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Food insecurity and rural adolescent personal health, home and academic environments

Amy Shanafelt, MA,
University of Minnesota, Department of Family Medicine and Community Health, Minneapolis, MN 55414, Phone: 612-626-4273

Mary Hearst, MPH, PhD [Associate Professor and Director],
Public Health. St. Catherine University. St Paul, MN 55105

Qi Wang, MS [Research Fellow], and
University of Minnesota, Clinical and Translational Science Institute, Minneapolis, MN 55414

Marilyn (Susie) Nanney, PhD, MPH, RD [Associate Professor]
University of Minnesota, Department of Family Medicine and Community Health, Minneapolis, MN 55414

Amy Shanafelt: shanafel@umn.edu; Mary Hearst: mohearst@stkate.edu; Qi Wang: wangx890@umn.edu; Marilyn (Susie) Nanney: msnanney@umn.edu

Abstract

BACKGROUND—Food insecure (FIS) adolescents struggle in school and with health and mental health more often than food secure (FS) adolescents. Rural communities experience important disparities in health but little is known about rural FIS adolescents. This study aims to describe select characteristics of rural adolescents by food security status.

METHODS—Baseline analysis using data from a randomized trial to increase school breakfast participation (SBP) in rural Minnesota high-schools. Students completed a survey regarding food security, characteristics, and home and school environments. Schools provided academic data and staff measured height and weight. Food security was dichotomized as FS vs. FIS. Bivariate analysis, multivariate linear/logistic regression and testing for interaction of food security and sex were performed.

RESULTS—FIS adolescents reported poorer health, less exercise, had lower grades and higher SBP ($p < .01$). FIS adolescents reported marginally fewer barriers ($p = .06$) and more benefits of breakfast ($p = .05$). All associations except reported benefits remained significant after adjustment. Interactions were identified with girls' GPA and with boys' caloric and added sugar intake.

CONCLUSIONS—Negative associations among food insecurity and positive youth development are identified in our sample. Policy and environmental strategies should address the complexities of these associations, including exploration of the role of school meals.

Correspondence to: Amy Shanafelt, shanafel@umn.edu.

Human Subjects Approval Statement

Recruitment and measurement protocol was reviewed and approved by the Institutional Review Board Human Subjects Committee at the University of Minnesota.

Keywords

adolescent health; food security; school outcomes; rural health; health disparities

The rate of food insecurity among children and adolescents in America persists despite its wealth as a nation. In 2014, 10% (3.9 million) of households with children experienced some form of food insecurity.[1] According to a 2007 United States Department of Agriculture (USDA) report, food insecurity was about twice as prevalent in households with adolescents as in households with children 4 years or younger, suggesting that adolescents may be at greater risk of experiencing food insecurity.[2] Households reporting more severe food insecurity were also more likely to have older children (85%) compared to households reporting moderate or low food insecurity (71%) suggesting a trend toward more severe food insecurity as children age.[2]

The implications of food insecurity span personal health, home and school context. At the personal health level, food insecurity is correlated with many adolescent health indicators. Food insecurity in adolescence is linked to lower energy intake[3], higher cholesterol intake[3], insufficient intake of important vitamins[4] and less fruit and vegetable consumption.[3,5] FIS adolescents report poor or fair health and experiencing chronic and acute health related problems more often than FS adolescents.[3,6] There is some evidence that FIS adolescents are less physically active than their FS counterparts.[7] The relationship between food insecurity and obesity is less clear, however some research suggests that FIS females may be more at risk for obesity.[8]

The home environment (eg, family meals, family functioning) is well-documented as having positive effects on adolescent health and development.[9,10] However, little is known about the implications of food insecurity on the household environment. One cross-sectional study identified associations between severe food insecurity and low family asset scores (safe and supportive home, good communication with parents)[11] among adolescents, suggesting a disruption in family functioning caused by food insecurity.

From a school perspective, food insecurity has been linked with lower cognitive function, lower school test scores, and lower attendance for younger children (age 6–11).[12] Whereas FIS adolescents (age 12–16) may have a harder time getting along with peers and making friends and are more likely to be suspended than FS students.[12]

The relationship between these environments is not easy to untangle. For example, the interaction between unhealthy diets, low activity levels and unstable home food environments may lead to FIS adolescents reporting poor or fair health and experiencing chronic and acute health related problems more often than FS adolescents.[3,6] Adolescents living in FIS homes are more likely to experience problems with psychosocial functioning and mental health[13,14] making school and peer experiences more challenging and reducing overall quality of life. Unhealthy diets may lead to chronic health issues,[6] which may lead to chronic absenteeism from school[12,15] and ultimately lower test scores.[12] Hungry children are often more irritable, leading to poorer psychosocial functioning and a harder time concentrating and getting along with peers.[15] Whereas the effect of food insecurity at each

level (personal/home and school) can contribute negatively to development, the multilevel interaction is the most critical.[16]

Most adolescent food insecurity literature focuses on US national samples,[3,14] international samples[4,17] or inner-city, urban, homeless and low income samples,[5,15,18] neglecting rural communities. Rural communities are unique environments and tend to experience a variety of disparities in health, including higher prevalence of obesity among adolescents.[19] Rural communities experience higher rates of food insecurity and struggle more with access to affordable healthy foods.[20] Additionally, rural communities see disparities in the presence, strength and application of school wellness policies supporting healthy eating strategies among secondary school students.[21]

Our study describes the unique personal health, home and school context of rural, FIS adolescents. Furthermore, the study aims to highlight the importance of the school breakfast program to reducing food insecurity among rural adolescents. Understanding the unique needs of this specific population experiencing food insecurity is important for developing policy and environmental changes to address those needs.

METHODS

This analysis uses baseline data from Project BreakFAST (Fueling Academics and Strengthening Teens). Study methods are described elsewhere (Hearst unpublished, Nanney unpublished) and briefly summarized here. The BreakFAST study is a randomized clinical trial, testing a school breakfast policy and environmental intervention with sixteen high schools in rural Minnesota.

Participants

Students in 9th and 10th grade available on the day of data collection at each high school (N = 5767) were screened for eligibility. Eligibility included students proficient in English, able to access a phone and Internet, were typically in school at the beginning of the day and ate breakfast 3 or fewer days per week (breakfast skipper) (N = 2512). A random sample of the eligible students was then taken from each of the 16 schools, oversampling for students of color. Parents were notified and provided passive consent. A cohort of students (N = 904) was enrolled into the study and data collection took place in 2 waves in spring 2013 and spring 2014.

Instrumentation

Enrolled students had their height and weight measured at school and completed a computer-based survey (at home or at school) and 24-hour dietary intake interviews over the phone. The school provided administrative data (grades, free/reduced priced meal eligibility) for each student in the cohort. Of the enrolled students, 92% completed baseline survey, 98% completed baseline anthropometric measurements and 82% completed at least one dietary recall.

Food security was measured by an online survey using a 9-item Child Food Security Survey Module validated for use with adolescent self-report.[22] Responses were categorized and

weighted based on the standard scoring criteria to determine food security status.[23] Food security was dichotomized as Food Secure (FS) vs. Food Insecure (FIS) (low/very-low insecurity combined).

Personal health variables included perceived health, weight status (overweight/obese vs. normal/underweight), sleep, physical activity, participation in sports teams and diet quality sourced from the objectively measured heights and weights, student survey, and dietary recall data. Self-reported health was measured through the following question, "How would you describe your health in general?" responses were categorized by students who reported "excellent or very good" vs. "good, fair or poor" health. Weight status was assessed through anthropometric height and weight measurements taken by trained staff on site at the schools, using a strict protocol described elsewhere (Hearst unpublished; Nanney unpublished). Students were categorized by body mass index (BMI) percentile based on the US Centers for Disease Control and Prevention (CDC) Growth Charts.[24] Standard BMI percentile (BMI %ile) cut-points were used to classify underweight (BMI%ile<5%), healthy weight (BMI %ile=5–85%), and overweight/obese (BMI%ile >85%). Students reported typical weekday bed and wake times to calculate mean sleep hours. Sleep hours were categorized by "Very Little Sleep >=0 and <5 hours"; "Below recommended sleep (>=5 and <9 hours)" and "at or above recommended sleep (9+)."[25] Physical activity was measured though the following question, "In a normal week, how many hours do you spend doing the following activities? a. Strenuous exercise (heart beats rapidly) b. Moderate exercise (not exhausting) c. Mild exercise (little effort)." Responses, none; less than 1/2 hour a week; 1/2 – 2 hours a week; 2 1/2 – 4 hours a week; 4 1/2 – 6 hours a week and 6+ hours a week, were categorized by students who reported "None or less than ½ hour a week" vs. "More than ½ hour a week." Responses were analyzed for each level of vigor (strenuous, moderate and mild) separately. Participation in school and non-school sponsored sports teams was categorized as "0 teams"; "1 team" and "2 or more teams." Dietary quality was assessed through 24-hour dietary recall telephone interviews conducted with enrolled students for two weekdays and one weekend day per standardized protocols.[26] The dietary recalls used the Nutrition Data Systems for Research (NDSR) nutrient calculation software, a computer based software application developed at the University of Minnesota that allows for direct, standardized diet data entry. The Health Eating Index-2010 (HEI-2010) score (0–100 where high score is better) was derived from the dietary recall data as a measure of dietary quality based on 2010 Dietary Guidelines for Americans per standard protocol.[27]

Home environment variables were self-reported by students using the online survey and included the number of hours the student works per week; how often a parent or guardian encouraged the student to eat breakfast at school (coded Never (0 times) and Ever (>0 Times) and the number of days in the last week in which most members of the student's family ate breakfast and ate dinner as a family (coded "0 times", "1–2 times" and "3–7 times")

School setting variables were attendance, grade point average (GPA), school breakfast participation (SBP) and student report of how often teachers or other school staff encourage the students to eat breakfast at school (coded by Never (0 times) and Ever (>0 Times)). Attendance, GPA and SBP data were derived from school provided data through a secure

data transfer system and linked to student participants by a participant identification (ID) number. Average attendance rates and GPAs were calculated. Student GPA was also categorized by percentile, accounting for different weighting systems at schools.

School breakfast participation was collected as a monthly count of complete reimbursable school breakfast meal purchases. Mean annual breakfast consumption categorized as Never (0% in a month); Sometimes (>0% and <= 25% in a month) and often (>25% in a month). Beliefs and barriers regarding eating school breakfast were assessed using three scales and analyzed by averaging student responses on the Likert scale (1 most negative response to 4 most positive responses). Barriers (α=0.62) included 10 items such as "I am too busy to eat breakfast" and "The bus arrives too late for me to eat breakfast." Beliefs (α=0.85) included 4 items such as "Eating breakfast helps me pay attention in class" and "I have more energy when I eat breakfast." Benefits (α=0.91) included 7 items such as eating school breakfast would "Improve math, reading and standardized test scores" and "Maintain or reach a healthy weight." Items were reverse coded where appropriate and mean scores were analyzed against food security status.

Data Analysis

Students' characteristics were summarized and presented using frequencies and percentages for categorical variables and means and standard deviations for continuous variables. In bivariate analysis, FS students and FIS students were compared using chi-square tests and 2-sample t-tests. In multivariate analysis, logistic regression with generalized estimating equations (GEE) and linear mixed models were conducted to examine the effect of food insecurity on student outcomes. Unadjusted models included random effect of school to account for clustering by school. Adjusted models included random effect of school and fixed effects of sex, race, grade, free/reduced price meal eligibility status, and weight status. Odds ratios and regression coefficients with their 95% CI were reported for continuous and dichotomous outcomes respectively. We further examined the interaction effect of food security and sex by adding the interaction to the adjusted models. All analyses were performed using the Statistical Analysis System (SAS, version 9.3, 2011, SAS Institute, Cary, NC). A 2-tailed p-value < .05 was considered statistically significant

RESULTS

Compared to Food Secure (FS) adolescents, Food Insecure (FIS) adolescents were more likely to be girls (64% vs. 53%, p = .03), students of color (42% vs. 29%, p < .01), and participate in the Free and Reduced Price Meals program (54% vs. 32%, p < .01) (Table 1). Most participants (81%) reported sleeping only 5–8 hours each night, less than the recommended hours of sleep for their age group (9 or more hours),[25] but there was no difference by food security status. Compared to their FS counterparts, FIS adolescents were less likely to report excellent or very good health (p < .01), participate in strenuous exercise more than ½ hour a week (p < .01) and less likely to participate in sports teams (p < .01). FIS adolescents ate significantly fewer calories than FS adolescents (p < .01). No statistically significant differences were seen in intake of added sugars, vegetable or fruit servings, or HEI-2010 score between FS and insecure adolescents. FIS adolescents trended

as less likely to eat dinner as a family (p = .06), although the difference did not meet the a priori level of statistical significance. There were no other significant differences observed by food security status. FIS adolescents were more likely to eat the school breakfast (p < .01) and be encouraged to eat the school breakfast by adults at school (p = .03). FIS students were more likely to have a lower cumulative GPA (p < .01) and fall in a lower GPA percentile (36th) than their FS counterparts (47th) (p < .01). FIS adolescents reported more benefits (p = .05) and slightly fewer barriers to accessing and eating the school breakfast (p = .06). No significant differences were observed in attendance rate.

After adjusting for grade level, sex, Free and Reduced Price Lunch (FRPL) status, race, and weight categories (Table 2), FIS students were significantly less likely to report excellent or very good health (0.42 (0.28, 0.64), p < .01); participate in strenuous physical activity (0.45 (0.32, 0.65), p < .01), participate in sports teams (0.41 (0.27, 0.63), p < .01). FIS students were less likely to eat family meals compared to FS students (0.69 (0.49, 0.98), p = .04). FIS students continued to be significantly more likely to have a lower cumulative GPA (−0.40 (−0.58, −0.22), p < .01) and fall in a lower GPA percentile (−10.1 (−15.5, −4.7), p < .01) and continued to be significantly more likely to eat the school breakfast (3.7 (0.3, 7.0). p = .03), reported barriers became significant (−0.93 (0.40), p = .02) whereas reported benefits was no longer significant (0.67 (0.55), p =.22). FIS adolescents trended toward a lower attendance rate than FS adolescents (−0.91 (−1.59, −0.22), p < .01), but this was no longer statistically significant after adjustment (−0.54 (−1.27, 0.19), p = .15).

Interaction models (Table 3) found significant interaction between food insecurity and sex for unweighted cumulative GPA (p = .02) calories (p = .03) and, added sugar (p = .01). FIS girls had a lower GPA than FS girls (−0.57 (−0.80, −0.34), p < .01), but the difference was not statistically significant for boys (−0.11 (−0.41, 0.18), p = .45). FIS boys ate fewer calories (−351 (−589, −113), p < .01) and added sugars (−17.0 (−31.6, −2.4), p = .02) than FS boys. However, the difference between FIS and secure girls with respect to caloric intake was not significant (−28 (−201, 145), p = .75) and FIS girls ate more added sugars than FS girls, but the difference was not statistically significant (5.8 (−4.8, 16.3), p = .29).

DISCUSSION

This analysis provides a snapshot of the associations between food insecurity and personal health, home and school environment characteristics of rural Minnesota adolescents. These findings may elucidate more important questions than answers, but 5 findings are of particular interest: (1) girls are more likely than boys to experience hunger; (2) hunger has a detrimental effect upon grades overall but especially among girls; (3) hunger among boys impacts caloric intake and added sugars, but in an unexpected direction; (4) FIS students are less likely to participate in strenuous activities or sports teams for both sexes; (5) whereas FIS do participate in the SBP more often, positive associations with health and academics may be convoluted.

It is difficult to tease apart these findings as they relate to the rural location of the participants. In this study, there was no association with BMI and food insecurity, however evidence suggests rural adolescents have higher BMIs and are at greater risk for overweight/

obesity than urban and suburban adolescents.[19] It is possible that that rurality outweighed food insecurity as an effect on BMI. We also did not see an association with overall diet between FIS and FS adolescents in this sample, but the evidence suggests a similar pattern with rural youth and poorer diet related outcomes.[28] Research on the influence of rurality vs. food insecurity and low income could shed some light on these unique findings.

There is evidence that food insecurity impacts adolescent boys and girls differently, which aligns with the findings of this study. It is possible that girls react more emotionally to the stressors of food insecurity leading to higher reporting, as found in this study, and higher levels of emotional distress.[14] For girls, the effect may be more mechanical and seen through dietary patterns, as found in this study, resulting in a physical rather than emotional outcome, as seen in one other study looking at bone density.[29] More research is needed to tease apart these unique effects for adolescents based on their sex.

Our data suggest that boys and girls in this rural sample participate in physical activity (PA) and sports teams equally, but food security status plays a bigger role. Studies do link low levels of PA with food insecurity, similar to the findings in this study.[7] However, the causal relationship is unclear. The FIS adolescents in this sample were more likely to qualify for the free and reduced price lunch program, a proxy for low socio economic status, and low levels of PA and school sports participation have been linked with poverty.[30] Exploration into facilitators and barriers to PA among rural, FIS adolescents could help to tease apart this causal pathway.

Breakfast consumption in particular may be a strategy to reduce the negative impact of food insecurity on cognitive outcomes. Two systematic reviews of studies investigating the impact of breakfast versus no breakfast on cognitive outcomes suggest that eating breakfast, and in particular school breakfast, is more positively associated with higher cognitive function and academic outcomes in undernourished children and adolescents.[31,32] Children and adolescents experiencing food insecurity, thus nutrient deficiency, may be the highest benefactors of regularly eating school breakfast.

The school meals program represents a promising moderator to childhood food insecurity,[33–35] yet, participation in the school breakfast program remains low nationally, with about half of children who qualify for a free breakfast, eating the school breakfast.[36] Breakfast skipping also increases with age[37] suggesting that adolescents may be prime targets for increasing school breakfast participation.

Whereas school breakfast may be an important source of energy intake for FIS adolescents, this cross-sectional evidence suggests that it alone may not influence the health, and academic outcomes in a positive direction. A social-ecological approach to healthy youth development[38] would suggest that programs must address multiple risk factors (low family functioning, poor school connection, unhealthy diet) to successfully circumvent the negative effects of each risk factor. Longitudinal, randomized trials could highlight the role of school breakfast among FIS adolescents by isolating its influence from other confounders.

In this study, FIS adolescents were more likely to participate in the school breakfast program than FS adolescents. However, there is room for improvement given that only 25% of FIS

adolescents in the current study reported eating school breakfast at least one-fourth of the days enrolled in school and 28% reporting never eating the school breakfast, and participation among FS adolescents in our sample was strikingly low with 40% never eating the school breakfast. Generally low SBP, as well as other confounders, also could contribute to remaining negative influence of FIS on adolescents despite the subset who regularly participate in the SBP.

Limitations

This study had some limitations. First, this analysis is baseline data and a cross-sectional analysis. Therefore, we are unable to determine causality but instead are presenting associations. The sample studied here were screened specifically as 'breakfast skippers' (eating breakfast 3 or fewer days in a school week) to meet the aims of the group randomized trial. Despite this initial screening, we still see a distribution of breakfast eaters and breakfast skippers among the sample, which tends to align with food security and SES.

Conclusions

This study describes a unique population of rural adolescent breakfast skippers in rural Minnesota high schools. Describing this population is one step in identifying further investigation needed and thus appropriate interventions to mitigate consequences of hunger on rural youth development. The evidence supporting a school breakfast program as a mechanism for improving adolescent health outcomes is compelling. School breakfast is also an important mechanism to reduce the harmful effects of hunger. This study adds to the evidence base supporting the school breakfast program as a promising approach to address food insecurity among youth. Further large scale investigations into the impact of increased school breakfast participation on reducing food insecurity among rural youth is needed.

IMPLICATIONS FOR SCHOOL HEALTH

This study highlights the school environment as an important arena to intervene on the negative influences of food insecurity in adolescence. Recommendations for schools include:

- A Whole School Whole Child[43] approach, including specific attention to school meals, may be instrumental in alleviating the negative influence of food insecurity on adolescent health and school outcomes.[44]
- Normalizing school meals through communication and promotion to reduce stigma and increase the likelihood that adolescents experiencing food insecurity will take advantage of them.[39,40]
- Consider adding supplemental meal programs such as, afterschool meal programs[41] and summer meals programs[42] to further stabilize food availability and nutrition for food insecure students.

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Table 1

Characteristics of Student Breakfast Skippers Attending 16 Rural Minnesota High Schools by Food Security Status

		Food Security		
	Overall (N = 791)	**Insecure (N = 112)**	**Secure (N = 679)**	**p value**
Demographics				
Socioeconomic status, N (column %)				
free/reduced priced school meal eligibility	275 (35%)	61 (54%)	214 (32%)	<.01
full priced school meal eligibility	515 (65%)	51 (46%)	464 (68%)	
Race, N (column %)				
white	534 (71%)	60 (59%)	474 (73%)	.004
nonwhite	220 (29%)	42 (41%)	178 (27%)	
Grade, N (column %)				
9	386 (49%)	52 (46%)	334 (49%)	.59
10	405 (51%)	60 (54%)	345 (51%)	
Sex, N (column %)				
female	435 (55%)	72 (64%)	363 (53%)	.03
male	356 (45%)	40 (36%)	316 (47%)	
Personal Health				
Weight categories, N (column %)[1]				
Underweight/normal	505 (64%)	64 (59%)	441 (65%)	.19
Overweight/obese	280 (36%)	45 (41%)	235 (35%)	
General health, N (column %)				
Excellent/Very Good	388 (49%)	33 (29%)	355 (52%)	<.01
Good/Fair/Poor	401 (51%)	79 (71%)	322 (48%)	
Sleep hours, N (column %)				
Very Little Sleep (>=0 and <5 hours)	1 (0.1%)	0	1 (0.2%)	.57
Below recommended sleep (>=5 and <9 hours)	624 (82%)	84 (79%)	540 (82%)	
At or above recommended sleep (9+)[2]	139 (18%)	22 (21%)	117 (18%)	
mean sleep hours (SD)	8.1 (0.9)	8.0 (1.0)	8.1 (0.9)	.34
Participate in strenuous exercise, N (column %)				
None or less than ½ hour a week	185 (23%)	43 (38%)	142 (21%)	<.01
½ hour or more a week	606 (77%)	69 (62%)	537 (79%)	
Participate in moderate exercise, N (column %)				
None or less than ½ hour a week	152 (19%)	27 (24%)	125 (19%)	.16

		Food Security		
	Overall (N = 791)	**Insecure (N = 112)**	**Secure (N = 679)**	**p value**
½ hour or more a week	630 (81%)	84 (76%)	546 (81%)	
Participate in mild exercise, N (column %)				
None or less than ½ hour a week	152 (19%)	28 (25%)	124 (18%)	.1
½ hour or more a week	638 (81%)	84 (75%)	554 (82%)	
Participate in sports teams during the past year, N (column %)				
0 team	236 (30%)	53 (48%)	183 (27%)	<.01
1 team	208 (26%)	34 (31%)	174 (26%)	
2 or more teams	343 (44%)	24 (22%)	319 (47%)	
0 or 1 team	444 (56%)	87 (78%)	357 (53%)	<.01
2 or more teams	343 (44%)	24 (22%)	319 (47%)	
HEI 2010 total score, mean (SD)[3]	52.2 (10.6)	52.1 (10.3)	52.2 (10.6)	.92
Calories, mean (SD)[3]	1710 (644)	1531 (542)	1740 (655)	<.01
Added sugars (by Total Sugars), g, mean (SD)[3]	54.5 (37.1)	51.0 (35.8)	55.1 (37.4)	.31
Total fruit servings in cup equivalents, mean (SD)[3]	0.6 (0.7)	0.6 (0.6)	0.6 (0.7)	.62
Total vegetable servings in cup equivalents, with fried potatoes and fried vegetables, mean (SD)[3]	0.8 (0.5)	0.7 (0.5)	0.8 (0.5)	.13
Home Environment				
Eat breakfast as a family, N (column %)				
0 times	413 (52%)	57 (51%)	356 (53%)	.51
1 time or 2 times	211 (27%)	27 (24%)	184 (27%)	
3–7 times	166 (21%)	28 (25%)	138 (20%)	
Eat dinner as a family, N (column %)				
0 times	62 (8%)	13 (12%)	49 (7%)	.06
1 time or 2 times	94 (12%)	18 (16%)	76 (11%)	
3–7 times	634 (80%)	80 (72%)	554 (82%)	
Encouraged to eat breakfast by parent/guardian(s), N (column %)				
Never	378 (48%)	47 (42%)	331 (49%)	.18
Ever	413 (52%)	65 (58%)	348 (51%)	
Average hours of work for pay per week, mean (SD)	3.3 (7.1)	3.7 (6.7)	3.2 (7.2)	.48
School related outcomes				
Attendance rate (%)				

		Food Security		
	Overall (N = 791)	**Insecure (N = 112)**	**Secure (N = 679)**	**p value**
mean (SD)				
attendance rates are all >50%	97.4 (4.0)	96.7 (4.7)	97.5 (3.9)	.09
Encouraged to eat breakfast by teachers or other staff at school				
Never	509 (65%)	62 (56%)	447 (66%)	.03
Ever	276 (35%)	49 (44%)	227 (34%)	
Unweighted cumulative GPA *, mean (SD)[4]	2.8 (0.8)	2.4 (0.8)	2.9 (0.8)	<.01
Cumulative GPA percentile, mean (SD)	45.5 (27.0)	35.4 (23.9)	47.2 (27.1)	<.01
Participation, National School Breakfast Program (SBP), %				
0%	298 (38%)	31 (28%)	267 (40%)	<.01
>0% and <= 25%	375 (47%)	53 (47%)	322 (47%)	
>25%	117 (15%)	28 (25%)	89 (13%)	
mean (SD)	10.5 (18.2)	17.2 (22.5)	9.3 (17.1)	<.01
Breakfast beliefs scale (4–16), mean(SD)	10.4 (2.5)	10.5 (2.7)	10.4 (2.4)	.61
Breakfast barriers scale (9–36), mean(SD)	19.6 (3.7)	19.0 (3.8)	19.7 (3.6)	.06
Breakfast benefits scale (7–28), mean(SD)	19.4 (5.0)	20.3 (5.0)	19.3 (5.0)	.05

Note.

[1] Weight categories were determined by BMI percentiles calculated based on CDC growth chart using age and sex as part of the calculation. Underweight (BMI percentile < 5%); Normal (BMI percentile >= 5% and < 85%); Overweight (BMI percentile >= 85% and < 95%) and Obese (BMI percentile >= 95%)

[2] Pediatrics AA of. School Start Times for Adolescents Abstract.; 2014. doi:10.1542/peds.2014-1697.

[3] Derived from multi-pass 24 hour dietary recall data

[4] Three high schools were excluded, because only weighted GPA data was provided.

Table 2

Associations of Food Security and Student Outcomes

	Unadjusted models[a]		Adjusted models[b]	
Outcome	**estimated effect of food insecurity[**] (95% CI)**	**p value**	**estimated effect of food insecurity (95% CI)**	**p value**
Personal Health				
General health (excellent/very[1] good vs. good/fair/poor)	0.38 (0.26, 0.56)	<.01	0.42 (0.28, 0.64)	<.01
Number of sleep hours[2]	−0.11 (−0.30, 0.07)	.23	−0.09 (−0.29, 0.10)	.36
Participate in strenuous exercise (More than ½ hour a week vs. None or less than ½ hour a week)[1]	0.43 (0.31, 0.59)	<.01	0.45 (0.32, 0.65)	<.01
Participate in sports teams (2 or more teams vs. 0 or 1 team)[1]	0.32 (0.21, 0.49)	<.01	0.41 (0.27, 0.63)	<.01
HEI 2010 total score[2]	−0.03 (−2.31, 2.25)	.98	−0.30 (−2.69, 2.09)	.81
Avg. calories[2]	−209 (−348, −71)	.003	−139 (−279, 0.5)	.051
Avg. added sugars (by Total Sugars), g[2]	−3.9 (−11.9, 4.1)	.34	−2.2 (−10.7, 6.4)	.62
Avg. total fruit servings in cup equivalents[2]	−0.04 (−0.18, 0.11)	.63	−0.06 (−0.21, 0.10)	.46
Avg. total vegetable servings in cup equivalents, with fried potatoes and fried vegetables[2]	−0.09 (−0.21, 0.02)	.12	−0.06 (−0.18, 0.06)	.35
Home Environment				
Encouragement to eat school breakfast by parents (ever vs. never)[1]	1.31 (0.88, 1.93)	.18	1.16 (0.73, 1.83)	.53
Eat dinner as a family (3–7 days vs. 0–2 days)[1]	0.55 (0.39, 0.78)	.0008	0.69 (0.49, 0.98)	.04
School Related Outcomes				
Attendance rate (%)[2]	−0.91 (−1.59, −0.22)	.009	−0.54 (−1.27, 0.19)	.15
Encouragement by adults at school (ever vs. never)[1]	1.55 (0.93, 2.57)	.09	1.42 (0.83, 2.44)	.20
Unweighted cumulative GPA[*2]	−0.41 (−0.59, −0.23)	<.01	−0.40 (−0.58, −0.22)	<.01
Cumulative GPA percentile[2]	−11.9 (−17.2, −6.5)	<.01	−10.1 (−15.5, −4.7)	<.01
SBP participation (%)[2]	7.3 (3.9, 10.6)	<.01	3.7 (0.3, 7.0)	.03
Breakfast Beliefs scale	0.11 (0.25)	.66	0.11 (0.27)	.68
Breakfast barriers scale	−0.76 (0.38)	.04	−0.93 (0.40)	.02

	Unadjusted models[a]		Adjusted models[b]	
Outcome	**estimated effect of food insecurity[**] (95% CI)**	**p value**	**estimated effect of food insecurity (95% CI)**	**p value**
Breakfast benefits scale	0.84 (0.51)	.11	0.67 (0.55)	.22

Note.

A Unadjusted models included random effect of school.

B Adjusted models included random effect of school and fixed effects of sex, race, grade level, frpl status, and weight categories.

* Three high schools were excluded because they were limited to weighted GPA.

** Estimated effect of food insecurity presents regression coefficient for linear regression and odds ratio for logistic regression. Food security is the reference level.

1 Logistical model

2 Linear Model

Table 3

Associations of Food Security and Student Outcomes by Sex

		Boys		Girls	
Outcome	**p value for interaction between food security and sex**	**estimated effect of food insecurity** ** **(95% CI)**	**p value**	**estimated effect of food insecurity (95% CI)**	**p value**
Personal Health					
Number of sleep hours[2]	.96	−0.10 (−0.42, 0.22)	.55	−0.09 (−0.34, 0.16)	.49
General health (excellent/very good vs. good/fair/poor)[1]	.77	0.38 (0.15, 0.98)	.04	0.45 (0.28, 0.73)	<.01
Participate in strenuous exercise (More than ½ hour a week vs. None or less than ½ hour a week)[1]	.65	0.40 (0.21, 0.75)	.004	0.48 (0.30, 0.78)	<.01
HEI 2010 total score[2]	.81	0.10 (−4.00, 4.18)	.96	−0.51 (−3.47, 2.46)	.74
Avg. calories[2]	.03	−351 (−589, −113)	.004	−28 (−201, 145)	.75
Avg. Added sugars (by Total Sugars), g[2]	.01	−17.0 (−31.6, −2.4)	.02	5.8 (−4.8, 16.3)	.29
Avg. total fruit servings in cup equivalents[2]	.71	−0.02 (−0.28, 0.25)	.89	−0.08 (−0.27, 0.11)	.42
Avg. total vegetable servings in cup equivalents, with fried potatoes and fried vegetables[2]	.38	0.02 (−0.19, 0.22)	.87	−0.10 (−0.25, 0.05)	.20
Home Environment					
Encouragement by parents (ever vs. never)[1]	.22	0.86 (0.52, 1.43)	.57	1.39 (0.76, 2.55)	.28
Eat dinner as a family (3–7 days vs. 0–2 days)[1]	.44	0.95 (0.36, 2.50)	.92	0.60 (0.38, 0.94)	.02
School Related Outcomes					
Attendance rate (%)[2]	.54	−0.24 (−1.44, 0.95)	.69	−0.71 (−1.64, 0.21)	.13
Encouragement by adults at school (ever vs. never)[1]	.45	1.20 (0.62, 2.29)	.59	1.57 (0.85, 2.87)	.15
Unweighted cumulative GPA *[2]	.02	−0.11 (−0.41, 0.18)	.45	−0.57 (−0.80, −0.34)	<.01

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		Boys		Girls	
Outcome	**p value for interaction between food security and sex**	**estimated effect of food insecurity** ** **(95% CI)**	**p value**	**estimated effect of food insecurity (95% CI)**	**p value**
Cumulative GPA percentile[2]	.18	−5.4 (−14.2, 3.4)	.23	−13.0 (−19.8, −6.2)	<.01
SBP (%)[2]	.24	6.3 (0.8, 11.8)	.02	2.1 (−2.1, 6.4)	.33

Note.

* Three schools were excluded because they were limited to weighted GPA.

** Estimated effect of food insecurity presents regression coefficient for linear regression and odds ratio for logistic regression. Food security is the reference level.

[1] Logistical model

[2] Linear model