two or three affirmative responses as food insecure without hunger and those with four affirmative responses as food insecure with hunger. Questions included in the CWHS were selected after discussion with U.S. Department of Agriculture (USDA) staff to bracket thresholds for these categories of food insecurity. Questions for the 1998 CWHS were selected in 1997, before a standard short form of the HHFSM had been published (14). Severe food insecurity could not be evaluated using the subset of questions included in the 1998 and 1999 CWHS.

Categorization of variables. Outcome measures and covariates used in the analysis were categorized (see **Table 2**). Obesity was identified by a BMI $\geq$ 30 kg/m^2. Income was categorized by percentage of the federal poverty level. Walking was used as a proxy for activity and was characterized as city blocks walked per day. Participants were asked to report the single race/ethnicity with which they most identified and to rate their health status as excellent, very good, good, fair or poor.

Data analysis. The prevalence of obesity was determined relative to food security status and race/ethnicity; linear trends were evaluated using chi-square analysis. Logistic regression was used to evaluate the relationship between food insecurity and obesity, with the model controlling for characteristics expected to be related to obesity status, including income level, a four-category [Asian, Black, Hispanic and non-Hispanic White (NHW)] or a two-category (NHW and other race/ethnicities) race/ethnicity variable, age group, education, country of birth, walking and general health status. Two-way interactions between food insecurity status and all other variables in the model were tested individually; the interactions with NHW ($P < 0.01$), race/ethnicity ($P < 0.05$) and country of origin ($P < 0.05$) were significant. Because the interaction between NHW race/ethnicity and food security status was significant, and to maintain adequate numbers for analysis in each strata, logistic regression analyses were stratified by NHW and other race/ethnicities. Within these strata, there were no significant two-way interactions with food security status. All analyses were weighted for discrepancies in age and race between the CWHS sample and the California female population (13) and were carried out by use of SAS (Statistical Analysis System, Release 8.1 for Windows; SAS Institute, Cary, NC) and Epi-Info 2000 (Centers for Disease Control and Prevention, Atlanta, GA).

TABLE 1

Food security questions asked in the California Women's Health Survey, 1998–1999

For two questions, the interviewer made a statement about a phenomenon, then asked about its frequency in the last 12 mo:
Q1. "The food that I bought just didn't last, and I didn't have money to get more." Was that often, sometimes or never true for you in the last 12 months?
Q2. "I couldn't afford to eat balanced meals." Was that often, sometimes or never true for you in the last 12 months?
For the two remaining questions, the interviewer asked a question about conditions in the last 12 mo:
Q3. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?
Q4. In the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food?

TABLE 2

Characteristics of adult California women, 1998–1999[1,2]

Characteristic	%
Age, *y*	
18–24	14.5 (13.7–15.2)
25–34	24.7 (23.8–25.7)
35–44	20.7 (19.8–21.6)
45–54	13.1 (12.4–13.8)
55–64	10.5 (8.5–13.0)
≥ 65	16.5 (15.7–17.3)
Race/ethnicity	
Asian	9.8 (9.2–10.5)
Black	6.8 (6.3–7.4)
Hispanic	21.3 (20.4–22.2)
White, non-Hispanic	62.1 (61.1–63.2)
Household income % *of poverty*[3]	
≤ 100	18.8 (18.0–19.7)
101–200	20.6 (19.7–21.5)
> 200	60.6 (59.5–61.7)
General health status	
Excellent or very good	55.9 (55.4–57.6)
Good or fair	40.2 (38.4–40.5)
Poor	4.0 (3.6–4.5)
Food security	
Food insecure with hunger	4.3 (3.9–4.7)
Food insecure without hunger	13.9 (13.2–14.7)
Food secure	81.8 (81.0–82.6)
Body mass index, *kg/m*^{2}	
< 18.5	2.9 (2.5–3.2)
18.5–24.9	51.6 (50.5–52.7)
25.0–29.9	26.7 (25.7–27.7)
≥ 30.0	18.8 (18.0–19.7)
Born in United States	76.5 (75.5–77.4)
Education	
< High school diploma	15.5 (14.7–16.3)
High school diploma/equivalent	25.8 (24.8–26.7)
Education beyond high school	31.4 (30.4–32.4)
≥ College degree	27.4 (26.4–28.4)
City blocks walked, *n/d*	10.7 ± 15.4

[1] Estimates are from the California Women's Health Survey (n = 8169). All variables are self-reported.

[2] Values are weighted percentages and confidence intervals (CI), for all characteristics except city blocks walked per day which is the mean ± SD.

[3] Percentage of federal poverty level.

RESULTS

The CWHS sample included 8169 women. Almost one fifth of the women (18.8%) had incomes below the poverty level, and 41.3% had at least a high school education (Table 2). Just over half (51.4%) were married, and 76.5% were born in the United States. Almost one fifth (18.8%) were obese. The overall prevalence of food insecurity was 18.2%. In all, 13.9% of the women surveyed were food insecure without hunger and 4.3% were food insecure with hunger. The prevalence of obesity varied with food security status and race/ethnicity (**Table 3**). In NHW women, the prevalence of obesity increased with food insecurity, but did not increase further as food insecurity became more severe. In contrast, for

TABLE 3

Prevalence of obesity by food security status and race/ethnicity among California women[1–3]

	All	Food secure	FI, without hunger	FI, with hunger
Race/ethnicity				
Asian	9.1 (580)	6.6 (497)	17.4 (61)	38.5 (22)*
Black	29.9 (471)	27.0 (365)	36.2 (80)	52.1 (26)*
Hispanic	25.5 (2103)	20.7 (1339)	32.1 (615)	42.1 (149)*
White, non-Hispanic	17.0 (4810)	15.6 (4336)	28.1 (339)	26.5 (135)*
All	18.8 (7964)	16.2 (6537)	29.7 (1095)	35.2 (332)*

[1] FI, food insecure.
[2] Participants (n = 7964) had complete data for all variables and were included in this analysis.
[3] Values are weighted percentages and unweighted n (n). * Chi-square test for linear trend within race/ethnicity, $P < 0.05$.

women of other race/ethnicities, the prevalence of obesity increased with increasing severity of food insecurity.

In the stratified logistic regression analysis, after statistical control was imposed for all other variables in the model, NHW women who were food insecure without hunger were 36% more likely to be obese than those who were food secure (**Table 4**); however, NHW women who were food insecure with hunger were no more likely than food secure women to be obese. In other women, the risk of obesity increased with increasing severity of food insecurity. Those who were food insecure without hunger were 47% more likely to be obese than the food secure, and those who were food insecure with hunger were 2.8 times as likely to be obese.

DISCUSSION

The idea that food insecurity increases the risk of obesity may seem counterintuitive, but the present study is at least the third to confirm this association. In our study, NHW women who were food insecure without hunger were 36% more likely to be obese than food secure NHW women; women of other race/ethnicities reporting food insecurity without and with hunger had 1.5 and 2.8 times the risk of obesity, respectively, compared to their food secure counterparts. The studies of Olson and Townsend also found intermediate levels of food insecurity to be positively associated with risk for obesity or overweight (3,12). Olson categorized household food insecurity according to the Radimer/Cornell measure and found that mean BMI and prevalence of obesity (BMI > 29 kg/m^2) were greater for women from food insecure households compared to women from food secure households. Townsend categorized household food insecurity (mild, moderate or severe) using the USDA food sufficiency indicator, and found that women from households with mild food insecurity were 30% more likely than food secure women to be overweight (BMI ≥ 27.3 kg/m^2).

Our findings are consistent with those of Olson and Townsend despite differences in tools used to identify food insecurity, BMI cutoffs used to identify obesity and in populations studied. The CWHS used questions from the HHFSM, whereas Townsend used the USDA food sufficiency indicator (12). Food insufficiency is a concept closely related to food insecurity; it is more severe than the concept of food insecurity, and less severe than the concept of hunger (15). The CWHS population included greater ethnic diversity than did Olson's or Townsend's and this may have enabled us to observe contrasts in the relationships between food insecurity with hunger and obesity for NHW women vs. others. Findings may have implications for other states with similarly diverse populations and comparable levels of food insecurity.

Other researchers have also reported that risk of obesity or overweight is not increased with increasing severity of food insecurity as we found in NHW women. Olson reported that although BMI increased with moderate food insecurity, it decreased as the condition became more severe for women in rural New York State (3). Similarly, at the more severe levels of food insecurity, Townsend found that risk for overweight did not differ from that of food secure women. As noted in the Methods, we were unable to analyze the relationship between severe food insecurity and obesity using CWHS data.

Unlike earlier studies, the current study revealed contrasting relationships between obesity and food insecurity with hunger for NHW women compared to others. In women of other race/ethnicities, the risk for obesity increased with increasing severity of food insecurity, suggesting a dose–response relationship. In contrast, for NHW women, adjusted analyses revealed an increased risk of obesity associated with food insecurity without hunger, but not with the more severe food insecurity with hunger. Reasons for observed differences could not be determined from these analyses. However, factors that may contribute to observed differences include differences in strategies used to cope with food insecurity, cultural attitudes toward body size and characteristics of those experiencing food insecurity in each group. The language of interview is not thought to explain differences between groups. Although we did not control for language in our regression analyses because of collinearity with ethnicity, similar relationships between obesity and food insecurity were observed for Blacks, Asians and Hispanics (Table 3), suggesting that differences between strata are not fully explained by language.

To explore the relationship between overweight (BMI > 25 kg/m^2) and food insecurity, additional analyses were carried out using the same logistic regression model that was used to assess the relationship between food insecurity and

TABLE 4

Crude and adjusted odds ratios for obesity among California women by food security status for women of non-Hispanic White and other race/ethnicities[1,2]

	Crude odds ratio	Adjusted odds ratio
White, non-Hispanic race/ethnicity		
Food insecure, hunger	1.84 (1.26–2.67)*	0.82 (0.57–1.55)
Food insecure, no hunger	2.10 (1.66–2.65)*	1.36 (1.00–1.84)*
Food secure	1.00 (reference)	1.00 (reference)
Asian, Black and Hispanic race/ethnicity		
Food insecure, hunger	3.64 (2.62–5.05)*	2.81 (1.84–4.28)*
Food insecure, no hunger	2.04 (1.65–2.51)*	1.47 (1.07–1.94)*
Food secure	1.00 (reference)	1.00 (reference)

[1] Data are from California Women's Health Survey, 1998–1999. For non-Hispanic Whites, n = 3699 had complete data for all variables in the model and were included in this analysis; for Asian, Black and Hispanic race/ethnicity, n = 2352. (Note: Survey n = 8169.)
[2] Variables included in the adjusted model were income level, race/ethnicity, country of birth, age group, education, general health status and walking.
[3] Values presented for odds ratios and adjusted odds ratios represent weighted values and 95% confidence intervals (CI). * $P < 0.05$.

obesity. Risk of overweight associated with food insecurity followed similar patterns as risk for obesity in NHW and other women, but the magnitude of the odds ratios was smaller and significant only for women of Asian, Black and Hispanic race/ethnicity.

Questions remain about the direction of the association between food insecurity and obesity and the mechanisms that may explain it. One possibility is that obesity causes food insecurity attributed to increased food consumption. Although the relative energy needs of the obese are likely to be increased for weight maintenance or movement compared to others (16), food-related costs will depend in part on foods selected, and may not be directly related to total caloric intake, making obesity an unlikely cause of food insecurity.

A growing body of evidence suggests that the association may be reversed, with food insecurity causing obesity. However, a causal relationship between food insecurity and obesity has not been established, although some of the criteria supporting causality have been met, including plausibility, evidence of dose–response relationship and consistency of findings across studies. A variety of mechanisms support the biological, social and behavioral plausibility of a causal association. Increased risk for obesity in women who are food insecure may be related to the direct effects of food insecurity on diet. Food insecurity may limit the variety of foods available and result in consumption of high energy, low cost foods. Diets of food insecure or food insufficient women have been shown to include fewer fruits and vegetables (3) and to be deficient in a variety of nutrients (4,5) compared with those who are food secure or food sufficient.

Less direct mechanisms by which food insecurity may cause obesity are supported by other research. There is strong evidence from populations of dieters, prisoners of war and children with food-restrictive parents that food deprivation may lead to overconsumption of previously restricted foods after the restriction ends (17–19). As proposed by Dietz (11), "either food choices or physiologic adaptations in response to episodic food shortages could cause increased body fat." Adverse environmental and health effects associated with an inadequate food supply may also be associated with increased risk for obesity. Food insufficiency has been linked with depression, poor health and physical limitations in adults (20), and with depression, poor health and impaired cognitive and psychosocial development in children (21–23). Interrelationships among food insecurity and BMI and factors such as sociodemographic characteristics, health status and cognitive abilities need further study.

Positive relationships between poverty and BMI (24) and between poverty and food insecurity (25) have been documented. In this study the effect of food insecurity with and without hunger remained significant, even after controlling for poverty status, suggesting that food insecurity is not simply a proxy for income.

In addition to poverty status, other potential confounders of the relationship between food insecurity and obesity were controlled in these analyses, including education, race/ethnicity, country of birth, health status and walking. However, the possibility that the association between food insecurity and obesity is explained by confounding cannot be ruled out by this or previous studies; further investigation of the possible role of confounding is needed.

Limitations of some variables used in this analysis and in methods of data collection must be considered, but are unlikely to explain study results. Food insecurity was determined from a four-question subset of the 18-item HHFSM. The subset used has not been validated as a tool to detect food insecurity, although questions were selected to identify food insecurity thresholds used in the 18-item scale. Although two or more affirmative responses roughly correspond to food insecurity as reported in the USDA national reports, and three or more roughly correspond to food insecurity with hunger, the scale is not precise enough to directly compare our findings with prevalence rates obtained from the 18-item scale (personal communication, M. Nord, Economic Research Service, Washington, DC, May 14, 2002). However, shifts in cutoff points used to identify food insecurity with and without hunger would not be expected to create the associations reported here and are not thought to explain the results of this study.

Self-reported weight and height data used to determine BMI may underestimate weight and overestimate height (26), resulting in underestimation of BMI and prevalence of obesity. Such misclassification would be expected to attenuate relationships observed. When logistic regression analyses were repeated, adjusting weights and heights for expected reporting bias according to the method of Rowland (27), results did not change in direction or significance of odds ratios (results not shown).

It should be noted that the variable used to indicate physical activity (city blocks walked per day) may have resulted in some misclassification. For example, some women who are extremely active might walk only a few blocks per day.

Finally, data collection methods used in the CWHS excluded from participation women without a phone and those unable to complete the survey in Spanish or English. It is likely that excluded women differed from participants in characteristics such as income, education and race, and were among those most likely to be food insecure. As a result, the prevalence of food insecurity may be underestimated and conclusions must be limited to the population that could be reached using CWHS methodology.

Despite California's prosperity in the late 1990s, both food insecurity and hunger are evident in the state. Food insecurity has been linked with obesity, an important public health problem. Increased risk of obesity associated with the more severe form of food insecurity with hunger was not consistent for all race/ethnicities. Diet and physical activity may play a role in this energy imbalance, but further research is needed to clarify which determinants of obesity are associated with food insecurity and to clarify the reasons for differences by race/ethnicity. Results of this and earlier studies (3,12) suggest that the relationship between food insecurity and obesity could be causal in nature, but this needs further investigation. Work is also needed to develop programs and policies to promote food security, access to healthful foods and a healthy weight for all California women.

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