



Household food insecurity and educational outcomes in school-going adolescents in Ghana

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Abstract

Objectives: We examined the association of household food insecurity with educational outcomes and explored the moderating effect of gender and school lunch programme.

Design: The study used a cross-sectional design. Data were collected in 2014 using interviewer-administered questionnaires and school administrative records. We measured household food insecurity using the Household Food Insecurity Access Scale. Educational outcomes referred to knowledge, attitudes and skills that students are expected to obtain while attending school. We obtained sixteen different measures of educational outcomes, ranging from academic grades to beliefs and attitudes towards school and education. Data were analysed using multilevel modelling with covariates at the student and school levels. We conducted moderation tests by adding a two-way interaction between food insecurity and gender, and between food insecurity and school lunch programme.

Setting: The study was conducted in 100 schools located in fifty-four districts within Ghana's eight administrative regions in 2014.

Participants: Participants included 2201 school-going adolescents aged 15–19 years.

Results: More than 60% of adolescents were from food-insecure households. Household food insecurity was negatively associated with Math grade and school attendance. Food insecurity was also inversely associated with socio-emotional outcomes, including academic self-efficacy, commitment to school and academic aspirations and expectations. We did not find a moderating effect of gender and school lunch programme.

Conclusions: Food insecurity is negatively associated with wide-ranging educational outcomes related to both learning and socio-emotional abilities. Our study supports prior evidence suggesting the importance of food access on both cognitive and non-cognitive educational outcomes.

Keywords
Adolescent
Food security
Schools
Students
Educational outcomes
Ghana

Globally, food insecurity, defined as access to inadequate food at all times⁽¹⁾, disproportionately affects young people⁽²⁾. Evidence shows consistent association of food insecurity with adolescent health in countries of all income levels^(3–8). In contrast, research pertaining to the association of food insecurity and educational outcomes has been conducted primarily in high-resource countries, such as the USA^(9–11). In sub-Saharan Africa, evidence that links food insecurity to poor educational outcomes has come from Ethiopia^(12,13). Generalisability of those studies is limited because the study sample came from one administrative zone in one region of the country. In addition, studies in

Ethiopia and other low- and middle-income countries^(14,15) have primarily examined the association of food insecurity with school absenteeism and academic grades⁽¹²⁾. In low- and middle-income countries, research pertaining to the effect of food insecurity on non-cognitive or socio-emotional outcomes remains scant. In contrast, research in the USA and other high-income countries has found a consistent negative association of food insecurity with socio-emotional outcomes, such as school engagement⁽¹⁶⁾, self-control and interpersonal skills^(17,18) and emotional and behavioural difficulties^(19,20). However, generalisability of those findings is limited given the differences in food safety

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net programmes and school investments in low- and high-resource countries, as well as cultural and geographic variations in the definition and understanding of adolescents' socio-emotional outcomes^(21–23).

Despite scarce research on the relationship of food insecurity and educational outcomes in low-resource countries, school meals programmes (SMP) have been widely implemented as a strategy to improve food and nutrition security of school-going children and adolescents^(24,25). One programme rationale has prolonged access to adequate food and nutrition improves educational outcomes^(26–28). However, evidence suggests a heterogeneous effect of SMP on educational outcomes⁽²⁴⁾. In Ghana, the country's SMP led to moderate increases in Math and literacy test scores for the average student, whereas biggest gains in learning and cognitive skills were observed in girls and the poorest students⁽²⁹⁾. These findings are promising given that more persistent exposure to food insecurity among girls and children living in poverty put them at a greater disadvantage than boys and children in affluent households^(30,31). Research also indicates a heterogeneous effect of SMP on educational outcomes in high-resource settings^(32–34). This heterogeneity may suggest that indicators of poverty, such as household food insecurity, may moderate the effect of SMP on educational outcomes. In other words, food-insecure students may benefit more from SMP than their food-secure peers. However, there is limited evidence that suggests a moderating effect of SMP on the relationship between household food insecurity and educational outcomes. This lack of empirical evidence restricts our knowledge of whether SMP are sufficient to improve educational outcomes for poor students, or whether additional food and nutritional support are needed to offset pre-existing disadvantages.

Current study

The current study was conducted to address gaps in the literature and to expand what is known about the effect of food insecurity on educational outcomes in low- and middle-income countries by examining its association with non-cognitive outcomes. Further, the current study aimed to demonstrate whether the relationship of food insecurity with non-cognitive outcomes is similar to its documented relationship with academic grades and school absenteeism. The current study is one of the few studies to examine the link between food insecurity and education in sub-Saharan Africa, particularly outside Ethiopia. Also, two moderation effects were tested: gender and school lunch programmes. Given the higher prevalence of food insecurity in girls and women^(31,35) and evidence suggesting different education outcomes between girls and boys from food-insecure households^(11,18), the study examined whether gender moderated the relationship between food insecurity and educational outcomes. A separate moderation test

evaluated whether the relationship between household food insecurity and educational outcomes differed based on having a free lunch programme at school. These moderation tests build on the results of a recent SMP evaluation in Ghana that found more robust positive effects of the country's SMP on educational outcomes for girls and poor students, compared with boys and non-poor students⁽²⁹⁾.

Methods

Study design and sample

A cross-sectional design was used, and the data that were collected as part of a youth financial inclusion project in Ghana were analysed. The main project used a cluster-randomised trial design with pre- and posttest data collection. Pretest data were collected in 2011 and posttest data were collected in 2014. The current study analysed posttest data because household food insecurity items were collected only at posttest. Study protocol was approved by Institutional Review Boards at the University of Ghana and the University of North Carolina at Chapel Hill. Study recruitment was done by trained research staff who met with prospective participants (and their caregivers, if participant was a minor) to explain the financial inclusion project. For non-English-speaking persons, the information sheet and consent form were translated into local languages. Recruitment was conducted at schools. Informed consent (and assent for those <18 years old at the time of data collection) was obtained from all individual participants included in the study. For participants who were <18 years old at the time of posttest data collection, consent was obtained first from an adult caregiver. After receiving an adult informed consent, assent of the adolescent participant was also obtained.

The posttest or follow-up sample included 4289 adolescents and young adults. The study sample was limited to adolescents between the ages of 15 and 19 years at the time of data collection. In general, young Ghanaians finish their junior secondary school at age 15 and attend senior secondary school from age 16 to 19 years. The current study's age criterion resulted in a sample of 2201 youth. Missing data further reduced the analytical sample size. Results of cluster-adjusted bivariable tests indicated no significant differences on educational outcomes and key explanatory variables (e.g., food insecurity) between the final sample and the excluded observations due to missing data.

Study setting

In 2017, 22% of Ghana's population were adolescents, aged 10–19 years⁽³⁶⁾. The original study was conducted in the country's eight most populous administrative regions, which accounted for more than 90% of the population in 2014⁽³⁷⁾. Fifty-four districts from the eight regions were included in the study. These regions and districts



were selected based on the service coverage area of the financial service provider in the main study. Within the fifty-four districts, 581 schools were eligible for participation in the study. One hundred schools were randomly selected from the list of all eligible schools. At each school, between sixty-one and sixty-three students were randomly selected to participate in the study.

Data collection and sources

Data were collected using two methods: interviewer-administered questionnaires and abstraction of administrative records. First, the survey questionnaires included adolescent- and parent-reported data. The adolescent questionnaire included information on demographic, educational and socio-economic characteristics, including household food insecurity, of adolescents and their families. The parent questionnaire included information on a parent's involvement in their children's education. Second, administrative records comprised student- and school-level data. Student-level data included test scores and academic grades, whereas school-level data comprised school characteristics, such as availability of social and health services. Student-level data were obtained from teachers, whereas school-level characteristics were reported by school administrators.

Variables and measures

Food insecurity

Food insecurity was measured using an adaptation of the Household Food Insecurity Access Scale (HFIAS)⁽³⁸⁾. Previously validated in Burkina Faso⁽³⁹⁾ and Tanzania⁽⁴⁰⁾, HFIAS consists of nine items that ask respondents the frequency of experiencing different conditions and degrees of food insecurity within the past 30 d. We calculated a continuous HFIAS score by summing the score for all nine items. A higher HFIAS score indicates inadequate access to food and greater household food insecurity. For descriptive purposes, we also created a categorical measure of the different degrees (or prevalence) of food insecurity⁽³⁸⁾. This definition ranked access to food using four categories: *secure* and *mildly*, *moderately* and *severely* food insecure.

Educational outcomes

Educational outcomes referred to knowledge, attitudes and skills that students are expected to obtain while attending school. We used sixteen different measures of educational outcomes, ranging from academic grades to attitudes towards school and education. All outcomes were self-reported by students, unless noted otherwise.

Academic achievement measured students' grades in Math and English. Each subject comprised of students' continuous assessment (30 % of final grade) and exam (70 % of final grade) scores. Continuous assessment scores included in-class and take-home assignments throughout the

academic term prior to data collection. Exam scores referred to students' performance on their final exams for the academic term prior to data collection. We summed the continuous assessment and exam scores, separately for each subject, to calculate students' final grades. Higher scores indicated higher academic grades, with possible values ranging from 0 to 100. We analysed the association of food insecurity with Math and English grades, separately. Grades were obtained from the teachers.

Academic self-efficacy constituted beliefs about adolescents' abilities to complete schoolwork successfully and was measured using an eight-item, eleven-point Likert-type scale, ranging from 0 (*cannot do at all*) to 10 (*highly certain can do*)⁽⁴¹⁾. Higher scores indicated greater sense of academic self-efficacy. A previous validation study of the academic self-efficacy scale indicated suitable use of the scale for Ghanaian students⁽⁴²⁾.

Attendance referred to the number of days youth attended school during the academic term prior to data collection. We calculated each student's attendance percentage rate by dividing the number of days a student was present by total number of school days, then multiplying the quotient by 100. We used attendance percentage rate as our outcome variable.

Beliefs about the importance of education in life assessed young people's beliefs about the importance of education for their future and their plans for higher education. This variable comprised three items measured, using an eleven-point Likert-type scale ranging from 0 (*strongly disagree*) to 10 (*strongly agree*)⁽⁴³⁾. Higher scores indicated positive beliefs about education's importance in life.

Commitment to school represented youth's sense of belonging to their school, acceptance of school values and engagement in schoolwork. This variable was measured using a nine-item, eleven-point response scale ranging from 0 (*strongly disagree*) to 10 (*strongly agree*)⁽⁴⁴⁾. Higher scores on the scale indicated greater commitment to school. Prior factor analysis results supported the use of commitment to school scale with Ghanaian adolescents⁽⁴⁵⁾.

Concern about schoolwork referred to the extent to which students feel worried when they have (i) to read and understand something for a class assignment and (ii) to write an essay. This variable was measured using a two-item, five-point Likert-type scale with response options ranging from 1 (*never worried*) to 5 (*worried all the time*). A higher score indicated higher level of concern or worry.

Educational aspirations referred to the level of education a person hopes to achieve. We asked adolescents their academic aspirations. We also asked parents about their aspirations for their children. Both variables were binary, with university education or higher coded as 1 and lower than tertiary education coded as 0.

Educational expectations described the level of education that adolescents and their parents expected them to achieve. Adolescents reported their academic expectations. Parents



also reported their expectations for their children's higher education. Both variables were binary, with university education or higher coded as 1 and lower than tertiary education as 0.

Grade expectations referred to students' forecast of the grades that they will get in their Math and English classes, separately. Higher scores indicated higher grade expectations, with possible values ranging from 0 to 100. Research has shown that grade expectations are positively associated with academic performance⁽⁴⁶⁾.

Parental involvement measured parents' involvement in their children's education. Consistent with the results of a validation study⁽⁴⁷⁾, our measure of parental involvement included two domains: school and home. Parental school involvement described parents' level of participation in school meetings, events and engagement with schoolteachers. Parental home involvement described parents' level of support for their children's education through assisting with homework, ensuring completion of homework and communicating expectations. Both domains consisted of four items measured using a five-point Likert-type scale, with values ranging from 1 (*never*) to 5 (*very often*). Higher scores on each domain indicated a higher level of involvement in a youth's education. We analysed the association of food insecurity with school and home involvement, separately. Both domains of parental involvement were reported by a parent or a caregiver.

Planned effort represented the average number of hours per week youth reported spending on schoolwork after normal school hours.

Covariates

Student (or level 1) covariates included age (in years), gender (female or male), grade level (junior high or senior high), parent-adolescent relationship and asset ownership. Parent-adolescent relationship was measured using two indicators: parental connection and parental monitoring⁽⁴⁸⁾. Parental connection referred to the frequency of interaction that focused on expression of love, affection and care within a 30-d period, whereas parental monitoring described how often parents check adolescents' activities within a 30-d period. Parental connection was measured using four items from the Global School-based Student Health Survey, and parental monitoring was assessed using three items from the same survey⁽⁴⁹⁾. Higher connection scores indicated a warm and affectionate relationship. Higher monitoring scores indicated more frequent parental supervision. Asset ownership included four types of assets: land, transportation, livestock and household possessions. Land ownership was a binary variable, which described whether the respondent's family owned a plot of land (yes or no). Transportation assets included bicycles, motorcycles, canoe or boat and other vehicles (e.g., cars and trucks). Livestock consisted of chickens, pigs, goats, cattle, donkeys and sheep. Household possessions comprised of radio, electric or gas

stove, kerosene stove, electric iron, box iron, refrigerator, television, cellular phone and land phone. For the last three asset variables, we created distinct asset indices⁽⁵⁰⁾. Higher index values indicated greater ownership of assets. School (or level 2) covariate included school lunch programmes (yes or no). This variable referred to whether a school offered free lunch to students.

Analysis

Our analysis examined: (i) the association of food insecurity with adolescents' educational outcomes and (ii) whether the relationship between food insecurity and educational outcomes was moderated by student's gender or availability of a school lunch programme. We used multi-level modelling to analyse our nested data (i.e., adolescents were clustered within schools)⁽⁵¹⁾. Multilevel modelling takes the nesting of students within schools into account by allowing the use of individual and school variables at different levels and permitting the computation of between-school variances⁽⁵¹⁾. We used a two-level model (i.e., students as level 1 and schools as level 2) and a random intercept with covariates. We included predictors into the level 1 model, specified level 1 intercept as random at level 2 (with level 1 predictors having fixed effects at level 2) and included one predictor (school lunch programme) into the level 2 model. We conducted moderation tests by adding a two-way interaction between food insecurity and gender, and between food insecurity and free school lunch programme.

We estimated sixteen multivariable multilevel models that examined the direct relationship of a continuous measure of food insecurity with educational outcomes, one multilevel model for each of sixteen educational outcomes. Depending on the measurement level of our outcome variable, we used multilevel linear (continuous), logistic (binary) and negative binomial (count) regression to analyse our hypothesised relationships. Additionally, we reestimated the sixteen multivariable multilevel models with the two interaction terms (food insecurity × gender and food insecurity × school lunch programme). These moderation tests estimated both the main effects and the moderation effect of gender and school lunch programmes on the relationship between food insecurity and educational outcomes. Significance level was set at $P \leq 0.05$, two-tailed test. All analyses were conducted using Stata 15⁽⁵²⁾.

Results

Sample characteristics

Table 1 lists sample characteristics and the prevalence of food insecurity. Sixty-eight percentage of respondents reported experiencing food insecurity in their households. Nearly half (49%) of adolescents from food-insecure



Table 1 Sample characteristics and prevalence of food insecurity

Independent variable	Overall (n 2201)		Male (n 1057)		Female (n 1144)		Food secure (n 713)		Food insecure (n 1488)	
	% or M	SD	% or M	SD	% or M	SD	% or M	SD	% or M	SD
Food insecurity, continuous*	4.92	5.51	4.84	5.44	5.00					
Food insecurity, categorical										
Food secure	32		33		32					
Mildly food insecure	11		10		11					
Moderately food insecure	24		25		24					
Severely food insecure	33		32		33					
Dependent variables										
Educational outcomes										
Academic achievement: Math grade†	51.35	16.63	51.84	16.84	50.90	16.43	52.00	16.63	51.05	16.63
Academic achievement: English grade‡	52.99	17.00	52.56	17.31	53.39	16.70	53.55	17.02	52.73	16.99
Academic self-efficacy‡	60.32	11.20	60.32	11.35	60.32	11.07	61.27	11.37	59.87	11.10
Attendance‡	89.71	14.18	89.59	13.73	89.82	14.59	90.68	13.52	89.27	14.45
Beliefs about the importance of education in life§	22.96	5.68	23.13	5.53	22.85	5.81	23.81	5.28	22.59	5.82
Commitment to school	77.73	10.50	77.71	10.86	77.74	10.16	78.78	9.95	77.72	10.71
Concern about assignments¶	3.99	2.03	3.97	1.99	4.00	2.07	3.78	1.96	4.09	2.06
Educational aspirations (adolescent)										
University level	76		78		75		78		76	
Educational aspirations (parent)										
University level	80		85		75		83		78	
Educational expectations (adolescent)										
University level	43		45		41		49		40	
Educational expectations (parent)										
University level	48		54		42		54		45%	
Parental involvement (school)**	11.13	3.61	11.25	3.56	11.02	3.65	11.32	3.66	11.05	3.58
Parental involvement (home) **	12.29	4.15	12.17	4.23	12.41	4.06	12.53	4.20	12.19	4.12
Perceived academic grade: Math‡	65.57	17.39	66.93	17.67	64.30	17.04	65.39	18.03	65.65	17.09
Perceived academic grade: English‡	68.35	17.19	67.60	17.43	69.04	16.95	68.46	17.33	68.30	17.13
Planned effort (h)	7.57	5.31	7.55	2.27	7.58	5.36	7.86	5.06	7.43	5.43
Student-level covariates										
Age (years)	17.98	0.99	17.99	1.00	17.97	0.98	17.98	1.00	17.98	0.98
Gender										
Female			48		52		51		52	
Grade level										
Junior high school	29		30		27		31		28	
Senior high school	71		70		73		69		72	
Parental connection††	14.56	3.68	14.18	3.72	14.91	3.60	14.85	3.59	14.42	3.71
Parental monitoring‡‡	9.11	3.48	9.08	3.51	9.14	3.45	9.10	3.55	9.11	3.44
Landownership										
Yes	36		39		33		34		37	
No	64		61		67		66		63	
Transportation asset index	0.40	0.49	0.45	0.50	0.35	0.48	0.40	0.49	0.40	0.49
Livestock ownership index	0.55	0.50	0.57	0.50	0.54	0.49	0.52	0.50	0.57	0.50
Household possessions index	0.99	0.08	0.99	0.08	0.99	0.08	1.00	0.06	0.99	0.09
School-level covariate										
School lunch programme										
Yes	5		5		6		6		5	
No	95		95		94		94		95	

Mean and SD for continuous variables, and percentage distribution (%) for categorical variables.

*Range: 0–27; †Range: 0–100; ‡Range: 0–80; §0–30; ||Range: 7–90; ¶Range: 2–10; **Range: 4–20; †Range: 4–20; ‡Range: 3–150.



households were severely food insecure. Table 1 also displays sample characteristics by gender and food security status. As illustrated in Table 1, 52 % of adolescent girls reported experiencing food insecurity in their households compared with 48 % of adolescent boys. Overall, students reported high levels (i.e., mean scores were above the median of possible scores) of positive attitudes and beliefs about school (e.g., $M_{\text{commitment-to-school}} = 77.73$; range 0–90; $M_{\text{academic self-efficacy}} = 60.32$; range 0–80). The average attendance percentage rate was 90 %, with 22 % of adolescents not missing a day of school during the academic term prior to data collection. On average, students received 51 and 53 points for Math and English, respectively. These values are considered passing grades, albeit at the low end. Five percentage of the 100 schools that participated in the study offered free lunch to their students.

Association of food insecurity and educational outcomes

Table 2 presents the results of the multilevel models. Ten of sixteen outcomes were significantly and negatively associated with household food insecurity. Food insecurity was negatively associated with Math grades. For every unit increase in the HFIAS score, Math grades decreased by 0.14 points (95 % CI –0.24, –0.02). Food insecurity was also negatively associated with school attendance. For every unit increase in the HFIAS score, attendance decreased by a 0.12 percentage point (95 % CI –0.22, –0.02). Food insecurity was also inversely associated with beliefs and attitudes about school and education. Food insecurity was associated with lower academic self-efficacy ($\beta = -0.22$, 95 % CI –0.31, –0.14) and commitment to school ($\beta = -0.30$, 95 % CI –0.38, –0.21). Adolescents from food-insecure households were also less likely to believe that education is important for their future compared with their peers from food-secure households ($\beta = -0.10$, 95 % CI –0.15, –0.06). Food insecurity was associated with greater concern about one's ability to complete schoolwork ($\beta = 0.02$, 95 % CI 0.01, 0.04) and with lower English grade expectations ($\beta = -0.19$, 95 % CI –0.32, –0.05). Moreover, greater food insecurity was associated with a lower likelihood of aspiring (OR 0.98, 95 % CI 0.96, 0.99) and expecting (OR 0.94, 95 % CI 0.92, 0.96) to achieve university or higher level of education among adolescents. Similarly, for every 1-point increase in HFIAS score, parental expectations for their children to achieve university- or higher level education decreased by 3 % (95 % CI 0.95, 0.99). Under conditions of greater food insecurity, parents were also less likely to aspire for a university or higher level of education for their children (OR 0.98, 95 % CI 0.96, 1.00).

Sensitivity analysis

We examined whether the observed associations differed based on the level of food insecurity. We also explored whether the size of association was largest for severe food insecurity compared with mild and moderate food

insecurity. Given our multiple comparisons, results were based on Bonferroni-adjusted P values and 95 % CI. Results indicated that severe food insecurity had the largest effect on educational outcomes as measured by the coefficient size. For example, the association of HFIAS scores with Math grades differed based on severity of food insecurity. Adolescents from severely food-insecure households obtained the lowest Math grades; they scored 1.85 points lower in Math compared with adolescents from food-secure households ($P = 0.05$; 95 % CI –3.70, 0.02). Moreover, severe food insecurity was associated with the lowest academic self-efficacy ($\beta = -3.03$, 95 % CI –4.50, –1.55, $P < 0.001$), commitment to school ($\beta = -3.13$, 95 % CI –4.54, –1.72, $P < 0.001$) and beliefs about the importance of education ($\beta = -1.37$, 95 % CI –2.13, –0.60, $P < 0.001$) scores. Level of concern or worry about schoolwork was also the highest among adolescents living in severely food-insecure households ($\beta = 0.29$, 95 % CI 0.02, 0.56, $P = 0.03$). Compared with adolescents from food-secure households, the likelihood of expecting a university or higher level of education was lowest among adolescents from severely food-insecure households (OR 0.63, 95 % CI 0.46, 0.86, $P < 0.01$).

Moderation tests

Table 3 displays results of moderation or two-way interaction tests. We did not find a statistically significant interaction of gender or school lunch programmes with household food insecurity. The non-significant findings suggest that the relationship of household food insecurity and educational outcomes does not vary based on adolescent's gender and availability of a free lunch programme at school. Given no significant interaction results, we excluded both moderation tests from our final multivariable models, as presented in Table 2.

Association with other student- and school-level variables

School lunch programme was significantly associated with parental school involvement. Parents of adolescents attending schools that provided free lunch meals had higher level of school involvement, compared to parents with children attending schools without free lunch ($\beta = 1.86$, 95 % CI 0.77, 2.94, $P = 0.001$). At the student level, age, grade level, parental connection and parental monitoring were consistently associated with educational outcomes. Ownership of household possessions had the most consistent positive and statistically significant relationship with educational outcomes, compared with the three other types of assets – land, transportation and livestock.

Discussion

In our sample of Ghanaian adolescents, higher levels of food insecurity were associated with lower attendance

Table 2 Multilevel modelling results of the association between food insecurity and educational outcomes in Ghanaian adolescents

Variables	Educational outcomes									
	Academic achievement				Academic self-efficacy		Attendance		Beliefs about education's importance	
	Math		English		β	95% CI	β	95% CI	β	95% CI
	β	95% CI	β	95% CI						
Food insecurity	-0.14	-0.24, -0.02	-0.05	-0.17, 0.06	-0.22	-0.31, -0.14	-0.12	-0.22, -0.02	-0.10	-0.15, -0.06
Student-level covariates										
Age	-0.65	-1.30, -0.01	-1.25	-1.92, -0.58	-0.67	-1.19, -0.15	-0.85	-1.45, -0.25	-0.18	-0.44, 0.09
Gender (reference is male)	-1.05	-2.24, 0.15	0.34	-0.91, 1.59	0.04	-0.93, 1.00	0.38	-0.74, 1.50	-0.23	-0.74, 0.26
Grade level (reference is junior high)	-5.35	-6.82, -3.88	-6.80	-8.33, -5.27	-0.95	-2.09, 0.19	-0.45	-1.80, 0.92	-0.70	-1.30, -0.11
Parental connection	0.22	0.03, 0.41	0.28	0.09, 0.48	0.36	0.20, 0.51	0.07	-0.10, 0.25	0.03	-0.05, 0.11
Parental monitoring	-0.01	-0.21, 0.19	0.13	-0.08, 0.34	0.58	0.42, 0.74	0.22	0.03, 0.41	0.09	0.01, 0.17
Landownership (reference is none)	-0.53	-1.90, 0.84	-0.04	-1.46, 1.39	-0.72	-1.80, 0.36	-0.45	-1.71, 0.81	-0.44	-1.01, 0.12
Transportation asset index	0.84	-0.59, 2.26	0.32	-1.17, 1.80	2.12	1.03, 3.22	0.87	-0.43, 2.17	0.13	-0.45, 0.70
Livestock index	0.10	-0.40, 0.59	-0.08	-0.59, 0.43	0.17	-0.21, 0.56	0.37	-0.09, 0.82	-0.01	-0.21, 0.19
Household possessions index	0.48	-0.72, 1.68	0.59	-0.66, 1.84	0.43	-0.50, 1.37	1.30	0.19, 2.41	0.66	0.17, 1.15
School-level covariate										
Free lunch programme (reference is no)	-1.74	-11.48, 8.01	-1.74	-11.24, 7.77	-2.16	-5.38, 1.06	4.22	-0.92, 9.36	0.01	-1.88, 1.90
<i>n</i>		1736	1734		1863		1655		1863	

Variables	Educational outcomes									
	Commitment to school		Concern about schoolwork		Planned effort		Educational aspiration			
	β	95% CI	β	95% CI	β	95% CI	Adolescent		Parent	
							β	95% CI	β	95% CI
Food insecurity	-0.30	-0.38, -0.21	0.02	0.01, 0.04	1.00	0.99, 1.00	0.98	0.96, 0.99	0.98	0.96, 1.00
Student-level covariates										
Age	-0.59	-1.09, -0.09	0.10	0.00, 0.19	1.03	1.00, 1.06	0.86	0.76, 0.97	0.81	0.71, 0.94
Gender (reference is male)	-0.11	-1.05, 0.81	0.00	-0.18, 0.18	0.98	0.92, 1.04	0.78	0.62, 0.98	0.52	0.40, 0.68
Grade level (reference is junior high)	-0.96	-2.06, 0.13	0.17	-0.05, 0.38	0.83	0.77, 0.89	0.47	0.35, 0.63	0.66	0.47, 0.91
Parental connection	0.34	0.20, 0.49	-0.07	-0.09, -0.04	1.00	0.99, 1.01	1.04	1.00, 1.08	1.03	0.99, 1.07
Parental monitoring	0.34	0.19, 0.50	-0.04	-0.07, -0.01	1.01	1.00, 1.02	1.03	0.99, 1.07	1.05	1.01, 1.10
Landownership (reference is none)	-0.62	-1.66, 0.41	-0.14	-0.33, 0.06	1.03	0.96, 1.10	0.91	0.71, 1.18	0.85	0.63, 1.14
Transportation asset index	0.27	-0.76, 1.31	0.00	-0.19, 0.20	1.04	0.97, 1.12	0.97	0.75, 1.26	1.25	0.92, 1.71
Livestock index	-0.04	-0.41, 0.33	-0.01	-0.08, 0.06	0.99	0.97, 1.02	0.94	0.86, 1.03	0.94	0.84, 1.04
Household possessions index	0.87	-0.02, 1.76	-0.21	-0.38, -0.05	1.01	0.96, 1.07	1.35	1.09, 1.67	1.48	1.15, 1.89
School-level covariate										
Free lunch programme (reference is no)	0.92	-3.66, 1.82	0.11	-0.35, 0.56	1.02	0.84, 1.24	0.89	0.46, 1.73	1.56	0.76, 3.21
<i>n</i>		1863	1862		1863		1854		1532	

Continued



Table 2 Continued

Variables	Educational outcomes											
	Educational expectation				Parental involvement				Grade expectations			
	Adolescent		Parental		School		Home		Math		English	
Food insecurity	OR	95% CI	OR	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Student-level covariates	0.94	0.92, 0.96	0.97	0.95, 0.99	0.00	-0.03, 0.03	-0.02	-0.05, 0.02	-0.11	-0.25, 0.03	-0.19	-0.32, -0.05
Age	0.86	0.77, 0.96	0.92	0.82, 1.03	-0.22	-0.40, -0.04	-0.34	-0.55, -0.12	-0.41	-1.23, 0.42	-1.24	-2.04, -0.45
Gender (reference is male)	0.86	0.70, 1.06	0.60	0.48, 0.75	-0.19	-0.52, 0.15	0.05	-0.35, 0.46	-2.63	-4.17, -1.08	0.73	-0.76, 2.21
Grade level (reference is junior high)	0.56	0.44, 0.71	0.89	0.68, 1.16	-0.65	-1.06, -0.24	-0.39	-0.88, 0.09	-3.96	-5.84, -2.08	-5.52	-7.32, -3.71
Parental connection	1.02	0.99, 1.06	1.00	0.96, 1.03	0.05	0.00, 0.11	0.05	-0.01, 0.12	0.36	0.12, 0.61	0.34	0.11, 0.58
Parental monitoring	1.02	0.98, 1.06	1.00	0.96, 1.04	0.16	0.10, 0.22	0.19	0.13, 0.26	0.57	0.31, 0.83	0.54	0.29, 0.79
Landownership (reference is none)	1.00	0.79, 1.26	0.83	0.65, 1.06	0.28	-0.10, 0.66	-0.05	-0.50, 0.40	0.75	-1.00, 2.50	-0.33	-2.01, 1.35
Transportation asset index	1.08	0.84, 1.37	1.09	0.85, 1.41	0.25	-0.13, 0.64	-0.10	-0.55, 0.35	1.32	-0.47, 3.11	0.80	-0.95, 2.54
Livestock index	0.93	0.86, 1.01	1.04	0.95, 1.14	-0.03	-0.17, 0.10	0.00	-0.16, 0.16	-0.66	-1.28, -0.03	-0.57	-1.18, 0.03
Household possessions index	1.29	1.05, 1.59	1.59	1.28, 1.98	0.19	-0.13, 0.52	0.77	0.38, 1.15	2.27	0.75, 3.78	2.48	1.01, 3.94
School-level covariate												
Free lunch programme (reference is no)	0.52	0.22, 1.19	0.65	0.32, 1.29	1.86	0.77, 2.94	1.00	-0.20, 2.21	-1.27	-6.76, 4.21	-1.35	-7.48, 4.78
<i>n</i>		1828		1484		1561		1557		1765		1764

β , coefficient; OR, odds ratio; IRR, incidence rate ratio. Results were based on two-tailed tests and multilevel models that adjusted for the clustering of adolescents within schools.

rates and lower Math grades, consistent with studies in Ethiopia⁽¹²⁾. We also found that the negative association of food insecurity extended beyond attendance and academic grades. Our findings suggest that higher levels of food insecurity are associated with non-cognitive educational outcomes, including lower academic self-efficacy, commitment to school and grade expectations, as well as unfavourable attitudes about the importance of education and lower odds of aspiring and expecting to obtain a university or higher level of education. Additionally, adolescents from food-insecure households were more likely to be worried about schoolwork, while their parents were less likely to aspire and expect their children to obtain a university- or higher-level education, compared with adolescents and their parents from food-secure households. To date, our findings represent one of the first empirical studies to examine and show negative association of food insecurity with non-cognitive outcomes among school-going adolescents in sub-Saharan Africa.

Several propositions derived from theoretical and empirical literature have been cited to explain the association of food insecurity with educational outcomes^(28,53). For example, the association of food insecurity with low Math grades might be an artefact of the long-term effect of early nutritional deficiencies on learning abilities and academic performance during school years^(27,28). Similarly, frequent school absences resulting from food insecurity may be another pathway that heightens the risk of doing poorly in school. Adolescents may skip school due to the inability to purchase food to eat at school or due to inadequate food access at home to provide sufficient energy to walk long distances to school⁽⁵⁴⁾. It is also plausible that physical manifestations of hunger make it harder to concentrate and remain engaged while in school⁽⁵⁵⁾. Lack of concentration and inability to learn and master class materials may heighten poor academic performance characterised by low test scores and non-participation in class. Additionally, food-insecure households are likely to struggle with competing needs (i.e., to buy food or to pay for their children's school fees). Competing needs may result in missed school days, spending less time on studying or having fewer supplemental learning materials at home.

Additionally, the negative association of food insecurity with cognitive and non-cognitive outcomes may be explained by the documented relationship of food insecurity with mental health and psychosocial functioning^(3,9,56,57). When food is scarce, adolescents may experience higher levels of stress and mental health disorders, such as loss of interest and motivation, anxiety, distraction and frustration, and feelings of hopelessness^(55,58,59). The psychological and emotional consequences reflect many of the educational outcomes (e.g., commitment to school, academic self-efficacy and concern about schoolwork) that we found to be negatively associated with food insecurity. It is plausible that adolescents from food-insecure households experiencing higher levels of mental distress are also less likely to remain committed to school, less

Table 3 Multilevel modelling results of moderation effect of gender and school lunch programme on the relationship between food insecurity and educational outcomes

Variables	Educational outcomes											
	Academic achievement				Academic self-efficacy		Attendance		Beliefs about education's importance			
	Math		English		β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI
	β	95 % CI	β	95 % CI								
Food insecurity	-0.15	-0.31, -0.00	-0.04	-0.20, 0.12	-0.23	-0.35, -0.10	-0.13	-0.28, 0.01	-0.10	-0.17, -0.03		
Student-level covariate												
Gender (reference is male)	-1.22	-2.83, 0.38	0.53	-1.15, 2.20	0.11	-1.17, 1.39	0.22	-1.27, 1.71	-0.12	-0.78, 0.55		
School-level covariate												
Free lunch programme (reference is no)	-2.37	-12.42, 7.68	-2.34	-12.19, 7.50	-3.14	-6.93, 0.64	4.27	-1.33, 9.87	-0.88	-3.03, 1.28		
Two-way interaction												
Female \times food insecurity	0.03	-0.17, 0.24	-0.04	-0.25, 0.18	-0.01	-0.18, 0.15	0.03	-0.16, 0.22	-0.02	-0.11, 0.06		
Free lunch programme \times food insecurity	0.11	-0.31, 0.52	0.10	-0.33, 0.53	0.17	-0.17, 0.51	-0.01	-0.39, 0.37	0.15	-0.02, 0.33		

Variables	Educational outcomes									
	Commitment to school		Concern about schoolwork		Planned effort		Educational aspiration			
	β	95 % CI	β	95 % CI	IRR	95 % CI	Adolescent		Parent	
							OR	95 % CI	OR	95 % CI
Food insecurity	-0.39	-0.51, -0.27	0.02	-0.00, 0.04	0.99	0.99, 1.01	0.98	0.95, 1.01	0.96	0.93, 0.99
Student-level covariate										
Gender (reference is male)	-0.81	-2.05, 0.42	0.01	-0.23, 0.24	0.99	0.91, 1.08	0.79	0.58, 1.08	0.43	0.29, 0.62
School-level covariate										
Free lunch programme (reference is no)	-2.49	-5.82, 0.85	-0.17	-0.75, 0.42	1.00	0.79, 1.26	0.95	0.42, 2.15	2.25	0.80, 6.39
Two-way interaction										
Female \times Food insecurity	0.14	-0.02, -0.30	-0.00	-0.03, 0.03	1.00	0.99, 1.01	1.00	0.96, 1.03	1.03	0.99, 1.08
Free lunch programme \times Food insecurity	0.27	-0.06, 0.60	0.05	-0.01, 0.11	1.00	0.98, 1.02	0.99	0.92, 1.07	0.95	0.87, 1.05

Variables	Educational outcomes											
	Educational expectation				Parental involvement				Grade expectations			
	Adolescent		Parental		School		Home		Math		English	
	OR	95 % CI	OR	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI
Food insecurity	0.93	0.91, 0.96	0.96	0.93, 0.99	-0.00	-0.05, 0.04	-0.01	-0.06, 0.04	-0.14	-0.34, 0.06	-0.20	-0.39, -0.01
Student-level covariate												
Gender (reference is male)	0.80	0.61, 1.06	0.55	0.40, 0.74	-0.18	-0.64, 0.28	0.15	-0.40, 0.69	-2.94	-5.01, -0.86	0.75	-1.23, 2.74
School-level covariate												
Free lunch programme (reference is no)	0.45	0.18, 1.16	0.43	0.19, 1.01	1.61	0.30, 2.93	0.73	-0.76, 2.21	-1.48	-7.84, 4.88	-2.61	-9.48, 4.27
Two-way interaction												
Food insecurity \times gender	1.01	0.98, 1.05	1.02	0.98, 1.06	-0.00	-0.06, 0.06	-0.02	-0.09, 0.05	0.06	-0.21, 0.33	-0.01	-0.26, 0.25
Food insecurity \times free lunch programme	1.03	0.94, 1.11	1.07	0.99, 1.15	0.04	-0.08, 0.16	0.04	-0.10, 0.19	0.03	-0.51, 0.58	0.21	-0.31, 0.73

β , coefficient; OR, odds ratio; IRR, incidence rate ratio. Results were based on two-tailed tests and multilevel models that adjusted for the clustering of adolescents within schools. Models were adjusted for the following student-level variables: age, grade level, parental connection, parental monitoring, landownership, transportation asset, livestock and household possessions.



likely to believe in the value of education in their future and less likely to feel competent in their ability to do well in school, all of which are consistent with evidence in high-resource countries^(9,10,16).

Moreover, the association of food insecurity with parenting and mental health of parents adds another layer of plausibility pertaining to negative effects of food insecurity. Weakened family support systems and limited family assets (e.g., safe and loving home and healthy parent–adolescent relationship) are consequences of food insecurity^(60,61). In turn, weakened family support systems and an unsupportive home environment may affect adolescents' effort, engagement, commitment and positive attitudes about school and education. Another plausible explanation is the indirect effect of food insecurity on academic performance (e.g., Math grades), as mediated by non-cognitive outcomes (e.g., academic self-efficacy, aspirations and expectations, and commitment to school)⁽⁶²⁾.

Research has shown that non-cognitive factors, such as those that reflect socio-emotional skills, are associated with high academic achievement^(63,64). It is plausible that socio-emotional outcomes are a potential mechanism by which household food insecurity can affect changes on academic grades. For example, adolescents may lack academic self-efficacy and may become less committed to school because they do not have enough food at home. As a result, they may feel more compelled to focus on ways to help the household access food and pay less attention to their studies. In turn, low self-efficacy and less commitment to school may adversely affect adolescents' ability to learn and perform well on their assignments and exams. However, the cross-sectional nature of study data restricted our ability to examine this mediational pathway. Nonetheless, our findings pointed to the significance of adequate food access as a predictor of educational outcomes.

We also investigated whether the relationship between food insecurity and educational outcomes was moderated by gender or presence of a school lunch programme. We did not find a significant moderating relationship, which suggests that the effect of household food insecurity on educational outcomes did not differ between boys and girls or between students from schools with and without a free school lunch programme. Further, we examined whether a school lunch programme was directly associated with educational outcomes. The only significant relationship was between school lunch programmes and parental school involvement. Parents of adolescents attending schools with a free school lunch programme were more involved in school activities, compared to parents with children in schools without a free lunch programme. It is possible that parents from schools with free lunch meals participate in preparing, cooking and/or distributing free lunches. Our findings are consistent with the literature that indicates a heterogeneous effect of SMP on educational outcomes^(29,34,65). A review of SMP in low- and middle-income countries found a consistent positive effect on

school enrollment and attendance, but the effect on academic performance was less conclusive⁽²⁴⁾. In Ghana, a randomised trial of the government's school feeding programme showed substantial heterogeneity (i.e., modest increases in test scores for the average student, but substantial learning and cognitive gains for girls and the poorest students)⁽²⁹⁾.

The study's findings have implications. First, 68 % of the adolescent samples were living in food-insecure households. This high proportion of students from food-insecure households denotes a substantial number of Ghanaian students who may be left behind educationally given the adverse effect of food insecurity on cognitive and non-cognitive educational outcomes. Second, adolescents living in a household experiencing food insecurity and with poor educational outcomes may already be economically marginalised given that food insecurity is highly correlated with economic and social indicators of poverty⁽⁶⁶⁾. However, multivariable results imply that food insecurity may be a robust and distinct predictor of negative educational outcomes. Food insecurity remained significantly and negatively associated with ten of sixteen educational outcomes, after controlling for three types of assets. These multivariable results may indicate that food insecurity is not a proxy or substitute for income or other economic poverty indicators. The potential compounded effect of food insecurity and poverty on educational outcomes highlights the urgency of improving adolescents' access to food either through increased household income to purchase food or through a regular SMP to ensure all food-insecure adolescents have access to food.

In Ghana, expansion of the country's SMP to junior and senior high schools may offer one example of leveraging an existing nutrition programme as a platform to address the adverse effect of food insecurity on educational outcomes for high school students, particularly among girls and students living in poverty. A recent evaluation of the country's SMP indicated a promising effect on nutritional and educational outcomes for marginalised students, including girls, the poor and those living in the country's Northern regions⁽²⁹⁾. Third, parallel efforts to promote income generation should be implemented as one way to ensure adequate food access for adolescents, especially when SMP end.

The study has limitations. First, the sample may not be representative of all school-going adolescents in Ghana. Findings should be interpreted considering the current study's inclusion criteria and the main project's sampling design. For example, the study sample did not include adolescents and schools in Ghana's two northernmost regions (Upper East and Upper West), where poverty rates are the highest. Similarly, generalisability of the results is weakened by possible sample selection and social desirability biases. Social desirability bias might have influenced accuracy of self-reported data. Second, cross-sectional data provided weak evidence of causal relationship. Third, the





measures used may not have fully captured dimensions of the independent and dependent variables. Only the access component of food insecurity was measured. Study findings also did not explain food intake or access to food over time. Further, the measure of a school lunch programme was binary and did not include other key aspects of the school's programme, such as frequency and types of foods being served. Future research should address these limitations to increase rigour of current studies.

Conclusions

The wide-ranging association of food insecurity with cognitive and non-cognitive educational outcomes suggests the importance of adequate food access on a student's educational journey. Attitudes, beliefs and skills that are necessary to improve cognition and to enhance socio-emotional skills are inversely associated with food insecurity. The study's findings highlight the need for evidence-informed food and nutrition security interventions that can be easily leveraged or scaled up at the school (e.g., school meals) or community settings (e.g., sustainable agriculture or livelihood programmes). Unfamiliarity about the relationship of food insecurity and educational outcomes may create a cycle, with food insecurity resulting from poverty and low socio-economic standing increasing risk of substandard educational outcomes. In turn, poor educational outcomes heighten vulnerability to long-term food insecurity through limited earnings potential and higher probability of unemployment.

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were approved by the Institutional Review Boards at the University of North Carolina at Chapel Hill and at the University of Ghana, Legon. Written informed consent and assent were obtained from parents and adolescents, respectively.

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