

# Associations of food insecurity with body mass index among baby boomers and older adults

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**Abstract** Increasing obesity levels portend a challenging societal healthcare issue, while the current economic crisis may foster food insecurity, characterized by limited or uncertain access to adequate food. This study examines associations among food insecurity, meeting recommendations for dietary and physical activity patterns, and body mass index (BMI) among baby boomers and older adults completing the 2010 Brazos Valley Health Survey. Subjects included 2,985 respondents (1,589 baby boomers and 1,396 older adults). Thirty-six percent of participants were obese while 15 % of participants were food insecure. Approximately 8 % of baby boomers and older adults were both food insecure and obese. Among all study participants, an increased BMI was more common among those who were ethnic minorities and had depression. An increased BMI was less common among those who met fruit/vegetable intake and physical activity recommendations. There was a positive association between food insecurity and BMI only among baby boomer and older adult females. A combined emphasis on availability of healthy foods and increased opportunities for meeting physical activity guidelines can help to counter the food insecurity-obesity connection among both baby boomer and older adult females.

**Keywords** Obesity · Food insecurity · Fruit and vegetable intake · Physical activity · Baby boomers · Older adults

## Introduction

Obesity is a public health concern among older adults. In 2007–2008, obesity affected 34 % of females and 37 % of males aged 60 years or older in the United States (Flegal et al. 2010). Without successful intervention against this obesity epidemic, it is estimated that 51 % of the population will be obese (body mass index [BMI]  $\geq 30$  kg/m<sup>2</sup>) and 42 % will be severely obese (BMI  $\geq 40$  kg/m<sup>2</sup>) by 2030 (Finkelstein et al. 2012). The increasing prevalence of obesity among older adults critically challenges individual health and society as a whole. For instance, older adults who are obese were more likely to have increased risks of disability, chronic conditions, and poor life quality (Jensen and Hsiao 2010; Samper-Ternent and Al Snih 2012). Further, obesity and related conditions attributed to increased per capita Medicare expenditures of \$1,723 in 2006 (compared with \$1,006 in 1998), and the annual medical burden of obesity was nearly 8.5 % of annual Medicare expenditures in 2006 (Finkelstein et al. 2009).

The obesity epidemic may become more severe as baby boomers retire (Flegal et al. 2010). In 2007–2008, the highest rates of obesity were identified among middle-aged (40–59 years, 34.3 %) or older adults ( $\geq 60$  years, 37.1 %) as compared to younger peers (32.2 % for  $\leq 20$  years; 27.5 % for 20–39 years old adults) (Flegal et al. 2010). Emphasizing the value of a life course perspective, it is important to note the risk of death during midlife (age of 50 years) was two to three times higher among obese people than among those who had a BMI of 23.5 to 24.9 at that age (Adams et al. 2006), and being obese in middle age (33 to 64 years) was associated with a higher Medicare expenditure in older age ( $\geq 65$  years) (Daviglius et al. 2004). Obesity also increases the probability

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of taking early retirement and the incidence of disability by 1.5 % for men and 1.7 % for women (Renna and Thakur 2010). Nevertheless, there are many unknown factors related to obesity among baby boomers and older adults. Literature about food insecurity and its association with obesity among baby boomers and older adults is relatively sparse.

A household is considered food secure when it has the ability to acquire the food needed (Pinstrup-Andersen 2009). On the contrary, food insecurity of the household “exists whenever the availability of nutritionally adequate and safe foods or the ability to acquire acceptable foods in socially acceptable ways is limited or uncertain” (Blumberg et al. 1999). Food insecurity has recently increased among older adults aged 65 years or older. In 1999, rates of food insecurity in households with older adults were 5.8 and 6.3 % for older adults living alone (Dean et al. 2011), whereas in 2010, rates were estimated at 7.9 and 8.0 %, respectively (Coleman-Jensen et al. 2011). Investigating food insecurity, earlier study has focused on poverty and malnutrition (Wellman et al. 1997); however, there has been a growing literature showing the positive association between food insecurity and excess weight (Chubinski and Carrozza 2012; Dietz 1995; Dinour et al. 2007; Sharkey et al. 2012). This positive association was more pronounced among females given that they tend to have less socioeconomic status (Himmelgreen 2013). This association, however, may vary by the causes, mechanisms, and consequences of food insecurity (Frongillo 2013). Severe household food insecurity leads to weight deficit while moderate household food insecurity leads to weight excess (Frongillo 2013). Nevertheless, less is known about the positive association between food insecurity and obesity among baby boomers and older adults (Lee et al. 2011).

Given that obesity occurs in the lack of energy balance between food consumption and caloric expenditure, meeting recommendations for healthy eating (e.g., fruits, vegetables) and physical activity is suggested to improve body composition among older adults (Kruger et al. 2009). The Dietary Guidelines for Americans recommended in 2010 that adults (including older adults) consume five servings of fruits or vegetables a day (U.S. Department of Agriculture and U.S. Department of Health and Human Services 2010). Those who met this guideline tended to be healthier than their peers who did not (U.S. Department of Agriculture and U.S. Department of Health and Human Services 2010). The 2008 Physical Activity Guidelines for Americans also recommends that adults (including older adults) should do at least 150 min a week of moderate-intensity, or 75 min a week of vigorous-intensity aerobic physical activity (U. S. Department of Health Human Services 2008). Prior study found obese older adults who

met the guidelines showed better functional mobility (Riebe et al. 2009). Nevertheless, few studies investigate the associations of meeting these guidelines with obesity among baby boomers and older adults controlling food insecurity or other possibly confounding factors. Thus, the aims of the study were to: (a) identify characteristics of baby boomers and older adults who were food insecure or obese; (b) examine the association between meeting recommendations for healthy eating and physical activity and obesity among baby boomers and older adults; and (c) investigate the association between food insecurity and obesity among baby boomers and older adults stratified by sex. We hypothesize that food insecurity is positively associated with obesity; and obesity is less observed among those who met the recommendations for healthy eating and physical activity than those who did not meet recommendations.

## Methods

### Participants

Data used in these analyses were collected as part of the 2010 Brazos Valley Health Status Assessment (BVSHA). This assessment was conducted to examine community health in an eight-county region of Central Texas and identify vulnerable populations and modifiable health determinants. A standard random-digit dialing technique was used to produce a regionally representative sample of the non-institutionalized civilian population. Of those who could be reached by telephone, 52 % agreed to participate, and of those, 62 % returned completed instruments (i.e., overall response rate = 32 %). The 2010 BVHSA dataset contained data collected from 3,965 individuals. Study participants included in the current study were either baby boomers (persons born between 1946 and 1964;  $n=1,589$ ) or older adults (persons born before 1946;  $n=1,396$ ).

### Measures

**Dependent variable. Body mass index (BMI)** BMI was calculated from self-reported weight in pounds (converted to kilograms) divided by the square of self-reported height in feet and inches (converted to meters) and rounded to the nearest tenth as recommended by the original Quetelet calculation (Garrow and Webster 1985). BMI was categorized using the World Health Organization criteria: normal (18.5–24.9 kg/m<sup>2</sup>), overweight (25.0–29.9 kg/m<sup>2</sup>), and obese ( $\geq 30.0$  kg/m<sup>2</sup>) (World Health Organization 1998). Individuals with a BMI below 18.5 kg/m<sup>2</sup> were excluded

from the study sample because of the very low prevalence of underweight adults in our sample (<1.5 %).

**Independent variables. Demographics** Age groups consisted of baby boomers and older adults as previously described. Sex was coded as male or female. Race/ethnicity was categorized as non-Hispanic white, African American, and Hispanic. Income level was categorized into three levels: <200 % federal poverty level (FPL), 200 %–300 % FPL, and >300 % FPL.

**Food insecurity** Food insecurity was assessed utilizing the Six-Item Short Form of the Household Food Security Scale (Blumberg et al., 1999). Respondents were asked statements: “In the last 12 months, did you ever cut down the size of your meals or skip meals because there wasn’t enough money for food (yes or no);” “How often did this happen (almost every month, some months but not every month, in only 1 or 2 months, or never);” “In the last 12 months, did you ever eat less than you felt you should because there was not enough money for food (yes or no);” “In the last 12 months, were you ever hungry but did not eat because there was not enough money for food (yes or no);” “The food that I bought just did not last, and I didn’t have money to get more (often true, sometimes true, or never true);” and “I could not afford to eat balanced meals (often true, sometimes true, or never true).” Two or more affirmative responses (i.e., almost every and some months, often true/sometimes true, yes) of the six items indicate food insecurity (Gulliford et al. 2003).

**Fruit and vegetable intake** The National Cancer Institute (NCI) fruit and vegetable screener was used to assess both frequency and portion sizes of fruits and vegetables consumed (Thompson et al. 2000). Frequency was measured by asking how many times per month, week, or day the participant consumed fruits or vegetables. Portion sizes were measured by asking participants the quantity of fruits or vegetables in which they consumed, with response categories ranging from less than ½ cup to more than one cup. Responses to each item were converted into servings of fruits or vegetables per day by multiplying daily average frequency by the number of portion sizes. Given the U.S. Dietary Guidelines recommend five servings of fruits or vegetables per day among adults, we constructed a dichotomous variable (0 = not met the recommendation, 1 = met the recommendation) based on the number of servings of fruits or vegetables a day (Thompson et al. 2011).

**Physical activity** We utilized the physical activity items in the Behavioral Risk Factor Surveillance System to

measure physical activity level: “In a usual week, how many days per week do you do moderate activities or vigorous activities for at least 10 min at a time;” “On days when you do moderate activities for at least 10 min at a time, how much total time per day do you spend doing these activities” (Brown et al. 2004). Referring to the 2008 Physical Activity Guidelines for Americans, participants were considered meeting the physical activity recommendation when they engaged in physical activity for at least 150 min a week of moderate-intensity or 75 min a week of vigorous-intensity aerobic activity. We constructed a dichotomous variable (0 = not met the recommendation, 1 = met the recommendation).

**Mental health** Mental health was measured using the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al. 2001; Gary et al. 2007). The PHQ-9 ranges from 0 to 27 with five categories: no depression, mild, moderate, moderately severe, and severe (Monahan et al. 2009), which was grouped into three categories: no depression, mild, and moderate or severe because of the distribution characteristics.

### Analytical approach

Three sets of chi-square tests were used to examine the bivariate associations of study variables by age group (i.e., baby boomers or older adults), by being food insecure, and by BMI categories. Using Stata statistical software version 11 (StataCorp 2009), we performed generalized ordered logistic regression (*gologit2*) rather than ordered logistic regression since the data used in the study were not able to meet the strict proportional odds assumption (Long and Freese 2006). With three categories of BMI, generalized ordered logistic regression produced a series of logistic regression models: normal versus overweight or obese; normal or overweight versus obese. If variables met the proportional odds assumption, their parameter estimates would be identical in both models, consisting of a combined model. If not, two different estimates would be displayed at two unique models. To reduce likelihood of finding violations by chance alone, we decreased the level of significance to 0.001 using a Bonferroni adjustment (Williams 2006). See Williams (2006) for more detailed information of the estimation and interpretation of *gologit2* models. Sex was used to stratify the generalized ordered logistic regression analyses to investigate if sex modifies the association between food insecurity and BMI. Thus, three independent models were generated: all participants (model 1), male only (model 2), and female only (model 3). The Adjusted Wald test and Likelihood Ratio test were used to build the final model

**Table 1** Characteristics of study participants by age ( $N=2,985$ )

Variable		Baby boomers ( $N=1,589$ ) $N$ (%)	Older adults ( $N=1,396$ ) $N$ (%)	Total ( $N=2,985$ ) $N$ (%)	$p$ -value
BMI	Normal	420 (26.4)	453 (32.5)	873 (29.3)	<0.001
	Overweight	514 (32.4)	534 (38.3)	1,048 (35.1)	
	Obese	655 (41.2)	409 (29.3)	1,064 (35.6)	
Sex	Male	460 (29.0)	490 (35.1)	950 (31.8)	<0.001
	Female	1,129 (71.1)	906 (64.9)	2,035 (68.2)	
Race/ethnicity	Non-Hispanic white	1,046 (82.6)	899 (88.1)	1,945 (85.0)	0.001
	African American	106 (8.4)	54 (5.3)	160 (7.0)	
	Hispanic	115 (9.1)	68 (6.7)	183 (8.0)	
Federal poverty level (FPL)	<200 % FPL	401 (28.2)	479 (41.6)	880 (34.2)	<0.001
	200 %–300 % FPL	218 (15.3)	254 (22.1)	472 (18.3)	
	>300 % FPL	805 (56.5)	418 (36.3)	1,223 (47.5)	
Food insecure	No	1,300 (81.8)	1,234 (88.4)	2,534 (84.9)	<0.001
	Yes	289 (18.2)	162 (11.6)	451 (15.1)	
PHQ-9 depression <sup>a</sup>	No depression	988 (66.3)	916 (74.4)	1,904 (69.9)	<0.001
	Mild depression	285 (19.1)	203 (16.5)	488 (17.9)	
	≥Moderate depression	218 (14.6)	113 (9.2)	331 (12.2)	
Met recommendation for fruit or vegetable intake	No	1,040 (68.8)	922 (69.2)	1,962 (69.0)	0.822
	Yes	471 (31.2)	410 (30.8)	881 (31.0)	
Met recommendation for physical activity	No	911 (57.3)	717 (51.4)	1,628 (54.5)	0.001
	Yes	678 (42.7)	679 (48.6)	1,357 (45.5)	

Brazos Valley Health Status Assessment data (2010)

<sup>a</sup> PHQ stands for Patient Health Questionnaire

(Williams 2006), which was selected by the backward elimination algorithm (Kowalski and Huttmacher 2001). Additionally, we included income variable given its importance in the context of food insecurity and obesity. Odds ratio (OR) with 95 % confidence intervals are displayed.

## Results

Table 1 shows descriptive statistics for baby boomers and older adults. Approximately 29 % ( $n=873$ ) were normal weight, while 35 % ( $n=1,048$ ) were overweight and 36 % ( $n=1,064$ ) were obese. The study sample was predominantly female (68 %,  $n=2,035$ ) and non-Hispanic white (85 %,  $n=1,945$ ). More than one third of the participants reported having income less than 200 % FPL. About 15 % ( $n=451$ ) of study participants reported being food insecure. Twelve percent ( $n=331$ ) of study participants had moderate or severe depression symptomatology. Approximately 31 % ( $n=881$ ) and 46 % ( $n=1,357$ ) reported meeting recommendations of fruit/vegetable intake or physical activity, respectively. Table 1 also shows bivariate correlations of study variables by age group. A larger proportion of older adults met the 2008 Physical Activity Guidelines physical activity recommendation

compared to baby boomers ( $p=0.001$ ). A larger proportion of baby boomers were obese ( $p<0.001$ ), female ( $p<0.001$ ), African American or Hispanic ( $p=0.001$ ), had greater depression ( $p<0.001$ ), had income more than 300 % FPL ( $p<0.001$ ), and were food insecure ( $p<0.001$ ).

Table 2 presents bivariate analysis of study variables by food insecurity status. A significantly larger proportion of those who were food insecure were obese ( $p<0.001$ ), baby boomers ( $p<0.001$ ), female ( $p<0.001$ ), African American or Hispanic ( $p<0.001$ ), had income less than 200 % FPL ( $p<0.001$ ), had greater depression ( $p<0.001$ ), and did not meet recommendations for fruit/vegetable intake ( $p<0.001$ ) or physical activity ( $p=0.002$ ).

Table 3 shows bivariate correlations between study variables and BMI categories. A significantly larger proportion of obese participants were baby boomers ( $p<0.001$ ), African American or Hispanic ( $p<0.001$ ), food insecure ( $p<0.001$ ), had greater depression ( $p<0.001$ ), and did not meet recommendations for fruit/vegetable intake ( $p=0.022$ ) or physical activity ( $p<0.001$ ). A significantly larger proportion of female participants were normal weight or obese compared to their male counterparts ( $p<0.001$ ).

Table 4 presents results from the generalized ordered logistic regression models. In model 1 including all study

**Table 2** Characteristics of study participants by food insecurity ( $N=2,985$ )

Variable		Food secure ( $N=2,534$ ) $N$ (%)	Food insecure ( $N=451$ ) $N$ (%)	$p$ -value
BMI	Normal	770 (30.4)	103 (22.8)	<0.001
	Overweight	931 (36.7)	117 (25.9)	
	Obese	833 (32.9)	231 (51.2)	
Age	Baby boomers	1,300 (51.3)	289 (64.1)	<0.001
	Older adults	1,234 (48.7)	162 (35.9)	
Sex	Male	857 (33.8)	93 (20.6)	<0.001
	Female	1,677 (66.2)	358 (79.4)	
Race/ethnicity	Non-Hispanic white	1,737 (88.5)	208 (64.0)	<0.001
	African American	105 (5.4)	55 (16.9)	
	Hispanic	121 (6.2)	62 (19.1)	
Federal poverty level (FPL)	<200 % FPL	415 (22.4)	454 (64.6)	<0.001
	200–300 % FPL	360 (19.4)	111 (15.8)	
	>300 % FPL	1,081 (58.2)	138 (19.6)	
PHQ-9 depression	No depression	1,751 (75.2)	153 (38.8)	<0.001
	Mild depression	394 (16.9)	94 (23.9)	
	≥Moderate depression	184 (7.9)	147 (37.3)	
Met recommendation for fruit or vegetable intake	No	1,602 (66.6)	360 (82.4)	<0.001
	Yes	804 (33.4)	77 (17.6)	
Met recommendation for physical activity	No	1,352 (53.4)	276 (61.2)	0.002
	Yes	1,182 (46.7)	175 (38.8)	

Brazos Valley Health Status Assessment data (2010)

<sup>a</sup> PHQ stands for Patient Health Questionnaire

participants, sex listed in the unique models did not meet the proportional odds assumption, whereas all other independent variables met the assumption. African American or Hispanic participants were 2.28 ( $p<0.001$ ) or 1.61 ( $p=0.007$ ) times more likely to have higher BMI than non-Hispanic white participants, respectively. Those who had depression (i.e., mild or ≥moderate) were 1.77 ( $p<0.001$ ) or 2.21 ( $p<0.001$ ) times more likely to have higher BMI than those who had no depression, respectively. Older adults were 0.76 ( $p=0.003$ ) times likely to have higher BMI than baby boomers. Those who met the recommendations for fruit or vegetable intake were 0.81 ( $p=0.036$ ) times likely to have higher BMI than those who did not meet the recommendation. Those who met the recommendations for physical activity were 0.73 ( $p=0.001$ ) times likely to have higher BMI than those who did not meet the recommendation. Female participants were 0.53 ( $p<0.001$ ) times likely to be overweight or obese than male counterparts. In model 2, including only male participants, those who had moderate or severe depression were 2.42 ( $p=0.005$ ) times more likely to have higher BMI than those who had no depression, whereas older adults were 0.64 ( $p=0.007$ ) times likely to have higher BMI than baby boomers. In model 3, including only female participants, those

who were food insecure were 1.40 ( $p=0.049$ ) times more likely to have higher BMI than those who were food secure. African American or Hispanic participants were 2.66 ( $p<0.001$ ) or 1.97 ( $p=0.002$ ) times more likely to have higher BMI than non-Hispanic white participants, respectively. Those who had income between 200 and 300 % FPL were 1.40 ( $p=0.042$ ) times more likely to have higher BMI than those who had income less than 200 % FPL. Those who had depression (i.e., mild or ≥moderate) were 1.93 ( $p<0.001$ ) and 2.17 ( $p<0.001$ ) times more likely to have higher BMI than those who had no depression, respectively. Those who met the recommendations for physical activity were 0.69 ( $p=0.001$ ) times likely to have higher BMI than those who did not meet the recommendation.

## Discussion

The current study found approximately 36 % of baby boomers or older adults were obese, which is similar to the national study in 2007–2008: 34 % of middle-aged men (40–59 years), 38 % of middle-aged women; 37 % of older adult men (≥60 years), 34 % of older adult women (Flegal et al. 2010).



**Table 3** Characteristics of study participants by BMI ( $N=2,985$ )

Variable		Normal ( $N=873$ ) $N$ (%)	Overweight ( $N=1,048$ ) $N$ (%)	Obesity ( $N=1,064$ ) $N$ (%)	$p$ -value
Age	Baby boomers	420 (48.1)	514 (49.1)	655 (61.6)	<0.001
	Older adults	453 (51.9)	534 (51.0)	409 (38.4)	
Sex	Male	208 (23.8)	396 (37.8)	346 (32.5)	<0.001
	Female	665 (76.2)	652 (62.2)	718 (67.5)	
Race/ethnicity	Non-Hispanic white	590 (90.2)	710 (87.9)	645 (78.1)	<0.001
	African American	30 (4.6)	38 (4.7)	92 (11.1)	
	Hispanic	34 (5.2)	60 (7.4)	89 (10.8)	
Federal poverty level (FPL)	<200 % FPL	258 (35.4)	280 (31.2)	342 (36.1)	0.021
	200 %–300 % FPL	149 (20.4)	155 (17.2)	168 (17.7)	
	>300 % FPL	322 (44.2)	464 (51.6)	437 (46.2)	
Food insecure	No	770 (88.2)	931 (88.8)	833 (78.3)	<0.001
	Yes	103 (11.8)	117 (11.2)	231 (21.7)	
PHQ-9 depression	No depression	601 (76.6)	731 (75.1)	572 (59.3)	<0.001
	Mild depression	107 (13.6)	160 (16.4)	221 (22.9)	
	≥Moderate depression	77 (9.8)	82 (8.4)	172 (17.8)	
Met recommendation for fruit or vegetable intake	No	552 (65.9)	693 (68.8)	717 (71.8)	0.022
	Yes	286 (34.1)	314 (31.2)	281 (28.2)	
Met recommendation for physical activity	No	417 (47.8)	550 (52.5)	661 (62.1)	<0.001
	Yes	456 (52.2)	498 (47.5)	403 (37.9)	

Brazos Valley Health Status Assessment data (2010)

<sup>a</sup> PHQ stands for Patient Health Questionnaire

We found food insecurity affects 15.1 % of study participants (i.e., 18.2 % of baby boomer; 11.6 % of older adults), which is higher than the national average of 14.5 % of U.S. households and 8.0 % of older adults living alone who reported having food insecurity in 2010 (Coleman-Jensen et al. 2011). Given that food insecurity can substantially decrease health and quality of life of older adults (Holben et al. 2007; Stuff et al. 2004), it is certain that we need to address a dual problem of food insecurity and obesity among baby boomers and older adults. This reflects our understanding that a large proportion of Medicaid beneficiaries suffer from both hunger and obesity (Troy et al. 2011).

Food insecurity disproportionately affected baby boomers compared to older adults: 18.2 % of baby boomers; 11.6 % of older adults. A recent policy brief supports that from 2007 to 2009, food insecurity among adults between the ages of 40–49 and 50–59 years rose 63 and 37 % compared to those 60 years and older (26 %), respectively (Ziliak and Gundersen 2011). While considering the middle-aged are most vulnerable to food insecurity, the brief concludes that the middle-aged are likely to “slip through” the age-specific social safety net (e.g., Social Security, typically for those over age 62) and Temporary Assistance for Needy Families designed for families with children (Ziliak and Gundersen 2011). Such

differences in health profiles and patterns may be partially related to different proportions of food insecurity among baby boomers and older adults. Certainly warranted are further studies about how BMI status can moderate or mediate between age and having food insecurity. This information can expand the knowledge base to improve health outcomes and quality of life among baby boomers as more than 10,000 baby boomers are turning 65 years old each day.

As shown in a recent report regarding the coexistence of food insecurity and obesity (Troy et al. 2011), the current study found that 7.7 % of baby boomers and older adults were both food insecure and obese. Contrary to our initial study hypothesis, there was not a positive association between food insecurity and obesity when including all baby boomer and older adult participants. However, this positive association was observed only among female participants, which signals that sex could modify the association between food insecurity and obesity in sociobiological perspectives. This modifying relationship has been reported in previous studies, albeit in younger populations (Troy et al. 2011; Franklin et al. 2012; Larson and Story 2011). Before pregnancy, food insecure women were three times more likely to be severely obese than those who were food secure (Franklin et al. 2012). Obesity in early pregnancy was positively associated with food insecurity

**Table 4** Generalized ordered logistic regression of being obese ( $N=1,741$ )

BMI (1: normal, 2 = overweight, 3 = obese)		Model 1 (all) ( $N=1,741$ )	Model 2 (men) ( $N=561$ )	Model 3 (women) ( $N=1,180$ )
Combined model: 1 vs 2–3, 1–2 vs. 3				
Age	Baby boomers	—	—	—
	Older adults	0.76 (0.63, 0.91)**	0.64 (0.47, 0.89)**	0.81 (0.64, 1.02)
Race/ethnicity	Non-Hispanic white	—	—	—
	African American	2.28 (1.56, 3.32)**	1.51 (0.76, 3.03)	2.66 (1.68, 4.21)**
	Hispanic	1.61 (1.14, 2.27)**	1.16 (0.64, 2.11)	1.97 (1.28, 3.02)**
Federal poverty level (FPL)	<200 % FPL	—	—	—
	200 %–300 % FPL	1.29 (0.99, 1.70)	1.10 (0.65, 1.86)	1.40 (1.01, 1.92)*
	>300 % FPL	1.24 (0.99, 1.55)	1.35 (0.87, 2.08)	1.18 (0.90, 1.54)
Food insecure	No	—	—	—
	Yes	1.28 (0.96, 1.72)	0.96 (0.52, 1.78)	1.40 (1.00, 1.95)*
PHQ-9 depression	No depression	—	—	—
	Mild depression	1.77 (1.40, 2.25)**	1.51 (0.97, 2.35)	1.93 (1.45, 2.56)**
	≥Moderate depression	2.21 (1.63, 2.99)**	2.42 (1.31, 4.45)**	2.17 (1.52, 3.01)**
Met recommendation for fruit or vegetable intake	No	—	—	—
	Yes	0.81 (0.67, 0.99)*	0.86 (0.60, 1.24)	0.81 (0.64, 1.02)
Met recommendation for physical activity	No	—	—	—
	Yes	0.73 (0.61, 0.87)**	0.81 (0.59, 1.11)	0.69 (0.55, 0.86)**
Unique model: 1 vs 2–3				
Sex	Male	—	—	—
	Female	0.53 (0.41, 0.68)**	—	—
Unique model: 1–2 vs. 3				
Sex	Male	—	—	—
	Female	0.92 (0.74, 1.14)	—	—

Brazos Valley Health Status Assessment data (2010)

<sup>a</sup> PHQ stands for Patient Health Questionnaire\* $p<0.05$ , \*\* $p<0.01$ 

at 2 years postpartum (Olson and Strawderman 2008). During pregnancy, food insecure women were more than twice as likely to experience gestational diabetes (Franklin et al. 2012). A similar explanation could hold for baby boomer and older adult females given that there is a strong and positive association between gestational weight gain during pregnancy and long-term postpartum weight gain (Mannan and Mamun 2013). Nevertheless, future study should investigate the positive association between food insecurity and obesity among baby boomer and older adult females.

Our study findings supports prior research suggesting that food insecurity can lead to poor food choices because it encourages individuals to consume cheap, unhealthy foods with limited nutritional value. Consuming such diets can predispose individuals to becoming obese (Morley 2012). Additionally, a prior study found that childbearing women who were obese and living in rural areas were more likely to

become food insecure over time (Olson and Strawderman 2008). Similarly, a modest association between food insecurity and obesity was observed, especially among minority women (Laraia et al. 2010). The current study also showed that female participants tended to be food insecure, and that African American and Hispanic women were respectively 2.66 and 1.97 times more likely to have higher BMI compared to non-Hispanic white women. Nevertheless, future studies are needed to further investigate underlying mechanisms of why women with food insecurity tend to be obese, especially among middle-aged and older women who have been less studied.

The current study also identified the positive association between depression and an increased BMI. In the context of food insecurity and obesity, bivariate analyses of the current study suggest positive correlation among depression, food insecurity, and obesity. Prior studies also highlighted the importance of viewing food insecurity in terms of mental well-

being (Frongillo 2013). Since food insecurity is multidimensional, it is important to capture the psychological effects that food insecurity might have in households (Laraia et al. 2010). One of the prior studies about the positive relationship between food insecurity and obesity among older adults suggests stress and depression may affect the relationship between food insecurity and obesity (Kim and Frongillo 2007). Regarding the consequential relationship among food insecurity, depression, and obesity, the authors argued that food-insecure persons may cope with stress by eating excessively, leading to weight gain (Kim and Frongillo 2007). The current study also found that those who had mild depression or equal to or greater than moderate depression were respectively 1.77 and 2.21 times likely to have higher BMI, which is consistent with previous studies (Luppino et al. 2010; Blazer et al. 2002). As a potential health policy to ease food insecurity and obesity, it is recommended to provide eligible older adults with a food assistance program that can decrease body composition and depression symptomatology (Kim and Frongillo 2007).

Noteworthy are the lower odds of having an increased BMI among those who met recommendations for fruit/vegetable intake and physical activity, supporting the study hypothesis. Given that obesity develops when having more calories eaten than calories burned (Badman and Flier 2005), these findings seem quite straightforward. Referring to recent guidelines on obesity among older adults, lifestyle modification should be considered the first step on an individual level (Mathus-Vliegen et al. 2012). It is also recommended to make healthier diet options affordable and easily accessible as well as facilitating and promoting physical exercise at the societal level (Mathus-Vliegen et al. 2012). There have been concerted efforts to help older adults eat better and move more. Prior studies suggest older adults can lose weight by increasing eating self-efficacy (Rejeski et al. 2011), having congregate meals (Porter and Johnson 2011), receiving obesity screening and counseling (Ogden et al. 2012), and improving community design to increase their walkability (Kerr et al. 2012). Given that the positive association between being food insecure and being obese shown by the current study, community gardening can be one of the valid efforts to increase physical activity and fresh produce intake as well as life satisfaction among older adults (Sommerfeld et al. 2010).

Related to the socio-demographic factors, those who were African American or Hispanic were more likely to have an increased BMI, whereas female participants tended to have a decreased BMI. While racial/ethnic minorities were found to be more obese than their white counterparts (Ogden et al. 2006; Flegal et al. 2010), it is well known that racial/ethnic disparities in obesity have been closely

associated with a lack of financial resources (Kumanyika 1993), easy access to inexpensive and fattening fast food (Block et al. 2004), and different cultural backgrounds (Kumanyika et al. 2002). Our bivariate analysis found African American or Hispanic participants, compared to white participants, tended to have food insecurity, which was associated with obesity. In a recent study, African American participants reported poor adherence to recommendations for most food groups (Kirkpatrick et al. 2012). A national study also found that Hispanic participants were significantly more food insecure compared to white counterparts (Seligman et al. 2010). This research findings may suggest that the obesity issue among minorities can be also addressed in terms of food insecurity (Sharkey et al. 2011; Drewnowski and Specter 2004). Nevertheless, further studies are warranted to clarify the associations between race/ethnicity, food insecurity, and obesity.

Our analysis had several limitations that could have affected our results. First, the current study is based on a cross-sectional dataset, which did not allow for examination of change over time among individual participants. Second, the study findings should be interpreted in the context of the higher obesity prevalence in rural Texas where the current study was conducted. Third, all variables in this study were self-reported, which may lead to recall bias. It is also especially noteworthy that height can be generally overestimated and weight can be underestimated although self-reported height and weight data are valid when identifying relationships in epidemiological studies (Spencer et al. 2002; Brener et al. 2003). Next, in spite of our better-than-typical response rate (i.e., 32 %) in a community survey using a random-digit dialing (RDD) technique (ranging from 15.8 to 26.2 % from literature) (Callegaro et al. 2010), generalizing study findings should be cautious based on the 32 % of response rate and the RDD technique.

To our knowledge, this is the first study to assess the associations of food insecurity with BMI among baby boomers and older adults, controlling other possibly confounding factors. We also showed that food insecurity was inversely related to meeting recommendations for fruit/vegetable intake or physical activity, which decreased the odds of having an increased BMI. Further efforts are needed to investigate pathways explaining food insecurity disparities in BMI among baby boomers and older adults. These results from the current study also suggest the need to address food insecurity issues and enhance adopting recommended lifestyle behavior patterns by age groups to improve body composition especially among baby boomer and older adult females.

**Declaration of conflicting interests** The authors declare that they have no conflicts of interests with respect to their authorship or the publication of this article.



## References

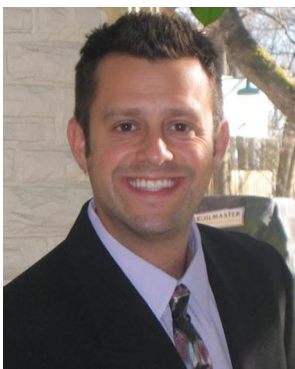
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