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Research Article

Assessing the Burden of Malnutrition and Anaemia Among School Children in Kumasi: Risk Factors and Health Implications

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Abstract

Background: Malnutrition and anaemia are persistent public health issues in Ghana, especially among school-aged children, affecting their growth and cognitive development. While most studies focus on younger children, there is limited data on children aged 5 to 16. Understanding the prevalence and risk factors in this age group is essential for developing targeted interventions to improve their health and academic performance.

Method: This cross-sectional study involved 276 school children from three basic schools in the Kumasi Metropolis. Sociodemographic and socioeconomic data were collected via questionnaires, following parental consent. Nutritional status was assessed using standard anthropometric measurements, while haemoglobin levels were determined with a haemoglobinometer. Stool samples were analyzed using the wet preparation method, and academic performance was evaluated based on participants' class rankings from the previous trimester.

Results: The overall prevalence of undernutrition among the children was 16.3%, with 12% stunted, 3.6% underweight, 0.7% both stunted and underweight, and 13% overweight/obese. Anaemia prevalence was 81.2% and significantly associated with the mother's education ($p = 0.024$). Male children (aOR = 3.567, 95%CI [1.525-8.342], $p = 0.03$), having a literate mother (aOR = 3.037, 95%CI [1.265-7.294], $p = 0.013$), and living in slum communities (aOR = 4.021, 95%CI [1.609-10.048], $p < 0.05$) significantly increased the odds of undernutrition. Stunting (aOR = 6.316, 95%CI [1.6-37.5], $p = 0.043$), severe anaemia (aOR = 5.316, 95%CI [0.1-0.9], $p = 0.049$), and helminth infection (aOR = 5.119, 95%CI [1.3-20.1], $p = 0.019$) were significantly associated with lower academic performance.

Conclusion: Malnutrition and anaemia are prevalent among school-aged children in the Kumasi Metropolis. Maternal education, poor living conditions, and gender are significant factors contributing to undernutrition. Additionally, impaired fasting glucose was linked to weight gain, emphasizing the need for early lifestyle interventions to prevent diabetes. Stunting, severe anaemia, and helminth infection were significant risk factors for poor academic performance which can result to long-term cognitive impairment when prolonged. Targeted public health interventions are crucial to mitigate these issues and improve children's health and academic outcomes.

Keywords: Prevalence; Undernutrition; Anaemia; Helminth Infection; Academic Performance

Introduction

Childhood and early adolescence are critical periods for physical, cognitive, and socio-emotional development, as children experience rapid growth and maturation in these areas. The foundation laid during these stages is essential for future health and well-being, emphasizing the importance of ensuring that children receive optimal care and nutrition from an early age [1,2]. However, despite global advances in reducing poverty and food insecurity over the past five decades, malnutrition and anaemia among children in low- and middle-income countries (LMICs) remain alarmingly high. These conditions continue to impede children's development and long-term health outcomes [3].

Malnutrition, defined as the imbalance between a person's nutrient intake and their requirements, whether through deficiencies, excesses, or imbalances [4], and anaemia in children remain pressing public health challenges in developing regions in the world [5,6]. It is estimated that nearly 90% of the world's undernourished children under the age of five live in developing countries, with around 40% of school-aged children in these regions suffering from anaemia [7]. In 2020, it was estimated that 149 million children under the age of five were stunted (too short for their age), 45 million were wasting (too short for their height), and 38.9 million were obese or overweight. Alarmingly, undernutrition contributes to approximately 45% of deaths among children under five, with the vast majority of these deaths occurring in LMICs. Meanwhile, the prevalence of childhood obesity and overweight is also rising in these same nations [7].

Anaemia especially iron deficiency anaemia (IDA) which also can arise due to micronutrient undernutrition (or other non-nutritional factors) is is prevalent among school-aged children which has a significant impact on their academic performance [8]. Globally, anaemia affects around 1.74 billion people (22.8% of the world's population), with 305 million (25.4%) of them being school-aged children. Children in this age group are particularly vulnerable to nutritional deficiencies, due to their rapid physical growth and developmental demands Anaemia not only impairs a child's cognitive abilities and academic achievements but can also lead to long-term consequences, such as diminished productivity in adulthood [9]. Furthermore, anaemia weakens immune function, increasing susceptibility to infections by impairing both humoral and cellular immunity [10].

In Ghana, despite improvements in socioeconomic development, malnutrition remains a significant public health issue, while iron deficiency remains the most common micronutrient deficiency affecting both mothers and children [11]. Ghana is among the 36 countries with the highest prevalence of stunting, and undernutrition continues to affect a significant portion of the child population. Rates of anaemia, stunting, and wasting have shown uneven progress, with marked disparities across different regions and economic strata in the country. National statistics reveal that 11% of Ghanaian children are underweight, 5% suffer from wasting, and 19% are stunted [12]. The consequences of malnutrition and anaemia in children are severe, leading to impaired cognitive development (which could be long-termed due to undernutrition), reduced economic productivity, and an increased risk of diet-related non-communicable diseases later in life [7,11,13].

Most research and policies addressing malnutrition and anaemia have primarily focused on preschool-aged children (those under five years old), with limited attention given to school-aged children and adolescents (aged 5-16 years). As nutritional challenges persist, especially in these older age groups, it is imperative to implement immediate interventions based on robust, reliable data [11]. This study aims to fill this gap by investigating the prevalence, risk factors, and effects of malnutrition and anaemia among school-aged children in Ghana. The findings will provide critical insights for policymakers, healthcare professionals, and educators, enabling the development of targeted interventions to address malnutrition and anaemia in school children aged 5 to 16 years in the Kumasi Metropolis, Ashanti Region of Ghana.

Materials and Methodology

Study Design and Site

This study was a cross-sectional one conducted between May 2023 to August 2023. The project was carried out in 3 basic schools in Kumasi, the capital city of the Ashanti Region in Ghana. Kumasi is located in the southern part of Ghana and is the second-largest city in the country with a population of approximately 1.5 million people [14]. Kumasi serves as a major economic, educational, and healthcare hub in the region and is home to a significant number of basic schools, including both public and private institutions.

Study Population and Sample Size Determination

The study involved 276 school children from 5 to 16 years old from the various basic schools which were visited. Simple random sampling technique was used to select the required number of participants who fit the inclusion criteria for the study. The sample size was calculated using the Raosoft Sample Size Calculator and confirmed using the Epi Info Application's sample size calculator. An acceptable error margin of 7%, expected frequency of 50%, design effect of 1.0, and confidence level of 95% were used, with the population set at the default software's number of 99,999 or more, which gave a sample size of 196 participants. However, the sample size used for this study was 276 to account for errors during sample taking and increase statistical power.

Inclusion and exclusion criteria

Participants were those who were aged 5-16 years, in either upper kindergarten, primary school or junior high school, and whose parents signed the consent forms for participation. All those who didn't meet the age criteria and provided no consent were excluded from this study.

Data Collection

Socio-demographic and socio-economics

A questionnaire was made to get information on the participants' sociodemographic and socioeconomic backgrounds. Each participant was interviewed and the questionnaire was filled at the study site by the co-investigator with the help of some of the teachers and other competent people. The information collected included age, gender, parent's educational background, parent's occupation, number of siblings, information about the residence, utilities in their homes, eating habits, religious status, position in class, participation, and a few others.

Anthropometric Measurements

The weight of participants was measured using a portable weighing scale, calibrated to zero. Height was determined by using a measuring tape calibrated in millimetres and inches. Body mass index (BMI) was calculated using the formula, weight (in kg)/ height^2 (in m) in Excel. The nutritional status was also determined using the z-scores for height-for-age and BMI-for-age according to the WHO Growth Standards. Physical examination was done to check for signs or symptoms indicating undernutrition or anaemia.

Blood Sample Collection and Haemoglobin Level Estimation

Blood sample was taken from each participant by finger pricking using disposable lancets. The level of haemoglobin was determined on the site using a Haemoglobinometer. Two groupings for haemoglobin levels were done. Haemoglobin (Hb) levels below 11.5g/dL for children from 5-11 and below 12g/dL for children from 12-16 were considered anaemic. The anaemia status was grouped as mild anaemia (Hb = 11.0-11.5/12.0), moderate anaemia (Hb = 8.0-10.9) and severe anaemia (Hb = < 8) according to WHO standard [15]. About 2 ml of blood was also taken for glucose level estimation. The samples were centrifuged at 500 rpm for 15 minutes and the serum and plasma were stored at - 80°C until assayed. The blood samples were taken under aseptic conditions.

Laboratory Analysis

The fasting blood sugar concentration in the blood samples was determined using spectrophotometric techniques and the glucose oxidase method.

Stool Sample Collection and Investigation

Each participant was given a stool container with a wooden applicator stick and was instructed to bring about 5mg of stool. The wet preparation method using saline was used to prepare the stool for examination on the same day. The stool sample of each participant was examined for helminths eggs, or the worms themselves. The examination of the stool samples was done at the KNUST Hospital, a few hours after collection of the sample for each day.

Ethical Approval

Ethical approval was sought from the Committee on Human Research, Publication, and Ethics (CHRPE) at the School of Medicine and Dentistry (SMD) of the Kwame Nkrumah University of Science and Technology. Approval was also sought from the Ghana Education Service (GES) Kumasi Metropolis branch. Permission and approval to conduct this study in the selected schools was sought from the various schools' authorities. Children who gave their approval and whose parents or guardians signed the provided consent forms had their data and samples taken.

Data Analysis

The data was transferred from Google Forms to an Excel file where it was edited and exported to an IBM-Statistical Package for Social Sciences (IBM-SPSS) version 26.0 document for analysis. Z-scores were calculated using the WHO's Anthroplus 1.0.4 statistical software. Participants with a Z-score for height-for-age (HAZ) below -2 were considered stunted, z-score for BMI-for-age (BAZ) below -2 were considered as wasting. Participants were considered undernourished when they had a Z-score value for height-for-age (HAZ) or BMI-for-age (BAZ) which was less than -2. Frequencies for various variables were run using descriptive statistics. Logistic regression (bivariate and multivariate) was used to measure the strength of the association of various factors including socioeconomic factors to nutritional status and anaemia. Variables were considered statistically significant when with P values < 0.05 and the confidence interval when used was 95%.

Results

In the study, a total of 191 participants were included, representing various sociodemographic characteristics. Out of 276 participants, 22.1% were mildly anaemic, 54% were moderately anaemic, and 5.1% were severely anaemic. In total 81.2% were anaemic and 18.8% were non-anaemic. 18.8% of the participants had low academic performance, 42.4% had moderate academic performance, and 38.8% had high academic performance. Table 1 shows the socio-demographics and other characteristics of the study population. Out of the total 276 participants, 12% were stunted, 3.6% were underweight and 0.7% were both stunted and underweight. Overall, 45 participants were undernourished which is 16.3% of the total population- table 2.

Association of socio-demographics among anaemic participants

Out of the 224 anaemic participants, a majority of them were those aged between 10 to 13 years (52.2%). However, there was no statistically significant association between anaemia and age category. A larger percentage of anaemic participants were found to be females (68.3%), participants with illiterate fathers (56.7%) and mothers (76.8), and those living in urban communities (80.4). %). A statistically significant difference was observed between participants' mothers' educational status (p = 0.024). Table 3 shows the various associations between the anaemic participants and the socio-demographics of the participants.

In the multivariate logistic model for the anaemia category (Table 4), the risk of developing mild anaemia was insignificant with the socioeconomic and sociodemographic factors. However, there was a significant and lower risk of participants with literate mothers developing mild anaemia (aOR = 0.316, 95%CI [0.1-0.9], p < 0.05) than illiterate mothers. Also, there was a significant but lower risk for participants aged from 10-13 years to develop severe anaemia (aOR = 0.040, 95%CI [0.1-0.9], p < 0.05).

Variable	Frequency (276)	Percentage (%)
Age category		
5-9	66	23.9
10-13	158	55.1
14-16	52	21
Gender		
Male	88	31.9
Female	188	68.1
Community type		
Non-slum community	201	72.8
Slum community	75	27.2
Residence		
Urban	225	81.5
Rural-like	51	18.5
Type of Housing		
Owned Apartment	127	46
Rented Apartment	149	54
Guardian/Father's Edu. Status		
Literate	121	43.8
Illiterate	155	56.2
Mother's Edu. Status		
Literate	73	26.4
Illiterate	203	73.6
Guardian/Father's occupation		
Unemployed	23	8.3
Informal	142	51.5
Formal	111	40.2
Mother's occupation		
Unemployed	23	8.3
Informal	234	84.8
Formal	19	6.9
Anaemia Status		
Anaemic	224	81.2
Non-Anaemic	52	18.8
Anaemia Category		
Mild Anaemia	61	22.1
Moderate Anaemia	149	54
Severe Anaemia	14	5.1
Normal	52	18.8
Academic Performance		
Low Performance	52	18.8
Average Performance	117	42.4
High Performance	107	38.8

Table 1: Characteristics of study participants.

Illiterate = cannot read and write or school dropout during or after basic education,

Literate = attained at least secondary school education**.**

Undernourished	Frequency (45)	Percentage%
Stunted	33	12
Underweight	10	3.6
Stunted and underweight	2	0.7

Table 2: Undernourished population in its category.

Stunted = HAZ < -2; Underweight = BAZ < -2.

		Anaemia status		Nutrition status	
Variable	**Total (N = 276)**	**Anaemic (N = 224)**	**p-value**	**Undernourished (N = 45)**	**p-value**
Age categories			0.2		0.216
5-9	66 (23.9)	55 (24.6)		6 (13.4)	
10-13	158 (55.1)	117 (52.2)		30 (66.8)	
14-16	52 (21)	52 (23.2)		9 (19.8)	
Gender			0.842		0.003
Male	88 (31.9)	71 (31.7)		25 (55.6)	
Female	188 (68.1)	153 (68.3)		20 (44.4)	
Guardian/Father's Edu Status			0.663		0.084
Literate	121 (43.8)	97 (43.3)		26 (57.8)	
Illiterate	155 (56.2)	127 (56.7)		19 (42.2)	
Mother Edu. Status			0.024		0.036
Literate	73 (26,4)	52 (23.2)		19 (42.2)	
Illiterate	203 (73.6)	172 (76.8)		26 (57.8)	
Guardian/Father Occupation			0.58		0.702
Unemployed	23 (8.3)	17 (7.6)		3 (6.6)	
Informal	142 (51.5)	113 (50.4)		26 (57.8)	
Formal	111 (40.2)	94 (42.0)		16 (35.6)	
Mother's Occupation			0.135		0.519
Unemployed	23 (8.3)	15 (6.7)		1 (2.2)	
Informal	234 (84.8)	194 (86.6)		41 (91.2)	
Formal	19 (6.9)	15 (6.7)		3 (6.6)	
Community type			0.934		0.004
Non-slum community	201 (72.8)	163 (72.8)		23 (51.2)	
Slum community	75 (27.2)	61 (27.2)		22 (48.8)	
Residence			0.445		0.730
Urban	225 (81.5)	180 (80.4)		38 (84.4)	
Rural	51 (18.5)	44 (19.6)		7 (15.6)	
Type of Housing			0.6		0.614
Owned Apartment	127 (46)	104 (46.4)		19 (42.2)	
Rented Apartment	149 (56)	120 (53.6)		26 (57.8)	

Table 3: Association and distribution of socio-economic and socio-demographic characteristics among Anaemic and Non-Anaemic participants.

Data is presented as frequency (proportion) followed by chi-square for trend/ Fischer's Exact test. P-value ($p < 0.05$) was considered statistically significant between groups. Edu: Education.

Anaemia Category	Variables	p-values	aOR (95% CI)
Mild Anaemia	**Gender**		
	Male	0.662	0.774 (0.2-2.4)
	Females		ref
	Mother's Edu. status		
	Literate	0.463	0.630 (0.1-2.3)
	Illiterate		ref
	Family size		
	5 or less	0.053	6.933 (0.9-49.5)
	6 to 10	0.295	2.764 (0.4-18.6)
	Greater than 10		ref
	Age category		
	5 to 9	0.132	0.240 (0.04-1.5)
	10 to 13	0.242	0.417 (0.1-1.8)
	14 to 16		ref
Moderate Anaemia	Gender		
	Male	0.908	0.944 (0.4-2.5)
	Females		ref
	Mother's Edu. status		
	Literate	0.035	0.316 (0.1-0.9)
	Illiterate		ref
	Family size		
	5 or less	0.276	2.350 (0.5-11.0)
	6 to 10	0.201	2.564 (0.6-11.0)
	Greater than 10		ref
	Age category		
	5 to 9	0.631	0.678 (0.1-3.3)
	10 to 13	0.208	0.425 (0.1-1.6)
	14 to 16		ref
Severe Anaemia	Gender		
	Male	0.416	0.404 (0.05-3.6)
	Females		ref
	Mother's Edu. status		
	Literate	0.891	0.829 (0.1-12.1)
	Illiterate		ref
	Family size		
	5 or less	0.992	523.6 (-)
	6 to 10	0.993	312.5 (-)
	Greater than 10		ref
	Age category		
	5 to 9	0.059	0.040 (0.1-1.1)
	10 to 13	0.010	0.040 (0.2-3.3)
	14 to 16		ref

Table 4: Logistic regression analysis of socio-economic and socio-demographic features among anaemic categories of participants. $P < 0.05$ was considered statistically significant between groups Ref: reference, aOR: Adjusted odds ratio, CI: confidence interval, Edu: Education **Table 4:** Correlation of BMI and FPG.

Helminth infection among anaemic and non-anaemic subjects

Out of the 276 participants, 147 brought stool samples for helminth detection of which 58.5% had helminth infection and 41.5% were free from helminth infection. Among the 117 anaemic participants who brought stool sample, 60.7% had helminth infection and 39.3% had no helminth infection. Table 5 shows the distribution of the various helminth type among the participants. In the univariate regression model of sociodemographic factors among helminth-infected individuals (Table 6), there was a significant association and high risk of helminth infection among participants from 5 to 9 years (a = 4.119, 95%CI [1.2-15.1], p < 0.05) than the other age groups. The other sociodemographic factors analyzed were all insignificant although there were higher odds for some variables.

Variable	Total (N = 212)	Anaemic (N = 169)	Non-Anaemic (N = 43)	p-value
Helminth infection				0.289
Yes	124 (58.5)	103 (60.9)	21 (48.8)	
No	88 (41.5)	66 (39.1)	22 (51.2)	
Helminth type				0.283
None	88 (41.5)	66 (39.1)	22 (51.2)	
A. lubricoides	51 (23.8)	38 (22.5)	13 (30.0)	
Hookworm	7 (3.4)	6 (3.5)	1 (2.3)	
S. stercoralis	33 (15.6)	32 (18.9)	1 (2.3)	
Co-infection	33 (15.6)	27 (16.0)	6 (14.0)	

Table 5: Prevalence of helminth infections among Anaemic and Non-Anaemic subjects.

Data is presented as frequency (proportion) followed by chi-square for trend/Fischer's Exact test. P-value (p < 0.05) was considered statistically significant between group.

Association of socio-demographic characteristics among the nutritional status (undernourished population) of the participants

Gender (p = 0.003), mother's education status (p = 0.036), and community type (p = 0.004) were found the be statistically significant, where males (55.6%), participants with illiterate mothers (57.8%) and participants living in non-slum community (51.2%) were found to have a higher undernourished population among the socio-demographic characteristics for the 45 undernourished participants (Table 3).

Variables	p-values	aOR (95% CI)
Age categories		
5 to 9	0.028	4.199 (1.2-15.1)
10 to 13	0.159	0.768 (0.8-5.0)
14 to 16		ref
Gender		
Male	0.713	1.208 (0.5-2.9)
Female		Ref
Residence		
Urban	0.138	2.326 (0.8-7.1)
Rural		ref

Table 6: Association of socio-economic and socio-demographic features among helminth-infected participants.

P < 0.05 was considered statistically significant between groups Ref: reference, aOR: Adjusted odds ratio, CI: confidence interval.

Variables	p-values	aOR (95% CI)
Gender		
Male	0.003	3.567 (1.525-8.342)
Female		ref
Mother's Edu. status		
Literate	0.013	3.037 (1.265-7.294)
Illiterate		ref
Community type		
Slum community	0.003	4.021 (1.609-10.048)
Non-slum community		ref

Table 7: Association of socio-economic and socio-demographic features among Undernourished (HAZ and BAZ < -2) participants. P < 0.05 was considered statistically significant between groups Ref: reference, aOR: Adjusted odds ratio, CI: confidence interval, Edu: Education

In the univariate logistic model for the socio-demographics (Table 7), the risk of becoming undernourished was significant and higher in males than female participants (aOR = 3.567 95%CI (1.525-8.342)], p < 0.05), participants with literate mothers also had a significantly high risk for undernourishment (aOR = 3.037; 95%CI [1.265-7.294], p < 0.05). There was a significant and higher risk among for participants residing in slum community in becoming undernourished (aOR = 4.021 95%CI (1.609-10.048), p < 0.05).

Association of Undernourishment, Anaemia, and Helminth Infection with Academic Performance

In the multilinear regression model of nutrition states and anaemia categories with academic performance, there was significant and a high risk for stunted individuals to have low academic performance (aOR = 6.316, 95%CI [1.6-37.5.4], p < 0.05) and for severe anaemic individuals to have low academic performance (aOR = 5.316, 95%CI [0.1-0.9], p < 0.05) than average or high academic performance. Although there were high odds for underweight individuals to have a low academic performance, this relation was insignificant. There was insignificant risk prediction for mild anaemia and moderate anaemia. There was a significant association and high risk for those with helminth infection to have low academic performance (aOR = 5.119 95%CI [1.3-20.1], p < 0.05] than average or high academic performance. (Table 8).

Prevalence of obesity and fasting blood sugar among the study participants

The overall prevalence of obese was found to be 3.6% of which all were females. Overweight had a prevalence of 9.4% of which males were 6.9% and females were 2.5%. The prevalence of children who were obese or overweight from the two schools was 13.0% of which 6.9% were males and 6.1% were females. (Table 9). Playing outdoor games and television watching were found to be associated to obesity and was statistically significant (p = 0.016 and p = 0.014 respectively) - Table 11. All the participants recorded a normal blood pressure except one whose blood pressure was 220/150.

Fasting blood sugar concentration was not found to be high between both genders. Table 10 outlines the distribution of fasting blood sugar by gender. None of the participants recorded a high fasting blood sugar. However, 26 participants had lower than the average level of fasting blood glucose.

Discussion

This study investigated the nutritional status of 276 school-going children from three basic schools in Ghana. The findings revealed that 16.3% of the children were undernourished, with 12% being stunted, 3.6% underweight, and 0.7% both stunted and underweight. This brings the overall prevalence of stunting to 12.7% and underweight to 4.3%. The stunting prevalence observed in this study aligns with the findings of Alelign., *et al*. (2015a), who reported a similar rate of 11.2%. However, Alelign., *et al*. reported a much higher prevalence of underweight (27.1%) and overall undernutrition (32.3%) compared to our study [7]. The difference in underweight prevalence may be attributed to regional differences.

In comparison, Agbozo., *et al*. (2016) also studied malnutrition in public and private schools in Ghana and found a comparable stunting prevalence in public schools to our findings. The underweight prevalence in Agbozo., *et al*. study was slightly lower than

Variables		p-values	aOR (95% CI)
Stunting	**Academic Performance**		
	Low	**0.043**	**6.316** (1.6-37.5.4)
	Average		ref
	High	0.700	1.177 (0.5-2.7)
Underweight	Academic Performance		
	Low	0.995	5.946 (-)
	Average		ref
	High	0.993	0.993 (0.1-10.1)
Mild Anaemia	Academic Performance		
	Low	0.759	1.3 (0.3-5.315)
	Average		ref
	High	0.950	0.970 (0.4-2.6)
Moderate Anaemia	Academic Performance		
	Low	0.132	2.595 (0.8-9.0)
	Average		ref
	High	0.700	1.177 (0.5-2.7
Severe Anaemia	Academic Performance		
	Low	0.049	5.316 (0.1-0.9)
	Average		ref
	High	0.257	2.350 (0.5-11.0)
Helminth infection (Yes)	Academic Performance		
	Low	0.019	5.119 (1.3-20.1)
	Average	0.943	0.411 (2.887)
	High		ref

Table 8: Association of Stunting, Underweight, Mild Anaemia, Moderate Anaemia, Severe Anaemia, and Helminth Infection with Academic Performance.

P < 0.05 was considered statistically significant between groups Ref: reference, aOR: Adjusted odds ratio, CI: confidence interval.

Prevalence of obesity			
	Overweight	**Obese**	**Obese or overweight**
Total	26 (9.4%)	10 (3.6%)	36 (13.0%)
Male	19 (6.9%)	0 (0%)	19 (6.9%)
Female	7 (2.5%)	10 (3.6%)	17 (6.1%)

Table 9: Prevalence of obesity among the study participants.

Data presented in percentages (%).

FBS	Male	Prevalence (%)	Female	Prevalence (%)
FBS (High)	0	0	0	0
FBS (Normal)	78	88.7	172	91.5
FBS (Low)	10	11.3	16	8.5

Table 10: Gender related prevalence of fasting blood sugar between the two schools.

Prevalence presented in frequencies and percentages; FBS: Fasting Blood Sugar.

Variables	Total Number (226)	Obese/Overweight (36)	p-value
Mother's Edu Status			0.131
Illiterate	73 (26,4)	7 (19.44)	
Literate	203 (73.6)	29 (80.56)	
Guardian/Father's Edu Status			0.052
Literate	121 (43.8)	0 (0.0)	
Illiterate	155 (56.2)	36 (100)	
Outdoor Games			0.016
Less than 30 minutes	52 (18.84)	16 (44.44)	
30 minutes or more	224 (81.16)	20 (55.56)	
Video Games			0.447
Less than 30 minutes	179 (64.86)	20 (55.56)	
30 minutes or more	97 (35.14)	16 (44.44)	
Television Viewing			0.014
Less than 30 minutes	23 (8.33)	10 (27.78)	
30 minutes or more	253 (91.67)	26 (72.22)	
Computer Usage			0.881
Less than 30 minutes	136 (49.28)	20 (55.56)	
30 minutes or more	140 (50.72)	16 (44.44)	
Supper			0.535
Early	205 (74.28)	29 (80.56)	
Late	71 (25.72)	7 (19.44)	
Family history of obesity or diabetes			0.28
Yes	117 (42.39)	10 (27.78)	
No	159 (57.61)	26 (72.22)	

Table 11: Risk factors for obese/overweight: Individual Characteristics.

Data is presented as frequency (proportion) followed by chi-square for trend/ Fischer's Exact test.
P-value ($p < 0.05$) was considered statistically significant between groups. Edu: Education.

that observed in this study, yet similar to findings in private schools [16]. Furthermore, Akubuilo., *et al*. (2020) reported similar underweight prevalence rates to our study, reinforcing the consistency of these results across different regions in Ghana [17]. Aboagye., *et al*. (2022) also conducted research in Ghana and reported similar underweight (3.8%) and stunting (10.4%) rates, with a slightly higher overall prevalence of undernutrition (21.5%) [4]. Other studies conducted outside hospital settings, such as those by Berhanu., *et al*. (2023), Khan., *et al*. (2022), and Alelign., *et al*. (2015a), found higher total undernutrition prevalence than this study [7,18,19]. The lower prevalence observed here could be due to differences in socioeconomic, demographic, and cultural factors, as well as environmental conditions, which influence nutritional outcomes [20].

An overall prevalence of obesity among the selected children was 3.6% and prevalence of overweight/obesity was 13.0%. A study by Kumah., *et al*. (2015) of students in Kumasi reported an obese prevalence of 0.8% and overweight/ obese prevalence of 13.0% [21] and another study by [22] of children in Accra reported an overweight/obese prevalence of 10.9%. This is comparable to results obtained from other studies outside Ghana; obese prevalence of 0.8% and overweight/obesity prevalence of 7.5% recorded from children of the ages (10-19) years in Ado-Ekiti in South West Nigeria (Oluwayemi., *et al*. 2015), and 1.2% and 4.3% respectively obtained from school children in Wardha City, Central India (Bharati., *et al*. 2006). Another study by (Sethi., *et al*. 2003) reported prevalence of overweight/ obese of 7.8%. The difference in prevalence between this study and the other studies could be as a result of the time of survey, method used and geographical locations (Chigozie., *et al*. 2007).

The study found that 8.5% of participants had low fasting glucose levels, while 91.5% had normal fasting glucose levels. A study by (Bharati., *et al*. 2006) recorded a prevalence of 70.7% for normal fasting plasma glucose concentration, 0.6% for high fasting glucose concentration and 28.7% for impaired fasting plasma glucose concentration. None of them recorded a low fasting plasma glucose concentration. Another study by (Guerrero - Romero., *et al*. 2007) recorded a prevalence of 75.9% for normal fasting plasma glucose concentration, 0.6% for high fasting glucose concentration, 18.3% for impaired fasting plasma glucose concentration, and 5.3% for low fasting plasma glucose concentration.

Even though no fasting plasma glucose exceeded the normal range (3.6 - 6.4 mmol/L), 15 (17.6%) of the participants recorded FPG between 5.6 and 6.9 mmol/L and per American Diabetic Association (ADA), they are considered to have impaired fasting glucose (IFG) and would therefore need monitoring to prevent the development of diabetes mellitus.

The prevalence of anaemia among the study population (81.2%) was higher than that from several studies [23-25]. However, a certain study conducted here in Ghana by Ewusie., *et al*. also gave a similarly high prevalence of anaemia (78.4%) among children under 5 years [26]. Another study conducted in Togo reported a high prevalence of anaemia (70.9%), yet slightly lower than that in this study [24]. This shows that anaemia is a matter of concern and could be widespread in Ghana. The significantly lower reports from other studies could also be a result of differences in the demographic and socioeconomic factors, especially with the age groups on which the studies are conducted.

Undernutrition was found to be significantly associated with gender, community type, and mothers' education status. This falls in line with a study by Roy., *et al*. who also reported on the association of these factors with malnutrition [27]. Although the population of females was higher than males, there was found to be a higher risk of being stunted in males than in females which falls in line with a study by Samuel., *et al*. [28]. The association of gender with malnutrition is similarly reported by Jabbour., *et al*. and Jawaregowda., *et al*. [29,30]. This association can be due to the biological differences and growth levels, especially at the adolescence stage, physical activity levels and nutritional requirements, and economic and cultural factors among many other factors [29,31]. Concerning religion, there have been very few studies done on religion and nutritional status [32]. There was also a significantly higher risk of residents of slum communities being undernourished than those in non-slum communities from this study. Studies such as that by Bhattacharyya., *et al*. and Gelu., *et al*. also found that slum communities contribute to malnutrition in children both below 5 years and above 5 to 16 years, which is comparable to this study [33,34]. Education status of mothers has been one of the common associations and risk of undernutrition among children found in many studies and comparable to this study's outcome [27,35-37].

From the study, television viewing and outdoor games were contributing factors to the development of overweight/obesity in children. Television viewing for 30 minutes or more daily ($p = 0.01390$) and playing of outdoor games for less than 30 minutes daily ($p = 0.01552$) was found to be significant. (Pandez., *et al*. 2005) reported similar predisposition in Portuguese children. All these factors are related with affluence and sedentary lifestyle. Food in urban areas have been replaced by high calorie snacks and junk food. Due to unsafe roads, lack of free space for playing, increased television viewing and computer use has made life sedentary (Bhave., *et al*. 2004). (Giammattei., *et al*. 2003) also reported that children who spent more time watching television had a higher BMI and a higher per cent of body fat and were less physically active.

A strong correlation has been established between a high BMI and the development of type-2 DM from a study of more than 7000 British men (mean follow-up of 12 years) (Kahn CR, 1994). These observations were expected as obesity is known to induce insulin resistance due to decrease in insulin-sensitive receptors as the weight increases (Sue., *et al*. 1993). In a recent study in healthy post- pubescent female Nigerians (16-23 years), FPG best positively and significantly correlated with BMI ($r = 0.15$; $p < 0.05$). This showed that relative to other indices of body mass and obesity (WC, HC, WHR, and WHtR), BMI best predicted FPG in this young female Nigerian population (Akinola., *et al*. 2014). In this study FPG significantly and best correlated with BMI ($r = 0.232$; $p = 0.003$) between FPG and BMI. We have therefore shown in the present study that the best anthropometric predictor of FPG and thus, metabolic status, in children is BMI. Thus, weight gain and increased FPG will correlate well. The strong association between diabetes and obesity suggests that our priority is maintenance of healthy weight and obesity prevention.

Mother's education status (literacy status) was found to be related to the anaemia status of the participants. There was a higher risk of developing moderate anaemia in illiterate mothers compared to literate mothers. This has also been a recurring finding among many studies that included these factors [28,35-41]. All these studies find an increased risk of anaemia in children with low maternal education status. There was a significant association between severe anaemia and individuals from the ages of 10-13 years, however, there were lower odds associated with it compared to the other group. A study conducted by Srivastava found that there was an increased prevalence of anaemia among adolescents [42]. Kounnavong., *et al*. reported in a study on anaemia among adolescents that there was no difference in anaemic prevalence at both the early and late adolescent stage which can account for the lower risk found in this study [43]. This is probably due to the onset of the adolescent state, where nutritional requirements and physiological activities increase.

Seemingly counterintuitive, there was no significant association of anaemia with helminth infestation or the type of helminth though the prevalence of helminth infection was high. Although insignificant, there was a high risk of having anaemia with infestation by Strongyloides stercoralis as well as with co-infestation. Studies like those by Djuardi., *et al*. and Degarege., *et al*. had similar risks of being anaemic with multiple worm infestations [44,45]. However, there was significant association of anaemia with helminth infection in these studies as well as other studies on these parameters. Although the total state of helminth infection has been significant among these studies, some species of helminth are found to be insignificant, and Djuardi., *et al*. reported an insignificant relation on multivariate regression concerning multiple infections and anaemia [45]. The insignificant relation of helminth infection with anaemia could be due to the different and many etiologies of anaemia, as well as the sociodemographic factors of participants used in the study such as residence. Helminth infection had a significant and high risk among individuals from the ages of 5-9 years. This finding falls in line with a study on the prevalence of helminth infection by Huat., *et al*. [46].

Low academic performance was found to be associated with stunting, severe anaemia and helminth infection. There was a high risk for stunted and severely anaemic individuals to have low academic performance. The association of stunting with low academic/cognitive performance can be compared with studies by Asmare., *et al*. and Kar., *et al*. [13,47]. The study by Kar., *et al*. showed various cognitive processes that can be affected by stunting and emphasized the risk of long-term cognitive impairment with prolonged stunting in childhood years. Anaemia and low academic performance found in this study are comparable with a study by Teni., *et al*. on anaemia and its relation with academic performance, which records similar results and risk of anaemia with academic performance as this study did [48]. Anaemia and undernutrition place a great health burden on children which affects their cognitive function and productivity resulting in poor academic performance [49,50]. A study by Donkoh., *et al*. which examined the evidence of helminth infestation with academic performance also found students with helminth infection to have reduced academic performance similar to this study [51]. This can be a result of chronic illness or other health issues resulting from the infestation that can affect participation in school activities. Also, this can be as a result of the hindrance in the development of some cognitive processes due to the chronic state of these health conditions which could cause poor academic performances.

Conclusion

Malnutrition and anaemia remain significant public health challenges among school-aged children in the Kumasi Metropolis, with children aged 10-13 years showing a particularly high prevalence of both conditions. The findings from this study underscore the critical role of maternal education and involvement in the health of their children, which is essential in mitigating the risks of malnutrition and anaemia. Additionally, male children and those residing in slum communities were found to be at a higher risk of undernutrition, particularly stunting, highlighting the need for targeted interventions in these vulnerable populations.

A noteworthy correlation was observed between weight gain and fasting plasma glucose (FPG) levels, indicating that individuals with elevated or impaired FPG should consider lifestyle modifications to delay or prevent the onset of diabetes. Children with impaired fasting glucose should not be overlooked or assumed to be in normal health. Instead, proactive measures should be taken to monitor and prevent the progression to diabetes mellitus, including the close supervision of their diet and daily activities by parents and caregivers.

Furthermore, this study identified severe anaemia, stunted growth, and helminth infections as significant risk factors for poor academic performance. Prolonged undernutrition (stunting) and anaemia during childhood can lead to permanent cognitive impairments and hinder age-related cognitive development. These findings underscore the urgent need for comprehensive public health strategies aimed at reducing malnutrition and anaemia in school-aged children to improve not only their physical health but also their academic outcomes and future cognitive potential.

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