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The school food environment in Ghana is associated with dietary diversity and anemia: Findings from the 2022 National Nutrition and Health Survey of In-school Adolescents

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Abstract

Background: School food environments may play an important role in shaping children's dietary habits, health, and nutrition.

Objectives: This study aimed to evaluate associations between the school food environment and nutrition among in-school adolescents in Ghana.

Methods: Data were collected in Ghana in 2022 in a national nutrition and health survey of adolescents attending junior (JHS) and senior high schools (SHS). Foods observed on campus or reported in dietary recall were aggregated, a composite Adolescent Dietary Diversity Score (ADDS) was derived, and the proportion achieving minimum dietary diversity was estimated. Multi-level regression models were used to assess associations between a ranked school food environment score (FES) and nutrition outcomes.

Results: The number of food groups served or available for purchase was 6.2 in JHS and 8.1 in SHS (p-value <.0001). The mean (95% CI) FES was 10.9 (10.1, 11.7) at JHS and 14.3 (13.6, 14.9) at SHS. ADDS ranged from 4.1 to 4.8 across strata. Higher FES was positively associated with

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Authorship

MJJ and OYA designed research, analyzed data, and wrote paper. MJJ had primary responsibility for final content. All authors gave technical input and read and approved the final manuscript.

Declaration of Conflicting Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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ADDS and minimum dietary diversity among SHS students and negatively associated with anemia in girls and boys. Girls from high FES schools had 24% lower odds of anemia (OR: 0.76, 95% CI: 0.63, 0.93) while boys had 46% lower odds (OR: 0.54, 95% CI: 0.34, 0.84) compared to students in low FES schools.

Conclusions: Higher FES was associated with greater dietary diversity among SHS students and lower odds of anemia in girls and boys, suggesting that the school food environment may play a role in determining nutrition outcomes.

Plain Language Summary

The foods that children eat while at school have an important impact on their health and nutrition. We collected data among in-school girls and boys aged 10–19 years in Ghana. Students were asked what they had eaten in the last 24 hours and were asked questions about their general food practices at school, such as what foods are included in school meals, what foods they typically bring to school, and what foods they buy at school. We also collected blood from students to test for anemia. School leaders were interviewed to better understand school programs and activities related to food and nutrition, including questions about the school meals program and food vendors present on campus. We used the information we gathered from these interviews to create a school food environment score. We found that, on average, students consumed fewer than 5 out of 10 food groups on a given day. We also found that senior high schools tended to have a larger variety of foods available and had a higher food environment score compared to junior high schools. In schools with higher food environment scores, students were more likely to eat a larger variety of foods and less likely to have anemia. These findings may be used to improve existing nutrition programs in Ghana and to design future programs focused on the health of school children.

Keywords

school food environment; adolescent nutrition; dietary diversity; anemia

Introduction

Adolescence is a unique life stage in which accelerated growth and development bring increased nutrient requirements and possible heightened risk of deficiencies[1–4]. In particular, adolescents are affected by iron deficiency[1,5], which frequently results in anemia and can lead to negative consequences including compromised growth, cognitive impairment, suboptimal immune function, and adverse birth outcomes[2,6–9].

In recent years, attention to the food environment as a critical influencer of health and nutrition outcomes has increased, and the body of research on this topic is steadily growing[10–13]. The food environment has been defined as “the consumer interface with the food system that encompasses the availability, affordability, convenience, and desirability of foods,”[10,11] and researchers have used the socio-ecological model to situate various types of food environments—wild, built, and cultivated—under the umbrella of influence from various sectors (e.g., agriculture, labor, media) and broader socio-cultural and political environments[11].

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Various theories and models have been proposed to help explain the multiple factors (e.g., context, ideals, personal beliefs, and resources) affecting the food choice process throughout the life course[14–16]. A 2002 paper offered a theoretical framework, based on social cognitive theory and an ecological perspective, for understanding the various factors —intrapersonal, interpersonal, community, and societal—that influence adolescent eating behavior[17]. Adolescence is a critical period for social development and is characterized by a marked increase in autonomy and agency[4,18]. As they mature, adolescents become more empowered to engage in decision-making and begin to form dietary habits that may persist in adulthood[3,4]. Although family influence remains strong in this life period, adolescents are increasingly influenced by social and cultural norms, which have an impact on their dietary patterns and nutritional status[1,17]. Social pressures from peers, body image, and mass media are key drivers of adolescent dietary choices[4,19]. Young people have strong opinions regarding their food consumption, and they are enabled to act on these opinions through access to funds in the form of pocket money and/or from their engagement in income generating activities[4]. Adolescents living in poverty and food insecurity experience additional food-related stressors that put their health at risk, and across contexts, adolescents frequently encounter food environments that are unconducive to healthy choices[4,14].

Schools are an important entry-point for reaching children with health and nutrition interventions including those focused on promoting healthy and diverse diets[20]. For example, it has been estimated that 370 million children globally receive school meals every day[21]. School meals are an important contributor to children and adolescents' daily intake of foods and nutrients, but the portion of a child's daily nutrient requirements that is satisfied through school meals varies by context[22–25]. In some contexts, children may consume as much as half of their daily energy at school[26]. A 2018 study in Nigeria found that school meals provided over one third of recommended nutrient intakes (RNI) for protein, vitamins A and C, and zinc, but fell short on meeting a third of the RNI for energy, calcium, and iron[24]. A 2019 study in Sweden found that school lunch provided approximately half of daily vegetable intake and two-thirds of daily fish intake, and that daily energy-adjusted nutrient intakes were lower for pupils of less educated parents[23].

The 2022 edition of the School Meal Programs Around the World report, based on survey data collected from 139 countries representing 81% of the world's population, revealed that 125 countries had at least 1 large-scale school meal program[27]. The Ghana School Feeding Program was initiated in 2005 as a social protection measure in support of achieving the Millenium Development Goals and aims to provide low-income school children with 1 free, nutritionally adequate meal per day[28].

The role of the school food environment in shaping adolescent nutrition is increasingly studied[22,26,29–33]; however, much of this research has focused on high-income countries, leaving a critical evidence gap in low- and middle-income countries. A 2020 systematic review found no standardized methods used to measure the school food environment[26]. The authors grouped various methods found across the literature into 4 dimensions as defined by Swinburn et al.[34]: physical, economic, socio-cultural, and policy. These dimensions can be used as a framework to guide a systematic approach to studies of the school food environment.

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The purpose of this study was to explore the extent to which the school food environment in Ghana, including but not limited to school meals, supports girls and boys to consume healthy and diverse diets. We used nationally representative data to characterize multiple dimensions of the school food environment that influence adolescent food access, food choice, and ultimately their health and nutrition status.

Methods

Data source and population

The data used in this study are from the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents, collaboratively designed and implemented by Ghana Health Service, Ghana Education Service, and the UNICEF Ghana country office, with technical assistance from the Centers for Disease Control and Prevention (CDC). This survey represents the most recent round of data collected in conjunction with the Girls Iron Folate Tablet Supplementation (GIFTS) Program, an integrated health and nutrition program that began in 2017 and has been implemented nationwide since 2019[35,36]. Through the GIFTS program, girls receive iron and folic acid tablets and both boys and girls receive targeted messaging related to anemia, dietary diversity, water, sanitation, and hygiene, and malaria prevention. The study population was adolescent girls and boys aged 10–19 years and school-level respondents from JHS and SHS participating in the 2022 survey. The Ethical Review Board of the Ghana Ministry of Health approved the study protocol. Informed consent was obtained from the parent or guardian of each selected student and students provided verbal assent before information was collected. School head teachers or representatives gave informed consent for the school's participation.

Study design and data collection

Data were collected in November 2022 in 4 ethnically and geographically diverse regions —Upper West, North East, Ashanti, and Greater Accra—spanning 3 ecologic zones, resulting in a nationally representative sample of in-school adolescents attending JHS or SHS. A 2-stage sampling strategy was used, in which schools were selected randomly using probability proportional to size in stage 1, and students were randomly selected within schools in stage 2. The survey design was guided in part by the framework for the Nutrition Friendly Schools Initiative jointly led by UNICEF, Ghana Health Service, and Ghana Education Service[37]. A cross-sectional mixed methods approach was used to collect information on adolescent micronutrient and health status, knowledge, attitudes and practices on anemia and iron-folic acid tablets, school health and nutrition education, the school food environment, student dietary intake (i.e., 24-hour and 7-day recall) and food acquisition practices, and the impact of the COVID-19 pandemic on food security and nutrition. Prior to data collection, interviewers and laboratory teams received in-depth training at a centrally located facility in Kumasi, Ashanti region. Trainees participated in a pilot field exercise, resulting in minor revisions to data collection tools and procedures. Separate questionnaires were designed and implemented for girls, boys, and a school-level respondent, and all adolescent participants underwent anthropometric measures (height and weight). Trained phlebotomists collected venous blood from all girls to assess micronutrient status and capillary blood in a subsample of girls to assess malaria and anemia status and

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enable comparison of Hb and anemia by blood source. From boys, only capillary blood was collected to enable the detection of anemia and malaria[38].

Variables

Our analysis draws principally on the survey modules related to school meals, food practices, and dietary intake from the girls' and boys' questionnaires, and modules related to school facilities and school programs (including provision of school meals) from the school questionnaire, in addition to firsthand observations made by data collectors. The HemoCue® Hb-301 System was used to quantify hemoglobin (Hb) and determine anemia status from capillary blood using WHO's Hb concentrations for the diagnosis of anemia: Hb <11.5 g/dL for children 5–11; Hb <12.0 g/dL for children aged 12–14 years and non-pregnant women aged 15 years and above; Hb <13.0 g/dL for men aged 15 years and above[39].

We used principal component analysis to generate a wealth index incorporating survey items related to family assets, sanitation facilities, and home structure, and ranked the wealth index into tertiles to yield a categorical variable for wealth[40]. A binary variable for puberty was created using survey items related to maturation for boys and girls (i.e., voice change and onset of menarche). A centered age variable was created for boys and girls using a quadratic age term to account for linear and curvilinear age effects in our prediction models[41].

Students were asked to recall their consumption of a list of 21 food groups (with example foods given in each group) in the past 24 hours, not only while at school. Their responses were subsequently aggregated into the 10 food groups that are used to calculate the Minimum Dietary Diversity for Women (MDD-W) indicator[42]. Data collectors observed foods served by the school during lunchtime and foods available for purchase on campus and recorded them using the same 21 food groups, which were later aggregated into the 10 MDD-W food groups. A composite metric (Adolescent Dietary Diversity Score or ADDS) was derived for each adolescent with a maximum score of 10 if all food groups were consumed[43]. An adolescent-specific cutoff of ≥6 food groups, established in our previous work[44], was applied to identify the proportion of the population achieving Minimum Dietary Diversity for Adolescents (MDD-A), in addition to the cutoff of ≥5 food groups recommended for calculating MDD-W.

Food environment score

The goal of the Nutrition Friendly Schools Initiative in Ghana is to provide a framework for integrated school-based programming focused on reducing the double burden of undernutrition and diet-related chronic disease. To develop a school food environment score (FES), we used the checklist for monitoring Nutrition Friendly Schools plus additional relevant survey items deemed important for a healthy school food environment[26,37]. Three dimensions of the school food environment were captured in the FES: policy, physical, and sociocultural. In addition to including items with a direct link to nutrition, we included nutrition-sensitive components, such as water, sanitation, and hygiene, which have been shown to be associated with greater dietary diversity[45]. One point was awarded for each item for a maximum possible FES of 23, and schools were ranked into tertiles based on their FES—low, medium, and high. A similar approach to score creation has been used in other

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studies of health and nutrition, for instance, to create a knowledge, attitudes, and practices score for anemia among adolescents[46].

Statistical analysis

Descriptive methods were used to establish basic characteristics of participating schools and adolescents as well as food availability, food acquisition practices, and dietary intake and diversity. All estimates were weighted (unless otherwise noted) to account for complex survey design, with school as the cluster and ecologic zone as the strata. A mini-census of school enrollment was used to calculate post-stratification sample weights (via inverse probability weighting) and account for the variability in school size and enrolment. Chi-square and *t*-tests were used to assess significant differences in proportions and means.

Multi-level ANCOVA models, with students nested within schools as a random effect and potential confounders as fixed effects, were used to estimate adjusted population marginal means and prevalence and explore associations between the ranked FES and study outcomes: dietary diversity, Hb, and anemia[47]. Confounders were selected based on the literature describing their theoretical linkage to the chosen outcomes, and models were stratified based on existing evidence and knowledge about the local context[1–4,48,49]. Models with dietary diversity as the outcome were stratified by school level due to important differences in school meal programs (e.g., most schools that serve meals to students in Ghana are SHS). Because anemia is an indicator that reflects multiple dimensions of health and wellness (i.e., iron deficiency, vitamin B12 deficiency, folate deficiency, chronic and infectious disease, and menstrual loss), it was deemed an appropriate outcome for this analysis. Due to marked differences in Hb and anemia status between adolescent boys and girls, driven by important changes in physiology and iron requirements during growth and development, sex-specific regression models were used for biological outcomes[50]. Statistical significance was set at a 2-sided alpha level of 0.05, and analyses were conducted using SAS software version 9.4 (SAS Institute Inc, Cary, North Carolina).

Results

Across the 4 regions, 239 of the selected 242 schools were reached (response rate: 99%), 117 of which were JHS, and 122 of which were SHS (table not shown). Two schools were not reached because one was closed at the time of data collection and the other was a school for the deaf where a translator was not available. In the third school, student questionnaires were conducted but there was not sufficient time to conduct the school-level questionnaire. Among the 117 JHS, 116 (>99%) were day schools and 1 (>1%) was a boarding school. Among the 122 SHS, 29 (24%) were day schools, 17 (14%) were boarding schools, and 76 (62%) had both boarding and day options. All schools were public schools. Most (63%) were located in an urban setting while 29% were in rural and 8% in peri-urban settings. From these schools, 4833 girls and 1498 boys participated in the survey, resulting in an analytical sample of 6331 adolescents aged 10–19 years (response rate: ˜90%) (Table 1).

The mean age among girls was 16.4 (95% CI: 16.3, 16.4), and 92% had reached menarche (Table 1). Among boys, the mean age was 16.5 (95% CI: 16.5, 16.6), and 69% had experienced voice change. Anemia prevalence was significantly higher among girls

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compared to boys (22% vs 11%, *p*-value <.0001) (Supplemental Table 1). Compared to boys, a significantly larger proportion of girls had heard of anemia (*p*-value <.01) and iron-folic acid tablets (*p*-value <.0001) and taken supplements containing iron and/or folic acid in the past 7 days (*p*-value <.0001).

Among SHS, 66% routinely provided free meals to all students, and 27% provided free meals to some students, while in JHS, 90% did not provide meals to any students. The presence of vendors (defined as anyone selling food on campus) was high at both JHS (88%) and SHS (99%) (table not shown). Sixty-four percent of students reported eating meals provided by the school while 54% and 85% reported bringing food to school and buying food at school, respectively (Supplemental Table 2). Most students reported eating meals sold or prepared at school 3–5 days each week (34%) or ≥6 days each week (57%, driven by boarding schools). Seventy-nine percent and 87% reported eating breakfast and lunch, respectively.

Among the 21 food groups observed by data collectors at SHS, the most prevalent were beans, peas, and lentils (92%), porridges, bread, rice, pasta, and other local starchy foods (91%), and other vegetables including tomatoes, okra, and peppers (90%) (Supplemental Figure 1). Conversely, at JHS, the most prevalent food groups observed on school grounds were eggs (76%), other vegetables including tomatoes, okra, and peppers (76%), and locally produced juices (72%). The proportion of SHS where the MDD-W food groups were observed was significantly higher for 7 out of the 10 food groups compared to JHS (Table 2). On average, 6.2 food groups were available at JHS and 8.1 at SHS, a difference that was significant (*p*-value <.0001). The mean FES was 10.9 (95% CI: 10.1, 11.7) and 14.3 (95% CI: 13.6, 14.9) for JHS and SHS, respectively (Table 3).

Nearly all adolescents reported that the food group made up of grains, cereals, white roots, and tubers was typically included in school meals (99%), brought to school (92%), and purchased at school (95%) (Figure 1). Other items typically included in school meals were pulses (91%), fish and seafood (57%), and other vegetables (52%) while items commonly brought from home were milk and milk products (62%), sweets and desserts (48%), and sweetened drinks (43%). When students were asked what food items they typically buy on campus, the most reported items after starchy foods (95%) were pulses (66%), meat and poultry (57%), eggs (53%), fish and seafood (48%), and other vegetables (47%).

Per 24-hour dietary recall of 21 food groups, the food group with the highest prevalence of consumption was porridge, bread, rice, pasta, and other local starchy foods (93% girls; 91% boys), followed by other vegetables including tomatoes, okra, and peppers (68% both sexes), plantains, white potatoes, yams, cassava, and other white tubers (53% girls; 56% boys), and fish and seafood (46% both sexes) (Supplemental Figure 2). The food groups with the lowest prevalence of consumption among girls and boys were mango and papaya (4% both sexes), organ meats (6% girls; 8% boys), and cheese and yogurt (9% girls; 7% boys).

We found significant differences in the consumption of 3 of the 10 MDD-W food groups by sex (Figure 2). A significantly greater proportion of boys consumed pulses compared to girls (45% vs 35%, *p*-value <.01), while girls were more likely to consume other vitamin

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A-rich fruits and vegetables (14% vs 11%, *p*-value = 0.03) and other fruits (23% vs 17%, *p*-value <.01) compared to boys. ADDS differed by school level (JHS: 4.8; SHS: 4.2) and wealth status (high: 4.4; medium: 4.2; low: 4.1) but not by sex (girls: 4.3; boys: 4.2) (Figure 3). The proportions of adolescents with minimally diverse diets based on the MDD-W (≥5 food groups) and MDD-A (≥6 food groups) also differed significantly by school level and wealth status. Among JHS students, 53% achieved MDD-W and 32% achieved MDD-A while among SHS students, 43% and 24% did so, respectively. The proportion of students achieving both MDD-W and MDD-A was positively associated with wealth status.

Being from a school with a higher FES was a significant predictor of higher ADDS and consuming ≥5 food groups among SHS students but not JHS students (Table 4). Among both girls and boys, FES was inversely associated with anemia. For girls, adjusted anemia prevalence was 27% in low FES schools and 22% in high FES schools (*p*-value <.01), with 24% lower odds of anemia for those from high FES schools (odds ratio [OR]: 0.76, CI: 0.63, 0.93) compared to low FES schools (Table 5). Among boys, adjusted anemia prevalence was 19% in low FES schools and 13% in high FES schools (*p*-value <.01), with 46% lower odds of anemia for those from high FES schools (OR: 0.54, CI: 0.34, 0.84) compared to low FES schools.

Maturation status as assessed by puberty was a significant predictor of higher ADDS, consuming ≥5 food groups, and consuming ≥6 food groups among SHS students but not JHS students (Table 4). Among girls and boys, puberty was a significant predictor of higher Hb, with pre-pubertal students having lower Hb by 0.1 g/dL and 0.3 g/dL for girls and boys, respectively (table not shown). Having reached puberty was associated with 43% lower odds of anemia (OR: 0.57, CI: 0.41, 0.78) in boys and 19% lower odds in girls (OR:0.81, CI:0.61, 1.08), but was significant only among boys (Table 5).

Wealth status was a significant predictor of higher ADDS, consuming ≥5 food groups, and consuming ≥6 food groups among both JHS and SHS students (Table 4). Among JHS students, the positive association between wealth and consumption of ≥5 food groups was particularly notable, with 62% of higher wealth students achieving this cutoff while only 46% of lower wealth students did so.

Discussion

Previous work has outlined limitations of the evidence base for adolescent nutrition due to a lack of data on adolescent diets, especially from low- and middle-income countries (LMICs), and called for future data collection and analysis efforts to include disaggregation by age, sex, socioeconomic status, and area of residence [1,4,51]. A 2022 paper presented dietary data from adolescents in China, Mexico, and India [4] while others have focused on adolescent diets in single-country settings including the Philippines [52], Tanzania [53], and the United States [14,54,55]. Despite this important progress, a 2024 systematic scoping review found that nationally representative dietary data for adolescents are still limited, and that among LMICs, only 8% of data sets contained dietary details for ≥7 food items or groups [56]. Our work contributes to the evidence base by offering a detailed account of adolescent

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food-related behavior, dietary intake, and nutrition outcomes disaggregated by school level, sex, maturation status, and wealth status in Ghana.

A limited number of publications have focused on the school food environment in Ghana and its impact on child dietary behavior and growth [30,57,58]. A 2017 study used data from household and school questionnaires to examine the role of the school food environment on child and adolescent dietary behaviors, with a focus on school meals, distance child lives from school, predictors of children bringing money to school, and broad categories of foods available on campus (i.e., meals, confectionary, fruit, and sugar-sweetened beverages) [30]. Similarly, a 2020 study in a single municipality in Ghana described students' typical purchases during morning break, focusing on energy-dense foods and general categories such as meals, packaged snacks, fried foods, and sweetened beverages [58]. Our study builds on this previous work by using nationally representative data from JHS and SHS to characterize multiple dimensions of the school food environment and provide a detailed assessment of multiple foods and food groups that are commonly accessible and consumed by in-school adolescents in Ghana.

Our study revealed notable differences in the foods served at lunchtime or available for purchase at JHS and SHS. This difference may be partially driven by the fact that the majority of SHS in our study offered meals to all or some students while most JHS did not offer meals to students. These trends are reflective of national norms. Many SHS are boarding schools and therefore provide meals to students. Conversely, most JHS are day schools and do not routinely serve meals, and thus students in these schools rely more heavily on food brought from home or available for purchase on campus or in the vicinity. Seven of the 10 MDD-W food groups were observed at a larger proportion of SHS compared to JHS, which could reflect the effort invested in menu planning where school meals are routinely served.

The mean FES, which takes into consideration both proximal and distal contributors to health and nutrition, was 3.4 points lower in JHS compared to SHS. Qualitatively, this difference seems largely to be driven by the physical elements of the school food environment (e.g., routine provision of meals, the number of food groups served or available for purchase, having a designated place where students eat, access to drinking water, etc.), for which proportions were generally higher at SHS compared to JHS. Simultaneously, the number of food groups observed at SHS was significantly higher than at JHS. Yet ADDS and the proportion of adolescents consuming ≥5 and ≥6 food groups were higher among JHS than SHS students. This disparity could be driven by a relatively less insular food environment in JHS, including the lack of school meals provision, which leads students in these schools to obtain most of their meals at home or by purchasing from vendors, either on campus or off school premises. Meals eaten at home, brought to school, or purchased by JHS students from vendors may offer greater variety and choice than SHS students have on campuses where meals are served to them. Further, the presence of more food groups on SHS campuses does not guarantee their desirability or affordability and thus does not necessarily translate to better dietary diversity for those students. A study in Tanzania found that diets in boarding schools were monotonous and composed mainly of cereal and legume intake [53]. JHS students are also relatively younger and could be more influenced by family

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members who encourage them to eat specific foods. A systematic review of family influence on adolescent diets concluded that increased autonomy in older adolescence alongside a reduction in the amount of parenting time are important factors in food choice and intake [59].

While dairy products are not a main component of traditional diets in Ghana, 62% of adolescents reported bringing milk and milk products to school. This tendency could be an indication of the success of marketing of dairy products toward children and a trend toward increasing dairy consumption in countries without strong dairy traditions[60,61]. The high proportions of adolescents who reported bringing sweets, desserts, and sweetened drinks to school are consistent with a recent study of adolescent diets in the context of the nutrition transition, which found a steady increase in added sugar intake in multiple countries over an 8-year period[62]. A key aim of the national Nutrition Friendly Schools Initiative is to address the double burden of undernutrition and diet-related chronic disease affecting school children in Ghana, and thus there may be room for enhancing school-level guiding principles and action plans to discourage students from bringing unhealthy foods to campus.

Our results showed that the foods adolescents tended to purchase at school were: grains, cereals, white roots, and tubers; pulses; meat and poultry; eggs, and; fish and seafood. This finding indicates that when adolescents have the purchasing power to do so, they often favor protein-rich food items, and that the foods purchased on campus could make an important contribution to daily micronutrient intakes. The difference in foods brought to school compared to foods purchased on campus may be due in part to the convenience to parents of giving their children pre-packaged items rather than preparing and packing meals at home.

Despite greater awareness of anemia and iron-folic acid tablets and consumption of supplements containing iron and/or folic acid in the past week among girls compared to boys, anemia prevalence was still significantly higher among girls. This result reflects the physiologic differences between boys and girls, and especially the higher biological requirements for iron for girls. Overall, boys and girls had similar food group consumption patterns, a finding that remained true when food groups were aggregated into the 10 MDD-W food groups. Boys were more likely to consume pulses while girls were more likely to consume other vitamin A-rich fruits and vegetables and other fruits. These differences could be related to personal preferences as well as perceptions of the health attributes of certain foods[4,17,19]. The high proportion of girls and boys consuming starchy foods, other vegetables, and fish and seafood is consistent with dietary practices and cultural norms in Ghana. The low proportion consuming mango and papaya could be driven by seasonality as data were collected in November when mangos were not in season. Research in Mozambique and Zambia has noted important differences in beta-carotene intake in and out of mango season[63,64].

The FES was a significant predictor of dietary diversity outcomes at the SHS level, but not at the JHS level, suggesting that adolescent dietary behavior at the JHS level is driven by factors other than the school food environment (e.g., wealth status). The FES was also inversely associated with anemia in both boys and girls. These results related to important program indicators (i.e., dietary diversity and anemia) suggest that the Nutrition Friendly

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Schools checklist—which we used to create the FES—appears to be well-designed to capture correlates of health and nutrition among school-aged children.

Maturation status was a significant positive predictor of all 3 dietary diversity outcomes at the SHS level and was also predictive of higher Hb in girls and boys, and lower prevalence of anemia in boys (but not girls), even after controlling for age. This finding could be an indication that, even as nutrient requirements increase during adolescence, the social changes that often accompany puberty, including heightened autonomy, access to spending money, and health consciousness, may result in improved dietary practices, especially related to the consumption of iron-rich foods[4,14,17]. Various studies have used the Health Belief Model to understand adolescent dietary behavior and have found that perceived benefits and threats, self-efficacy, and cues to action are important predictors of diet and food-related behavior[65–68].

A recent study in Filipino school-aged children and adolescents found that socioeconomic status played an important role in dietary intake, and that children from poorer households were more at risk of consuming a less diverse diet[52]. Similarly, we found that household wealth status was a significant predictor of dietary diversity outcomes at both the JHS and SHS level. However, the impact on ADDS was more pronounced in students from JHS compared to SHS, with low wealth JHS students consuming nearly a whole food group less compared to their peers from high wealth households. This could be explained by the fact that many SHS are boarding schools, and thus more insulated, such that wealth does not have as strong an effect on ADDS compared to JHS. Wealth was not a significant predictor of Hb or anemia in boys or girls, highlighting the complex nature of the relationship between diet and nutrition outcomes, in particular in the case of anemia. While increased access to resources may enable adolescents to access and consume a wider range of foods, anemia has a complex etiology involving substantial increase in nutrient requirements as children age alongside the effects of malaria, inflammation, infection rates, and other factors[69–73].

The strengths of this research include the use of a large, nationally representative sample of in-school adolescent boys and girls, the inclusion of both dietary intake data and biological data, and the creation of a 23-point score to quantify the school food environment. However, there are several limitations to this study. Our data are from a single population of in-school adolescents attending JHS and SHS in Ghana and thus may not be generalizable to other populations. We applied both the MDD-W indicator, validated only for women of reproductive age (15–49 years), and the MDD-A indicator, which we developed using NHANES data for US adolescents, but which has not yet been validated in other adolescent populations. Although neither indicator is perfectly suited to our study population of adolescents aged 10–19 years in Ghana, we applied both cutoffs to provide a more complete picture of the potential inadequacy of diets. These indicators are subject to the limitations of reported dietary data (i.e., biases like recall and social desirability as well as measurement error) relative to the more objective micronutrient status indicated by biomarkers[74]. Further, our single 24-hour recall data are based on what adolescents consumed in any environment, not only in school, and thus do not allow us to make inferences about usual intake or about intake during school only. While girls underwent venous blood draws, boys underwent capillary blood draws, which could introduce error to the comparison of anemia prevalence.

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Finally, the school FES we developed is intended only for use in Ghana and is not validated but could be used as a starting point for developing other country-specific and/or global school food environment scores.

Conclusions

Among in-school adolescents in Ghana, a higher school FES was positively associated with dietary diversity among SHS students, but not among JHS for whom factors beyond the school food environment (e.g., wealth) may have accounted for dietary diversity. For both girls and boys, high FES was inversely associated with anemia. The findings from this study help to fill key evidence gaps around reaching adolescents in Ghana with school-based health and nutrition programs to improve dietary diversity and reduce anemia. Our results suggest that a multi-pronged approach, which seeks to enhance the school food environment through policy, physical, and sociocultural improvements, could play a role in determining diet and nutrition outcomes among adolescents in Ghana.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Food groups	% included in school meals	% brought to school	% bought at school
Grains, cereals, white roots, and tubers	99	92	95
Pulses (beans, peas, and lentils)	91	21	66
Fish and seafood	57	33	48
Other vegetables	52	19	47
Milk and milk products	44	62	20
Nuts and seeds	44	19	24
Dark green leafy vegetables	41	8	27
Meat and poultry	39	16	57
Eggs	29	13	53
Orange colored fruits and vegetables	10	6	23
Fried dough or pastries	8	16	29
Other fruits	5	4	20
Sweets and desserts	3	48	25
Sweetened drinks	2	43	31
Potato chips, plantain chips, crisps, etc.	2	20	29

Figure 1. Items typically included in school meals, brought to school, and purchased at school as reported by adolescents in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=6331).

Note: Proportions are weighted and account for clustering and represent responses from those who reported eating meals provided by school, bringing food to school, and/or buying food at school. Darker color represents larger proportion.

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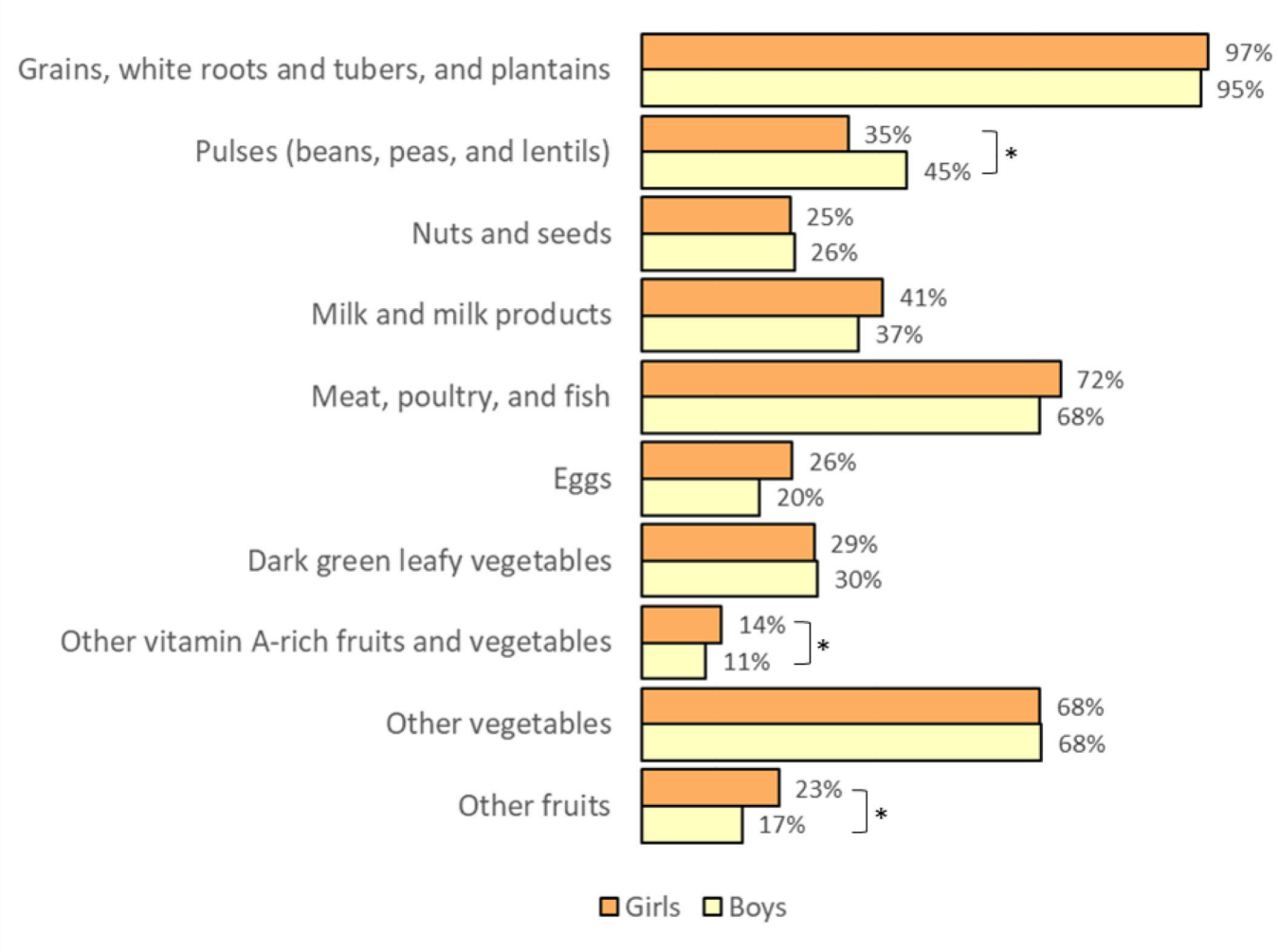


Figure 2. Consumption of Minimum Dietary Diversity for Women food groups in the previous day as reported by adolescents in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=6331).

Note: The 21 food groups from the questionnaire were aggregated into 10 food groups that make up the Minimum Dietary Diversity for Women indicator. Proportions are weighted and account for clustering. *p*-values for differences in proportion were estimated using Rao-Scott chi-square test. *Indicates significant difference at alpha <0.05.

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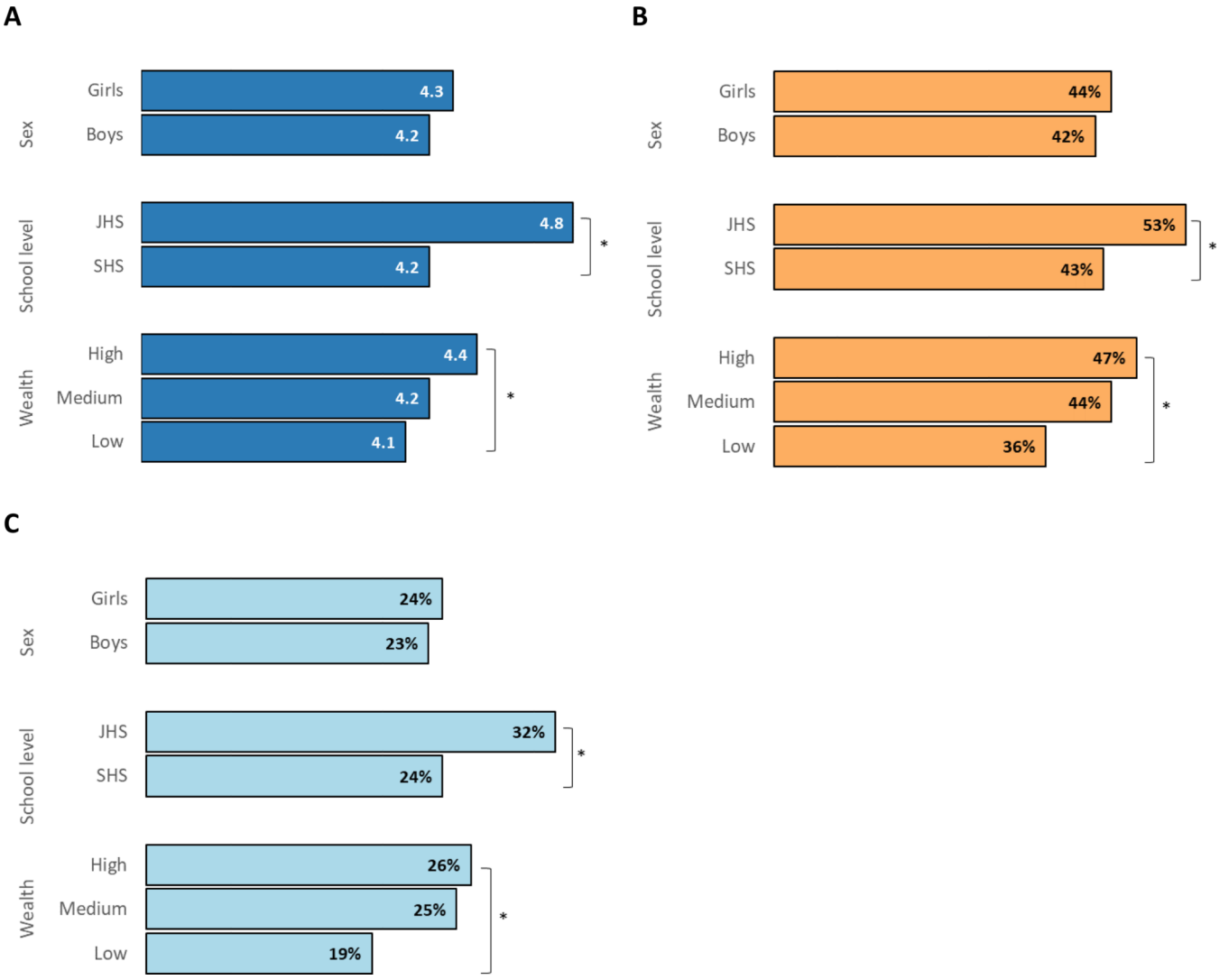


Figure 3. Dietary diversity metrics (A) Adolescent Dietary Diversity Score, (B) Minimum Dietary Diversity for Women, and (C) Minimum Dietary Diversity for Adolescents among adolescents in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=6331).

Abbreviations: ADDS, Adolescent Dietary Diversity Score; MDD-W, Minimum Dietary Diversity for Women; MDD-A, Minimum Dietary Diversity for Adolescents; JHS, junior high school; SHS, senior high school.

Note: ADDS is a composite metric of food group consumption on a scale of 0–10. MDD-W and MDD-A are defined as the consumption of ≥5 and ≥6 food groups in the past 24 hours, respectively. Proportions and means are weighted and account for clustering. Differences in means and proportions were estimated using *t*-test and Rao-Scott chi-square, respectively.

*Indicates significant at alpha <0.05.

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Table 1. Basic characteristics of adolescents included in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=6331).

	Girls (N=4833)		Boys (N=1498)	
	n	**Mean/% (95% CI)**	**n**	**Mean/% (95% CI)**
Mean age Junior High School Senior High School	4833 2377 2456	16.4 (16.3, 16.4) 15.1 (15.1, 15.2) 17.6 (17.5, 17.6)	1498 748 750	16.5 (16.5, 16.6) 15.4 (15.3, 15.5) 17.7 (17.6, 17.8)
School level Junior High School Senior High School	 2377 2456	 49.2 (47.8, 50.6) 50.8 (49.4, 52.2)	 748 750	 49.9 (47.4, 52.5) 50.1 (47.5, 52.6)
Form[1] 1 2	 2948 1885	 61.0 (59.6, 62.4) 39.0 (37.6, 40.4)	 923 575	 61.6 (59.2, 64.1) 38.4 (35.9, 40.9)
Boarding status Day Boarding	 3209 1624	 66.4 (65.1, 67.7) 33.6 (32.3, 34.9)	 984 514	 65.7 (63.3, 68.1) 34.3 (31.9, 36.7)
Wealth status Low Medium High	 1579 1642 1612	 32.7 (31.3, 34.0) 34.0 (32.6, 35.3) 33.4 (32.0, 34.7)	 531 469 498	 35.4 (33.0, 37.9) 31.3 (29.0, 33.7) 33.2 (30.9, 35.6)
Reached menarche Mean age when reached menarche	4465 4465	92.4 (91.6, 93.1) 13.3 (13.3, 13.3)	-- 	--
Ever had facial hair	--	--	400	26.7 (24.5, 28.9)
Voice has changed	--	--	1028	68.6 (66.3, 71.0)

Note: Results are unweighted to provide an accurate depiction of student characteristics across strata. Due to rounding to a single decimal point, upper and lower confidence limits may appear the same when intervals are narrow.

[1]Forms 1 and 2 are equivalent to 7th and 8th grades in the North American system.

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Table 2. Observations of food groups served during lunchtime or available for purchase on school grounds categorized into Minimum Dietary Diversity for Women food groups in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=239).

	JHS (N=117)	SHS (N=122)	*p*-value
Observed food groups aggregated into MDD-W food groups	**n (%/mean)**	**n (%/mean)**	
Grains, cereals, white roots and tubers, and plantains	83 (75.5)	116 (96.6)	<.001
Pulses (beans, peas, and lentils)	68 (66.8)	110 (92.3)	<.0001
Nuts and seeds	62 (64.2)	90 (73.7)	0.20
Milk and milk products	47 (49.1)	85 (80.2)	<.0001
Meat, poultry, and fish	75 (78.1)	109 (96.6)	<.0001
Eggs	70 (76.0)	87 (86.4)	0.04
Dark green leafy vegetables	37 (40.0)	74 (75.7)	<.0001
Other vitamin A-rich fruits and vegetables	36 (36.7)	51 (50.6)	0.09
Other vegetables	73 (76.3)	100 (90.0)	<.01
Other fruits	53 (55.6)	67 (66.1)	0.18
Number of food groups served or available for purchase	117 (6.2)	122 (8.1)	<.0001

Abbreviations: MDD-W, Minimum Dietary Diversity for Women; JHS, junior high school; SHS, senior high school.

Note: The 21 food groups from the questionnaire were aggregated into 10 food groups that make up the MDD-W indicator. Proportions, means, and 95% CI are weighted and account for clustering. *p*-values for differences in proportion were estimated using Rao-Scott chi-square test. It was not possible to complete the school-level questionnaire and observations in 1 senior high school due to time constraints on the day of data collection.

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Table 3. Characteristics of the school food environment in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=239).

			JHS (N=117)		SHS (N=122)	
School Food Environment Dimension	**FES item #**		**n (%/mean)**	**95% CI**	**n (%/mean)**	**95% CI**
Policy	1	School is implementing Nutrition Friendly Schools Initiative	26 (26.0)	16.0, 36.1	12 (6.6)	2.7, 10.5
	2	Teacher has ever attended training on GIFTS program	57 (53.9)	41.9, 66.0	52 (36.0)	25.5, 46.5
Physical	3	There are no pictures of unhealthy foods posted around the school	105 (86.3)	78.4, 94.2	101 (75.9)	65.6, 86.2
	4	Waste bins are placed around the school	59 (64.5)	55.1, 73.8	87 (81.5)	73.4, 89.6
	5	School has functioning latrines or toilets	86 (65.9)	52.8, 79.0	107 (92.9)	87.7, 98.0
	6	School has hand-washing facilities	83 (71.2)	58.6, 83.9	91 (76.0)	66.1, 86.0
	7	School has source of improved drinking water[1]	37 (42.6)	29.6, 55.6	64 (70.8)	59.0, 82.5
	8	Meals are routinely provided to students	11 (10.3)	3.5, 17.0	113 (93.5)	87.8, 99.2
	9	School has designated place with tables and chairs where students eat	37 (42.8)	31.1, 54.6	93 (87.7)	80.9, 94.5
	10	Place to eat is covered/protected from sun and rain[2]	29 (82.7)	69.0, 96.3	87 (94.3)	88.8, 99.8
	11	School has food vendors on premises	91 (88.0)	82.5, 93.5	115 (99.1)	98.0, 100.0
	12	Vendors are screened and certified[3]	68 (76.9)	66.7, 87.2	103 (91.3)	85.4, 97.1
	13	Vendors are trained on nutrition standards[3]	25 (30.0)	18.1, 41.9	46 (43.2)	32.0, 54.4
	14	School has garden	16 (11.1)	4.1, 18.0	32 (28.0)	18.0, 39.0
	15	Students participate in garden[4]	14 (67.1)	29.8, 100.0	26 (70.8)	49.7, 91.8
	16	Produce from garden is used in school meals[4]	4 (27.1)	5.0, 49.1	25 (68.5)	47.9, 89.0
	17	5 or more food groups were served at lunchtime or available for purchase on the day of data collection	74 (78.3)	70.7, 85.8	104 (93.5)	89.1, 98.0
	18	6 or more food groups were served at lunchtime or available for purchase on the day of data collection	61 (64.1)	52.1, 76.0	92 (88.2)	88.6, 93.8
Sociocultural	19	School has health clubs	42 (35.2)	24.2, 46.2	57 (51.2)	39.9, 62.5
	20	Health clubs are active[5]	26 (65.2)	46.8, 83.6	39 (73.7)	59.3, 88.1
	21	School has observed a fruit/vegetable day this term[6]	16 (52.5)	27.5, 77.5	3 (25.0)	0.0, 60.2
	22	Health talks were conducted at least once each term in the last academic year	109 (92.8)	86.4, 99.3	110 (85.1)	75.6, 94.5
	23	Activities related to anemia have been implemented in the last academic year	109 (91.8)	85.0, 98.6	105 (85.0)	76.3, 93.8

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			JHS (N=117)		SHS (N=122)	
School Food Environment Dimension	**FES item #**		**n (%/mean)**	**95% CI**	**n (%/mean)**	**95% CI**
Food environment score	Max score: 23		117 (10.9)	10.1, 11.7	122 (14.3)	13.6, 14.9

Abbreviations: FES, food environment score; JHS, junior high school; SHS, senior high school; GIFTS, Girls Iron Folate Table Supplementation.

Note: Proportions, means, and 95% CI are weighted and account for clustering. It was not possible to complete the school-level questionnaire in 1 senior high school due to time constraints on the day of data collection.

[1]Among schools that had handwashing facilities.

[2]Among schools with designated place where students eat.

[3]Among schools with vendors.

[4]Among schools with gardens.

[5]Among schools with health clubs.

[6]Among schools implementing the Nutrition Friendly Schools Initiative.

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Table 4. Population marginal estimates of covariate-adjusted dietary diversity indicators according to school food environment score among adolescents in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=6331).

		JHS (N=117)		SHS (N=123)	
Outcome	**Predictors**	**Adjusted mean/Prevalence (95% CI)**	***p*-value for difference**	**Adjusted mean/Prevalence (95% CI)**	***p*-value for difference**
ADDS (0–10)	FES level				
	High	4.8 (4.7, 5.0)	0.3	4.2 (4.1, 4.4)	0.04
	Medium	4.9 (4.8, 5.1)	0.8	4.3 (4.1, 4.4)	<.01
	Low	5.0 (4.8, 5.1)	Ref.	4.0 (3.8, 4.2)	Ref.
	Sex				
	Female	4.9 (4.8, 5.0)	0.8	4.2 (4.0, 4.3)	0.7
	Male	4.9 (4.7, 5.1)	Ref.	4.2 (4.0, 4.3)	Ref.
	Puberty				
	Yes	5.0 (4.9, 5.1)	0.05	4.3 (4.2, 4.4)	0.04
	No	4.8 (4.7, 5.0)	Ref.	4.0 (3.8, 4.3)	Ref.
	Wealth				
	High	5.2 (5.1, 5.5)	<.0001	4.3 (4.2, 4.5)	<.001
	Medium	5.0 (4.9, 5.2)	<.0001	4.2 (4.0, 4.4)	0.01
	Low	4.4 (4.3, 4.6)	Ref.	4.0 (3.8, 4.1)	Ref.
Consuming ≥5 (0–100%)	FES				
	High	54.3% (49.0, 59.7)	0.6	36.9% (32.8, 41.0)	0.05
	Medium	56.2% (52.2, 60.2)	0.9	39.1% (34.9, 43.3)	<.01
	Low	55.9% (52.9, 59.0)	Ref.	32.0% (27.1, 36.9)	Ref.
	Sex				
	Female	54.7% (51.5, 57.9)	0.5	35.8% (31.7, 40.0)	0.9
	Male	56.3% (52.5, 60.3)	Ref.	36.2% (32.0, 40.3)	Ref.
	Puberty				
	Yes	56.8% (53.8, 59.9)	0.3	40.3% (37.8, 42.7)	0.02
	No	54.1% (49.7, 58.6)	Ref.	31.7% (25.0, 38.5)	Ref.
	Wealth				
	High	62.4% (57.7, 67.0)	<.0001	39.3% (34.5, 44.0)	<.01
	Medium	58.5% (54.6, 62.5)	<.0001	37.3% (32.7, 42.0)	0.01
	Low	45.6% (41.8, 49.3)	Ref.	31.4% (26.9, 35.9)	Ref.
Consuming ≥6 (0–100%)	FES				
	High	33.6% (28.8, 38.4)	0.9	20.0% (16.6, 23.4)	0.5
	Medium	32.8% (29.1, 36.4)	0.5	21.9% (18.3, 25.5)	0.1
	Low	34.0% (31.1, 36.8)	Ref.	18.6% (14.6, 22.6)	Ref.
	Sex				
	Female	34.4% (31.4, 37.3)	0.4	19.8% (16.3, 23.2)	0.7
	Male	32.5% (28.8, 36.2)	Ref.	20.5% (17.1, 24.0)	Ref.
	Puberty				
	Yes	35.2% (32.3, 38.1)	0.1	23.7% (21.5, 25.9)	0.02
	No	31.7% (27.7, 35.8)	Ref.	16.6% (11.1, 22.1)	Ref.

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		JHS (N=117)		SHS (N=123)	
Outcome	**Predictors**	**Adjusted mean/Prevalence (95% CI)**	***p*-value for difference**	**Adjusted mean/Prevalence (95% CI)**	***p*-value for difference**
	Wealth				
	High	40.9% (36.6, 45.3)	<.0001	22.8% (18.8, 26.7)	<.01
	Medium	34.6% (30.9, 38.3)	<.0001	21.0% (17.2, 24.9)	0.04
	Low	24.8% (21.4, 28.2)	Ref.	16.7% (13.0, 20.3)	Ref.

Abbreviations: JHS, junior high school; SHS, senior high school; FES, food environment score; ADDS, Adolescent Dietary Diversity Score.

Note: Population marginals were calculated from mixed effects regression models, with students nested within school as random effect and controlling for region of school and age of child as fixed effects. It was not possible to complete the school-level questionnaire in 1 SHS due to time constraints on the day of data collection. To enable inclusion of this school in linear analysis predicting child-level outcomes, we assigned it an FES level of medium.

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Table 5. Population marginal estimates of covariate-adjusted anemia prevalence according to school food environment score among adolescents in the 2022 Ghana National Nutrition and Health Survey of In-school Adolescents (N=6304).

		Girls (N=4819)			Boys (N=1485)		
Outcome	**Predictors**	**Adjusted prevalence (95% CI)**	***p*-value for difference**	**Odds ratio (95% CI), student level**	**Adjusted prevalence (95% CI)**	***p*-value for difference**	**Odds ratio (95% CI), student level**
Anemia[1]	FES						
	High	22.2% (19.0, 25.3)	<.01	0.76 (0.63, 0.93)	12.7% (9.1, 16.4)	<.01	0.54 (0.34, 0.84)
	Medium	24.9% (21.9, 27.9)	0.2	0.89 (0.74, 1.06)	18.1% (14.2, 22.0)	0.6	0.92 (0.64, 1.32)
	Low	27.1% (24.0, 30.1)	Ref.	Ref.	19.4% (15.6, 23.2)	Ref.	Ref.
	Puberty						
	Yes	23.0% (21.5, 24.6)	0.2	0.81 (0.61, 1.08)	12.7% (10.1, 15.4)	<.001	0.57 (0.41, 0.78)
	No	26.4% (21.8, 31.1)	Ref.	Ref.	20.7% (16.6, 24.9)	Ref.	Ref.
	Wealth						
	High	24.7% (21.4, 28.1)	1.0	1.00 (0.79, 1.27)	15.2% (10.7, 19.6)	0.3	0.79 (0.48, 1.29)
	Medium	24.8% (21.6, 28.0)	0.9	1.01 (0.81, 1.25)	16.7% (12.5, 20.8)	0.5	0.89 (0.57, 1.37)
	Low	24.7% (21.6, 27.7)	Ref.	Ref.	18.4% (14.6, 22.2)	Ref.	Ref.

Note: Population marginals were calculated from mixed effects models, with students nested within school as random effect and controlling for region and level of school and age of child as fixed effects. It was not possible to complete the school-level questionnaire in 1 senior high school due to time constraints on the day of data collection. To enable inclusion of this school in linear analysis predicting child-level outcomes, we assigned it a food environment score level of medium.

[1]Anemia status was determined the World Health Organization's Hb concentrations for the diagnosis of anemia[39]: Hb <11.5 g/dL for children aged 5–11 years; Hb <12.0 g/dL for children aged 12–14 years and non-pregnant women aged 15 years and above; Hb <13.0 g/dL for men aged 15 years and above.