



The importance of precision: differences in characteristics associated with levels of food security among college students

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Abstract

Objective: To estimate the prevalence of high, marginal, low and very low food security among a sample of college students and identify characteristics associated with the four different food security status levels and note differences in associations from when food security status is classified as food-secure *v.* food-insecure.

Design: Cross-sectional online survey.

Setting: A large public university in North Carolina.

Participants: 4829 college students who completed an online survey in October and November 2016.

Results: Among study participants, 56.2 % experienced high, 21.6 % experienced marginal, 18.8 % experienced low and 3.4 % experienced very low food security. Characteristics significantly associated with food security status when using the four-level variable but not two-level variable were age, international student status and weight status. Characteristics that significantly differed between the marginal and high food security groups included age, race/ethnicity, year in school, international student status, employment status, financial aid receipt, perceived health rating, cooking frequency and participation in an on-campus meal plan. Characteristics with differences in significant associations between the low and very low food security groups were gender, international student status, having a car, weight status and participation in an on-campus meal plan. Even where similarities in the direction of association were seen, there were often differences in magnitude.

Conclusions: We found differences in characteristics associated with food security status when using the four-level *v.* two-level food security status variable. Future studies should look separately at the four levels, or at least consider separating the marginal and high food-secure groups.

Keywords
Food insecurity
College students
Universities
Cross-sectional studies

Food security refers to having consistent and dependable access to enough food to live an active, healthy life⁽¹⁾. The US Department of Agriculture (USDA) divides food security status into four categories or levels⁽²⁾:

1. High food security: no indications of problems or limitations related to food access
2. Marginal food security: one or two indications of problems or limitations, such as anxiety around accessing food, however little or no changes in food intake or diet
3. Low food security: reports of reduction in quality, variety or desirability of diet, but no reduction in food intake
4. Very low food security: reports of disrupted eating patterns and reduced food intake

In 2016, when this study was conducted, nearly 13 % of the non-institutionalised US civilian population (41.2 million people) lived in households that were food-insecure⁽¹⁾. Over 26.6 million (8.3 % of US non-institutionalised civilian population) lived in households experiencing low food security, and over 14.6 million (4.6 % of US non-institutionalised civilian population) lived in households experiencing very low food security⁽¹⁾.

Food insecurity is related to a variety of negative health outcomes in adults, including poorer dietary intake^(3–5),

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higher rates of mental health problems^(6,7) and higher rates of chronic health conditions such as diabetes^(8,9), hyperlipidaemia⁽⁸⁾ and hypertension⁽⁸⁾. College students are a group that have been overlooked in food insecurity research in the past; however, there has recently been an increase in the amount of research on this topic. The US Government Accountability Office recently released a report on food insecurity among college students that reviewed thirty-one studies containing a range of prevalence rates of food insecurity, yet national estimates are not currently available for this group⁽¹⁰⁾. Studies that looked at food insecurity among college students have found it to be a serious public health problem, with a systematic review finding an average prevalence rate of nearly 42 % (range 12.5–84 %)⁽¹¹⁾. Studies have linked food insecurity to the health and academic performance of college students, with prior studies showing food insecurity to be positively associated with poorer perceived health rating^(12–17), dietary intake^(15,17–20), academic performance^(12–15,21–24) and mental health outcomes^(18,19,21,23,25,26). A variety of characteristics have been associated with food security status among college students, including race/ethnicity^(20,22,26–29), year in school^(13,24), gender^(14,29), financial aid receipt^(14,26,30), income^(12,16,17), employment status^(12,17,23,24), car ownership/access^(14,20), living situation^(16,17,22,23,28,31) and cooking frequency^(14,32).

Most prior studies looking at the characteristics associated with food security status among college students have not examined all four of the USDA classifications and, instead, categorised students as either food-secure or food-insecure, with ‘food-secure’ referring to those experiencing high and marginal food security, and the term ‘food-insecure’ referring to those experiencing low and very low food security^(12–15,17–19,21,23–25,27,28). A few studies have looked at three levels of food security status using food-secure, marginal and food-insecure^(26,33), or food-secure, food-insecure without hunger and food-insecure with hunger^(16,29,30). We are only aware of three published peer-reviewed studies looking at factors associated with food security status that use all four of the USDA classifications^(20,22,32). The analyses from two of these studies are limited in that they use chi square tests or ordered logistic regression to assess associations between food security status and student characteristics, which does not allow for the associations between each different food security level and a characteristic to be presented^(20,22). The other study used a multiple regression analysis that used cooking self-efficacy and food preparation behaviour as dependent variables and did not assess the association of food security status with other student characteristics⁽³²⁾. These few more detailed studies represent a limited number of colleges and universities with fairly small sample sizes, indicating a need for additional research from larger samples at other universities.

Research quality is improved when it is more precise. In examining the characteristics associated with food security

status, we believe it is important to consider using all four food security status categories rather than the standard two larger groups as this may change our understanding of campus-based food insecurity and the policies needed to address it. For example, students experiencing marginal food security may have different characteristics and outcomes than those experiencing high food security. The objective of this study was to estimate the prevalence of each of the four USDA food security status levels among a large sample of students at a major flagship university in south-eastern USA; identify characteristics associated with food security levels using the more precise measurement; and note any differences with categorising students using only two levels (food-secure and food-insecure).

Methods

Study sample

This cross-sectional study collected data from students at a large public university in south-eastern USA in October and November 2016. Four times over a 6-week period, an email invitation and link to an anonymous questionnaire, through Qualtrics online survey software, were sent to all students with a publicly available email address. Email addresses were obtained through the university registrar’s office from their public directory. The survey links were personalised and could only be completed once in order to prevent duplicate responses. As an incentive, a drawing for a \$100 Amazon gift card was offered to students who completed the online questionnaire. Students who had missing values for items used to calculate the dependent variable, or any independent variables included in the models, or reported implausible values for height or weight were excluded from the analyses.

Measures

The questionnaire was originally used in a study of food insecurity among college students at Appalachian State University where it was determined to have content validity and pilot-tested in a small group of students⁽¹⁴⁾. The ten-item US Adult Food Security Survey Module was used to assess food security status over the past 12 months, using the USDA’s scoring system by adding up the number of affirmative responses. A score of zero indicates high food security; 1–2, marginal food security; 3–5, low food security; and 6–10, very low food security⁽³⁴⁾. For the analysis using only food-secure *v.* food-insecure, students experiencing high and marginal food security were considered food-secure and those experiencing low and very low food security were considered food-insecure.

Students self-reported demographic information, including age, gender, race/ethnicity, marital status and whether they had dependent children living with them. They also reported information on their student status, including year

**Table 1** Responses to the ten-item US Adult Food Security Survey Module by food security status for college students from a large university in south-eastern USA in October and November 2016

	Marginal food security (n 1043)		Low food security (n 908)		Very low food security (n 164)	
	n	%*	n	%*	n	%*
In the past 12 months, I worried whether my food would run out before I got money to buy more						
Never	740	71.0	216	23.8	6	3.7
Sometimes	293	28.1	607	66.9	91	55.5
Often	10	1.0	85	9.4	67	40.9
In the past 12 months, the food I bought just didn't last, and I didn't have money to get more						
Never	938	89.9	469	51.7	7	4.3
Sometimes	98	9.4	401	44.2	113	68.9
Often	7	0.7	38	4.2	44	26.8
In the past 12 months, I couldn't afford to eat balanced meals						
Never	420	40.3	143	15.8	4	2.4
Sometimes	574	55.0	582	64.1	68	41.5
Often	49	4.7	183	20.2	92	56.1
In the last 12 months, did you ever cut the size of your meals or skip meals because there wasn't enough money for food?						
No	902	86.5	161	17.7	0	0
Yes	141	13.5	747	82.3	164	100
How often did you need to cut the size of your meals or skip meals because there wasn't enough money for food? Please select the answer choice the BEST applies to you†						
In only 1 or 2 months	131	92.9	334	44.7	6	3.7
Some months, but not every month	9	6.4	304	40.7	87	53.1
Almost every month	1	0.7	109	14.6	71	43.3
In the last 12 months, did you ever eat less than you thought you should because there wasn't enough money for food?						
No	928	89.0	288	31.7	6	3.7
Yes	115	11.0	620	68.3	158	96.3
In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?						
No	987	94.6	473	52.1	4	2.4
Yes	56	5.4	435	47.9	160	97.6
In the last 12 months, did you lose weight because there wasn't enough money for food?						
No	1032	99.0	758	83.5	20	12.2
Yes	11	1.1	150	16.5	144	87.8
In the last 12 months, did you ever not eat for a whole day because there wasn't enough money for food?†						
No	1042	99.9	872	96.0	68	41.5
Yes	1	0.1	36	4.0	96	58.5
In the last 12 months, how often did you not eat for a whole day because there wasn't enough money for food?†						
In only 1 or 2 months	0	0.0	22	61.1	29	30.2
Some months, but not every month	1	100.0	10	27.8	43	44.8
Almost every month	0	0.0	4	11.1	24	25.0

*Percentages may not add up to 100 % due to rounding.

†Only includes respondents who answered affirmatively to the prior question.

in school (freshman, sophomore, junior, senior, graduate student), whether they were an international student, enrolment status (full-time *v.* part-time) and financial aid receipt. Additional information collected included employment status (unemployed, one or more part-time jobs, one full-time job), residency (on-campus *v.* off-campus), having a car, perceived health rating (excellent, good, fair, poor), cooking frequency (never, sometimes, often), perceived cooking skills (poor, fair, good, excellent) and participation in an on-campus meal plan. Self-reported height and weight was used to calculate BMI, with <18.5 considered underweight, 18.5–24.9 considered normal weight, 25–25.9 considered overweight and ≥ 30 considered obese⁽³⁵⁾.

Statistical analysis

Only students with complete data for all variables in the models were included in the analyses. Frequencies were

calculated for each of the food security status categories and for each question within the ten-item US Adult Food Security Survey Module by food security status category. Bivariate associations were assessed using Pearson's chi square tests for categorical variables, and ANOVA for continuous variables. Multiple logistic regression was used to examine the association of food security status classified using the two-level variable (food-secure and food-insecure) with the following characteristics: age, gender, race/ethnicity, marital status, having dependent children, international student status, full-time *v.* part-time student status, off-campus *v.* on-campus housing, employment status, having a car, financial aid receipt, perceived health rating, BMI, cooking frequency, perceived cooking skills and having a campus meal plan. Food-secure was used as the reference group. Multinomial logistic regression was used to examine the association of food security status

**Table 2** Characteristics of the overall sample and by food security status for college students from a large university in south-eastern USA in October and November 2016

	Overall sample (n 4829)		High food security (n 2714)		Marginal food security (n 1043)		Low food security (n 908)		Very low food security (n 164)		P-value†
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	n	%*	n	%*	n	%*	n	%*	n	%*	
Age (years)	23.0	5.5	23.3	5.8	22.5	4.4	22.6	5.4	23.1	5.9	<0.001
Gender											0.001
Female	3475	72.0	1937	71.4	777	74.5	658	72.5	103	62.8	
Male	1317	27.3	759	28.0	261	25.0	241	26.5	56	34.2	
Other	37	0.8	18	0.7	5	0.5	9	1.0	5	3.1	
Race/ethnicity											<0.001
White, non-Hispanic	3357	69.5	1991	73.4	707	67.8	577	63.6	82	50.0	
Asian	652	13.5	366	13.5	127	12.2	124	13.7	35	21.3	
Hispanic	323	6.7	153	5.6	94	9.0	63	6.9	13	7.9	
African American	268	5.6	87	3.2	64	6.1	94	10.4	23	14.0	
American Indian	22	0.5	9	0.3	8	0.8	4	0.4	1	0.6	
Multiracial/other	207	4.3	108	4.0	43	4.1	46	5.1	10	6.1	
Marital status											<0.001
Not married	4257	88.2	2336	86.1	935	89.7	833	91.7	153	93.3	
Married	572	11.9	378	13.9	108	10.4	75	8.3	11	6.7	
Dependent children											0.002
No	4623	95.7	2590	95.4	1016	97.4	867	95.5	150	91.5	
Yes	206	4.3	124	4.6	27	2.6	41	4.5	14	8.5	
Year in school											<0.001
Freshman	809	16.8	529	19.5	145	13.9	119	13.1	16	9.8	
Sophomore	625	12.9	325	12.0	123	11.8	149	16.4	28	17.1	
Junior	721	14.9	336	12.4	178	17.1	164	18.1	43	26.2	
Senior	721	14.9	321	11.8	195	18.7	172	18.9	33	20.1	
Graduate	1927	39.9	1187	43.7	398	38.2	299	32.9	43	26.2	
Other	26	0.5	16	0.6	4	0.4	5	0.6	1	0.6	
International student											0.009
No	4559	94.4	2577	95.0	977	93.7	859	94.6	146	89.0	
Yes	270	5.6	137	5.1	66	6.3	49	5.4	18	11.0	
Enrolment status											<0.001
Full-time	4584	94.9	2545	93.8	1008	96.6	873	96.2	158	96.3	
Part-time	245	5.1	169	6.2	35	3.4	35	3.9	6	3.7	
Residency											0.35
Off-campus	3060	63.4	1720	63.4	680	65.2	562	61.9	98	59.8	
On-campus	1769	36.6	994	36.6	363	34.8	346	38.1	66	40.2	
Employment status											<0.001
Unemployed	1910	39.6	1184	43.6	386	37.0	285	31.4	55	33.5	
≥1 part-time jobs	2355	48.8	1163	42.9	551	52.8	545	60.0	96	58.5	
Full-time job	564	11.7	367	13.5	106	10.2	78	8.6	13	7.9	
Have car											0.02
No	1687	34.9	918	33.8	352	33.8	348	38.3	69	42.1	
Yes	3142	65.1	1796	66.2	691	66.3	560	61.7	95	57.9	
Financial aid											<0.001
No	1722	35.7	1097	40.4	347	33.3	239	26.3	39	23.8	
Yes	3107	64.3	1617	59.6	696	66.7	669	73.7	125	76.2	
Perceived health rating											<0.001
Excellent	1632	33.8	1183	43.6	278	26.7	158	17.4	13	7.9	
Good	2677	55.4	1368	50.4	641	61.5	580	63.9	88	53.7	
Fair	468	9.7	148	5.5	119	11.4	151	16.6	50	30.5	
Poor	52	1.1	15	0.6	5	0.5	19	2.1	13	7.9	
Weight status											0.002
Underweight	167	3.5	87	3.2	35	3.4	38	4.2	7	4.3	
Normal weight	3140	65.0	1841	67.8	646	61.9	550	60.6	103	62.8	
Overweight	1099	22.8	583	21.5	256	24.5	221	24.3	39	23.8	
Obese	423	8.8	203	7.5	106	10.2	99	10.9	15	9.2	
Cooking frequency											<0.001
Never	676	14.0	436	16.1	114	10.9	111	12.2	15	9.2	
Sometimes	1944	40.3	1037	38.2	444	42.6	388	42.7	75	45.7	
Often	2209	45.7	1241	45.7	485	46.5	409	45.0	74	45.1	

**Table 2** *Continued*

	Overall sample (n 4829)		High food security (n 2714)		Marginal food security (n 1043)		Low food security (n 908)		Very low food security (n 164)		P-value†
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	n	%*	n	%*	n	%*	n	%*	n	%*	
Perceived cooking skills											0.25
Poor	333	6.9	176	6.5	66	6.3	74	8.2	17	10.4	
Fair	1240	25.7	700	25.8	278	26.7	227	25.0	35	21.3	
Good	2345	48.6	1308	48.2	522	50.1	437	48.1	78	47.6	
Excellent	911	18.9	530	19.5	177	17.0	170	18.7	34	20.7	
Meal plan											0.004
No	3384	70.1	1845	68.0	766	73.4	654	72.0	119	72.6	
Yes	1445	29.9	869	32.0	277	26.6	254	28.0	45	27.4	

*Percentages may not add up to 100 % due to rounding.

†Statistical significance was assessed using ANOVA for continuous variables, and Pearson's chi square tests for categorical variables.

using the four-level variable (high, marginal, low and very low food security) with the previously mentioned student characteristics. High food security was used as the reference group. All characteristics were included simultaneously in the models. Analyses were conducted using SAS, version 9.4. Statistical significance was considered $P < 0.05$.

Results

The online survey invitation and questionnaire link were sent to 29 895 students – 5502 agreed to participate and 5430 (18.2 %) responded to at least one question beyond the screener. The analytical sample used in this study was 4829 students (595 excluded for missing variables included in the models, and six excluded for implausible values for height or weight), which was 16.2 % of the students invited to participate.

Among students in the sample, 56.2 % experienced high food security, 21.6 % experienced marginal food security, 18.8 % experienced low food security and 3.4 % experienced very low food security. Table 1 shows the responses to each of the items in the ten-item US Adult Food Security Survey Module by food security status category. The results for the high food security status category are not included in the table because, in order to be classified in this category, the response to all questions must be 'never' or 'no'.

Table 2 shows the characteristics of students in the sample by food security status along with the bivariate associations. There were significant associations between food security status and the majority of characteristics examined, including age, gender, race/ethnicity, marital status, dependent children, year in school, international student, enrolment status, employment status, having a car, financial aid receipt, perceived health rating, weight status, cooking frequency and having a meal plan. The only characteristics examined that were not significantly associated with food

security status were residency (on- *v.* off-campus) and perceived cooking skills.

Table 3 shows the results of multiple logistic regression where food security status is classified as food-secure *v.* food-insecure. Characteristics associated with a greater adjusted odds of being food-insecure were being male, African American, having dependent children, having one or more part-time jobs and receiving financial aid. Sophomores and juniors also had greater adjusted odds of being food-insecure compared with freshman. Compared with students who never cooked, students who sometimes or often cooked were also more likely to be food-insecure. A lower perceived health rating was also associated with greater adjusted odds of being food-insecure. Characteristics associated with being less likely to be food-insecure were being married, having a car, having fair compared with poor perceived cooking skills and participating in an on-campus meal plan. Age, international student status, enrolment status, residency and weight status were not significantly associated with food security status when the two-level variable was used as the outcome.

Table 4 shows the results of multinomial logistic regression. Highlights of the findings include the following instances where a difference was found between the categories that would usually be grouped together. In other words, these findings would have been obscured using the more common catch-all categories of simply food-secure and -insecure. Age was negatively associated with experiencing marginal food security. Students were more likely to experience marginal food security if they were African American or Hispanic, juniors or seniors, an international student, had one or more part-time jobs, received financial aid, had a perceived health rating of good or fair, or sometimes or often cooked. Students receiving a meal plan were less likely to experience marginal or low food security, but there were no significant differences for very low food security. Low food security was positively associated with being a senior, and negatively associated with car ownership or having a meal plan,

**Table 3** Adjusted ORs† for the characteristics of college students from a large university in south-eastern USA in October and November 2016 by food security status using the two-level food security variable

	Food-insecure	
	AOR	95 % CI
Age (years)	1.01	0.98, 1.03
Gender		
Female	1.00	Ref.
Male	1.27**	1.08, 1.51
Other	1.64	0.76, 3.57
Race/ethnicity		
White, non-Hispanic	1.00	Ref.
Asian	1.06	0.84, 1.33
Hispanic	1.08	0.81, 1.45
African American	2.59***	1.95, 3.43
American Indian	1.40	0.50, 3.96
Multiracial/Other	1.33	0.95, 1.87
Marital status		
Not married	1.00	Ref.
Married	0.52***	0.38, 0.71
Dependent children		
No	1.00	Ref.
Yes	2.65***	1.68, 4.18
Year in school		
Freshman	1.00	Ref.
Sophomore	1.70***	1.28, 2.26
Junior	1.46*	1.07, 2.01
Senior	1.33	0.94, 1.87
Graduate	0.76	0.51, 1.12
Other	1.59	0.56, 4.53
International student		
No	1.00	Ref.
Yes	1.30	0.93, 1.81
Enrolment status		
Full-time	1.00	Ref.
Part-time	0.73	0.49, 1.11
Residency		
Off-campus	1.00	Ref.
On-campus	1.03	0.81, 1.32
Employment status		
Unemployed	1.00	Ref.
≥1 part-time jobs	1.48***	1.26, 1.75
Full-time job	1.13	0.83, 1.52
Have car		
No	1.00	Ref.
Yes	0.82*	0.68, 0.99
Financial aid		
No	1.00	Ref.
Yes	1.65***	1.40, 1.95
Perceived health rating		
Excellent	1.00	Ref.
Good	2.87***	2.38, 3.47
Fair	6.01***	4.63, 7.81
Poor	13.82***	7.44, 25.66
Weight status		
Underweight	1.33	0.91, 1.96
Normal weight	1.00	Ref.
Overweight	0.96	0.80, 1.15
Obese	0.77	0.59, 1.00
Cooking frequency		
Never	1.00	Ref.
Sometimes	1.45**	1.12, 1.89
Often	1.59**	1.17, 2.16
Perceived cooking skills		
Poor	1.00	Ref.
Fair	0.69*	0.50, 0.94
Good	0.76	0.56, 1.03
Excellent	0.83	0.59, 1.17

Table 3 Continued

	Food-insecure	
	AOR	95 % CI
Meal plan		
No	1.00	Ref.
Yes	0.75*	0.58, 0.97

AOR, adjusted OR.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

†Multiple logistic regression was used with food-secure as the reference group. Variables included in the models are age, gender, race/ethnicity, marital status, dependent children, year in school, international student, enrolment status, residency, employment status, have car, financial aid, perceived health rating, BMI, cooking frequency, perceived cooking skills and meal plan.

but there were no significant associations with these variables and very low food security. Males, international students and students who were obese were more likely to experience very low, but not low food security.

As expected, we also found instances where traditional groupings would have produced results in the same general direction as when using more precise measurement. Students were more likely to experience low or very low food security if they were African American, sophomores or juniors, had dependent children, had one or more part-time jobs, received financial aid, had a lower perceived health rating, or sometimes or never cooked. Students who were married or had fair perceived cooking skills were less likely to experience low or very low food security. Enrolment status and residency were not significantly associated with food security status.

Discussion

A large proportion of students in our sample experienced problems or limitations with accessing food, which is very alarming. Over 22 % of students in our sample had low or very low food security, which is higher than the national prevalence of nearly 13 %. Additionally, nearly 22 % of students experienced marginal food security. The rate of food insecurity that we found in our sample was within the range found in other studies of food insecurity among college students, with all of the US studies that we are aware of showing prevalence rates of food insecurity above the national rate^(12,14,15,18–28,33).

Many of the past studies examining the association of food security status with student characteristics have only used two categories of food security status – food-secure and food-insecure^(12–15,17–19,21,23–25,27,28). Some of the characteristics that were found to be significantly associated with food security status when using the four-level variable were NS when using the two-level variable. These characteristics included age, international student status and weight status. In particular, the importance of having a separate marginally food-secure category is clear. Although





Table 4 Adjusted ORs† for the characteristics of college students from a large university in south-eastern USA in October and November 2016 by food security status using the four-level food security variable

	Marginal food security		Low food security		Very low food security	
	AOR	95 % CI	AOR	95 % CI	AOR	95 % CI
Age (years)	0.95***	0.92, 0.97	0.98	0.96, 1.01	1.02	0.98, 1.07
Gender						
Female	1.00	Ref.	1.00	Ref.	1.00	Ref.
Male	0.97	0.82, 1.16	1.18	0.98, 1.42	1.86**	1.28, 2.70
Other	0.69	0.25, 1.93	1.21	0.49, 3.00	3.19	0.94, 10.77
Race/ethnicity						
White, non-Hispanic	1.00	Ref.	1.00	Ref.	1.00	Ref.
Asian	0.83	0.65, 1.06	0.93	0.72, 1.21	1.41	0.87, 2.31
Hispanic	1.63***	1.23, 2.17	1.27	0.91, 1.76	1.71	0.89, 3.29
African American	1.84***	1.30, 2.62	3.04***	2.18, 4.24	5.38***	3.05, 9.52
American Indian	2.47	0.92, 6.63	1.70	0.50, 5.78	5.10	0.59, 43.73
Multiracial/other	1.09	0.75, 1.58	1.32	0.90, 1.93	1.77	0.85, 3.72
Marital status						
Not married	1.00	Ref.	1.00	Ref.	1.00	Ref.
Married	0.93	0.71, 1.23	0.56***	0.40, 0.78	0.25**	0.11, 0.59
Dependent children						
No	1.00	Ref.	1.00	Ref.	1.00	Ref.
Yes	1.08	0.65, 1.81	2.38***	1.44, 3.93	6.39***	2.50, 16.34
Year in school						
Freshman	1.00	Ref.	1.00	Ref.	1.00	Ref.
Sophomore	1.30	0.96, 1.75	1.77***	1.30, 2.41	2.43*	1.22, 4.81
Junior	1.70**	1.23, 2.36	1.62**	1.14, 2.30	2.61**	1.26, 5.41
Senior	1.86***	1.30, 2.66	1.59*	1.09, 2.33	2.00	0.91, 4.36
Graduate	1.37	0.91, 2.07	0.86	0.55, 1.32	0.63	0.26, 1.55
Other	1.44	0.43, 4.81	1.75	0.55, 5.57	1.97	0.19, 20.34
International student						
No	1.00	Ref.	1.00	Ref.	1.00	Ref.
Yes	1.55*	1.10, 2.19	1.32	0.89, 1.94	2.51**	1.31, 4.80
Enrolment status						
Full-time	1.00	Ref.	1.00	Ref.	1.00	Ref.
Part-time	0.66	0.44, 1.01	0.69	0.44, 1.08	0.50	0.18, 1.34
Residency						
Off-campus	1.00	Ref.	1.00	Ref.	1.00	Ref.
On-campus	1.13	0.87, 1.47	1.08	0.81, 1.42	1.17	0.70, 1.96
Employment status						
Unemployed	1.00	Ref.	1.00	Ref.	1.00	Ref.
≥1 part-time jobs	1.27**	1.08, 1.50	1.63***	1.36, 1.96	1.52*	1.03, 2.22
Full-time job	1.13	0.85, 1.51	1.18	0.85, 1.64	1.21	0.58, 2.52
Have car						
No	1.00	Ref.	1.00	Ref.	1.00	Ref.
Yes	0.94	0.77, 1.15	0.80*	0.64, 0.99	0.80	0.52, 1.22
Financial aid						
No	1.00	Ref.	1.00	Ref.	1.00	Ref.
Yes	1.26**	1.07, 1.48	1.73***	1.45, 2.08	2.16***	1.44, 3.23
Perceived health rating						
Excellent	1.00	Ref.	1.00	Ref.	1.00	Ref.
Good	1.98***	1.67, 2.34	3.22***	2.64, 3.94	6.59***	3.62, 11.99
Fair	3.20***	2.39, 4.28	7.11***	5.26, 9.62	34.08***	17.49, 66.40
Poor	1.53	0.54, 4.30	9.95***	4.76, 20.79	101.67***	36.73, 281.43
Weight status						
Underweight	1.14	0.75, 1.72	1.44	0.94, 2.21	1.09	0.45, 2.59
Normal weight	1.00	Ref.	1.00	Ref.	1.00	Ref.
Overweight	1.18	0.98, 1.42	1.07	0.88, 1.30	0.77	0.50, 1.17
Obese	1.18	0.89, 1.55	0.92	0.68, 1.23	0.39**	0.21, 0.76
Cooking frequency						
Never	1.00	Ref.	1.00	Ref.	1.00	Ref.
Sometimes	1.58***	1.21, 2.06	1.57**	1.19, 2.09	2.62**	1.38, 4.98
Often	1.54**	1.13, 2.11	1.69**	1.21, 2.36	3.14**	1.50, 6.56
Perceived cooking skills						
Poor	1.00	Ref.	1.00	Ref.	1.00	Ref.
Fair	0.88	0.63, 1.24	0.69*	0.49, 0.98	0.47*	0.24, 0.92
Good	0.90	0.64, 1.26	0.75	0.54, 1.06	0.60	0.31, 1.14
Excellent	0.82	0.56, 1.19	0.79	0.54, 1.16	0.67	0.33, 1.39
Meal plan						
No	1.00	Ref.	1.00	Ref.	1.00	Ref.
Yes	0.70**	0.53, 0.92	0.65**	0.49, 0.86	0.73	0.43, 1.26

AOR, adjusted OR.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

†Multinomial logistic regression was used with high food security as the reference group. Variables included in the models are age, gender, race/ethnicity, marital status, dependent children, year in school, international student, enrolment status, residency, employment status, have car, financial aid, perceived health rating, BMI, cooking frequency, perceived cooking skills and meal plan.



high and marginal food security are typically combined to create the food-secure classification, there were many student characteristics, including age, race/ethnicity, year in school, international student status, employment status, financial aid receipt, perceived health rating, cooking frequency and participation in an on-campus meal plan, that significantly differed between the high and marginal food security groups, indicating these are actually two separate groups of students. There were also some differences in associations seen between the low and very low food security status categories. Even where similarities in the direction of association were seen, there were often differences in magnitude. These differences suggest that research findings using only the grouped food-secure or food-insecure categories may be flawed, as well as any programmatic or policy prescriptions flowing from those results. As an example, the results of the analysis using only food-secure *v.* food-insecure makes it seem as though international student status is not associated with food security status. When looking at the results using the four-level variable as the outcome, being an international student is associated with higher odds of experiencing marginal and very low food security. These results suggest that it may be beneficial to target this group of students with programmes or policies; however, the results of using only food-secure and food-insecure do not suggest this, which could cause this group to be overlooked in developing potential interventions or policies. In developing targeted strategies, it is important that they do not contribute to stigmatising particular groups of students, however, as stigma around receiving food assistance can be a barrier to college students seeking aid⁽¹⁰⁾. Targeted strategies can help to complement other programmes and policies that universities can implement to help normalise receiving food assistance and reduce stigma such as food pantries placed in the centre of campus⁽¹⁰⁾.

Differences among students in the different food security status categories are also highlighted by the differences in their responses to the questions in the ten-item US Adult Food Security Survey Module. A higher proportion of students with very low food security indicated that they experienced the items asked about more frequently compared with students with low or marginal food security. The items that students with marginal food security most commonly responded affirmatively to were that they could not afford to eat balanced meals (59.7) and worried that their food would run out before they got money to buy more (29.1 %). The majority of students with marginal food security who responded affirmatively to these items said they sometimes experienced them, whereas the majority of students with very low food security responded that they often experienced them. It is very concerning to see that a large proportion of students with low and very low food security responded affirmatively to questions related to not being able to eat because there was not enough money for food. Over 80 % of students with low food security and all

students with very low food security reported cutting the size of or skipping meals. Nearly 60 % of students experiencing very low food security reported not eating for a whole day because there was not enough money for food, with a quarter of these students saying they experienced this almost every month. Different strategies may be needed for addressing different challenges such as not eating balanced meals *v.* not eating for an entire day.

We recognise that there may be some challenges to reporting the four-level variable and that the ability to do so depends on the choice of instrument used to assess food security status. The ten-item US Adult Food Security Survey Module used in this study and the eighteen-item US Household Food Security Survey Module allow for classification into the four food security status levels⁽³⁴⁾. The ten-item US Adult Food Security Survey Module appears to be the most commonly used survey to assess food security status in studies of college students^(13–15,22,24,25,28,31,33). The US Household Food Security Survey Module: Six-Item Short Form, another commonly used survey to assess food security status that has the ability to classify individuals into four levels, is not as precise or reliable as the ten-item US Adult Food Security Survey Module, and many individuals who would have been classified as having marginal food security on the ten-item version would be classified as having high food security⁽³⁴⁾. This survey has been used in multiple studies of food insecurity in college students as well^(12,18,20,21,23,27). Some studies assess food security status with only one or two questions; however, it appears that few studies of food insecurity among college students have used this approach⁽¹⁹⁾. While shorter surveys reduce respondent burden, precision should be strongly considered when selecting a survey instrument. With the majority of studies assessing food security status in college students using the ten-item US Adult Food Security Survey Module or US Household Food Security Survey Module: Six-Item Short Form, it seems feasible that most future studies would be able to categorise students into the four levels given large-enough sample sizes.

In measuring food security status in college students, it is important to keep in mind that the previously mentioned instruments were not designed specifically for college students, and there has been limited testing of their appropriateness for this population. A study by Nikolaus and colleagues examined the psychometric properties of the ten-item US Adult Food Security Survey Module and US Household Food Security Survey Module: Six-Item Short Form, both alone and in combination with the two-item screener used in the Current Population Survey, in a sample of 462 undergraduate students from a single university in Illinois and found that the psychometric properties of these instruments were not ideal in their sample⁽³⁶⁾. Their results suggest that the ten-item US Adult Food Security Survey Module in combination with the two-item screener was the best measure that is currently available in this population⁽³⁶⁾. Additional research in larger and more diverse



samples that also include graduate students is needed to determine the best methods for assessing food security status among college students. If new instruments are being developed and adapted, the results of our study suggest that these instruments have the ability to classify students into four food security status levels.

Similar to other studies of food insecurity among college students, food insecurity was associated with lower perceived health rating^(12–17). However, marginal food security was also associated with lower perceived health rating, and the adjusted ORs were much larger for very low compared with low food security. As discussed earlier, the types of limitations and frequency of experiencing them differed between marginal, low and very low food security status groups. Our findings suggest that experiencing any type of limitation related to food access is related to lower perceived health rating; however, the number, specific types and frequency of experiencing these limitations may influence the extent to which they are related to lower perceived health rating. Perceived health rating is commonly used as an indicator of actual health and has been shown to be associated with health risk indicators and outcomes^(37,38), suggesting that the lower perceived health rating of students experiencing marginal, low and very low food security are related to poorer actual health. Our finding that students with part-time jobs were more likely to be food-insecure also agrees with the results of other studies^(17,24). While the adjusted odds of receiving financial aid were higher for students experiencing marginal, low or very low food security compared with high food security, they were highest for those experiencing very low food security, followed by low and marginal. These findings suggest that current financial aid packages may not be meeting the needs of students.

In addition – perhaps due to our much larger sample size, differences in student population or categorising food security status into four rather than two levels – some results contradicted prior research. Sophomores, juniors and seniors tended to have higher odds of being in lower food security status categories compared with freshman, but the results showed no differences between the food security status of graduate students and freshman. This result differs from a study by Hagedorn and Olfert that found freshmen more likely to be food-insecure compared with graduate students⁽¹³⁾. In another case of conflicting results, students who sometimes or often cooked were more likely to experience marginal, low or very low food security compared with students who never cooked, with students experiencing very low food security having highest adjusted odds for both sometimes and often cooking. This differs from a study by McArthur and colleagues that found that students were more likely to be food-insecure if they never cooked⁽¹⁴⁾, and a study by Knoll and colleagues that reported that students experiencing very low food security engaged in food preparation behaviours

less often than students experiencing high, marginal or low food security⁽³²⁾. It is possible that the students in our sample who cooked more often were cooking out of necessity because they could not afford a meal plan or eating out.

Students with a meal plan were less likely to experience marginal or low food security. Our results differ from prior studies that did not find a significant association between participating in a meal plan and food security status^(12–14,24,28,33). Meal plans provide students with access to meals on-campus, which may help to reduce the likelihood that they experience food insecurity. While some universities include the cost of meal plans in the on-campus housing cost and require students in on-campus housing to purchase meal plans, the university where this study took place does not require students to purchase meal plans. There is a cost associated with meal plans, so another possible explanation for this association is that students with high food security are more likely to be able to afford and, therefore, purchase meal plans.

We found that students who were married were less likely to experience low or very low food security, but students who had dependent children were more likely to experience low or very low food security. It is possible that married students with an additional income have sufficient money to purchase food, while students with additional members in their household may have less money to spend on food. A study by van den Berg and Raubenheimer found that unmarried students from a university in South Africa were more likely to be food-insecure compared with married students, although this finding was NS in adjusted models⁽²⁹⁾. Other studies examining the association of marital status and/or having dependent children with food security status among college students have not found significant differences^(12–14,28,33). Our ability to detect statistically significant differences may be due to differences in our sample, which consisted of 40 % graduate students who were more likely to be married and/or have dependent children compared with undergraduate students. Our results are similar to what is seen in the general US non-institutionalised population. Compared with the national rate, food insecurity rates are lower among US households with no children and more than one adult and higher among households with children⁽¹⁾.

Limitations

Because this study used a cross-sectional design, causality cannot be concluded. All measures were self-reported, which could have led to response bias. The study was also limited to one large, south-eastern public university, which may limit the generalisability of the results to students from other universities. Past studies of food insecurity among college students also faced these limitations, and our study used a larger sample size from a single university compared to other published studies.



Conclusion

A large proportion of students in our sample experienced marginal, low or very low food security, which indicates a need to identify strategies for improving food security status among college students. We also found differences in the characteristics associated with and magnitudes of associations with four food security status categories. Future studies should use the four established categories, whenever possible, as opposed to collapsing them into 'food-secure' and 'food-insecure'. If categories must be collapsed, studies should at least consider separating out marginal from high food security groups. By definition, marginally food-secure students are experiencing some problems or limitations around accessing food, and it may not be appropriate to consider them to be food-secure. Our results showed that these students were different than those who had high food security. Our study focused on characteristics associated with food security status. Future studies should also look at health and academic outcomes associated with food security status in college students using the four food security status categories.

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