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ANEMIA PREVALENCE AND ASSOCIATED FACTORS AMONG SCHOOL-AGE CHILDREN IN ACCRA AND KUMASI METROPOLIS IN GHANA

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ABSTRACT

Anemia remains a serious public health concern, globally, affecting learning ability and physical development of children. Anemic children are at a higher risk of diminished economic productivity and low earning capacity in adulthood due to impaired school performance and reduced work capacity. Anemia contributes to about a quarter of Africa's nutrition-related Disability Adjusted Life Years. The objective of this study was to determine the prevalence of anemia and its associated risk factors among school-aged children (SAC) between ages 9 and 15 years in urban Ghana. The analysis included a randomly selected subsample of 1,634 children from a larger study on nutrition of SAC enrolled between 2009 and 2012 in private and public basic schools in the Accra and Kumasi Metropolis in Ghana. Socio-demographic and household characteristics were collected with questionnaires. Weight and height were taken to the nearest 0.1kg and 0.1cm, respectively. Dietary information was collected using a food frequency questionnaire. Data were analyzed using IBM SPSS Statistic version 23. The relationship between hemoglobin levels and socio-demographic variables, and predictors of hemoglobin levels were determined using Chi-square and binary logistic regression. The mean hemoglobin concentration of the study participants was 12.9±1.3 g/dL. In Kumasi, SAC had higher mean hemoglobin concentration (13.1±1.2 g/dL) compared to those from Accra (12.6±1.3 g/dL; p=0.001). Mean hemoglobin concentration was significantly higher among males than females (13.0±1.4 g/dL vs 12.8±1.2 g/dL; p=0.002). Prevalence of anemia was 20.4%; mild anemia was most common (13.6% of total sample). Anemia cases were higher in public schools (24.6%) compared to private (18.2%). Two-thirds of anemia cases (64.0%) were from schools in Accra. Males had significantly higher prevalence of anemia (26.5%) than females (15.9%; p <0.05). In the adjusted logistic regression model, only city of residence (OR+1.65, 95% CI: 1.44–1.83), thinness (OR=2.60, 95% CI: 1.11-5.75), stunting (OR=1.85, 95% CI: 1.99-3.10) and overweight (OR=0.60, 95% CI: 0.36-0.94) were significantly associated with anemia. In this study, anemia was significantly associated with location and nutritional status.

Key words: anemia, Ghana, hemoglobin, schoolchildren, urban settings, metropolis, Accra, Kumasi

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INTRODUCTION

Anemia is an important public health problem that affects about 305 million (25%) school-aged children (SAC), globally [5]. The estimated prevalence of anemia reaches about 50% in low- and middle-income countries [1]. Anemia among children is an important concern because it affects both physical and cognitive development. Anemic children perform poorly in school and are at higher risk of diminished economic productivity and low earning capacity in adulthood, due to sub-optimal physical growth and reduced work capacity [2-4, 7]. Iron deficiency anemia has been linked with adverse effects on immune capacity, and thus increased risk of infectious morbidity [5]. Anemia contributes to a quarter of Africa's nutrition-related Disability-Adjusted Life Years (DALYs) [8].

In Ghana, there is limited evidence on anemia status of SAC [8, 9, 10]. The Demographic and Health Survey of 2014 reported that almost half (47.7%) of adolescent girls between 15 and 19 years are anemic [9]. One other study reported on anemia status of SAC in a rural setting [10]. There is, however, limited evidence on anemia among urban-dwelling SAC. The current analysis is on hemoglobin data collected as part of a larger study on nutrition of SAC in urban Ghana [11], 12]. The analysis describes the prevalence and risk factors of anemia among SAC in urban Ghana. The findings will be useful for policy and program planning aimed at addressing anemia among SAC.

MATERIALS AND METHODS

Study design, area and population

This study was part of a larger study of SAC as previously described by Aryeetey *et al*. [11] and Lartey *et al*. [12]. Using a cross-sectional design, SAC in two urban cities in Ghana (Accra and Kumasi) were recruited into the study. A multi-stage sampling approach was used, whereby 121 schools were identified through cluster sampling stratified by sex in Accra and Kumasi. Within each school, eligible SAC were randomly selected by ballot [11, 12]. The previous papers of this study reported findings related to prevalence and predictors of overweight, obesity [11], and lipid profile and dyslipidemia [12] among SAC in urban Ghana.

Household demographic and socioeconomic data were collected with structured pre-tested questionnaires. Hemoglobin (Hb) concentrations were measured in the SAC sample, and immediately analyzed in the field to the nearest 0.1 g/dL, using HemoCue Hb system 301, (Angelhom, Sweden). Weight and height measures of SAC were carried out, following standard anthropometric assessment protocols [13]. Participants removed all heavy clothing and accessories (where necessary) prior to the measurements. Weight was measured to nearest 0.1 kg using the TANITA body composition analyzer (model TBF-300A, TANITA, USA). Each child's height was taken to nearest 0.1 cm using the TANITA height rod (model HR-200, TANITA, USA) with the child in a standing position.

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Both parental consent and child assent were obtained prior to interviews and assessment of nutritional status (anthropometry and biochemical tests). The study was approved by the Institutional Review Boards (IRBs) of McGill University, Canada (protocol identification number – A09-B21-09A) and Noguchi Memorial Institute for Medical Research (NMIMR), University of Ghana, Legon (protocol identification number 004/09-10).

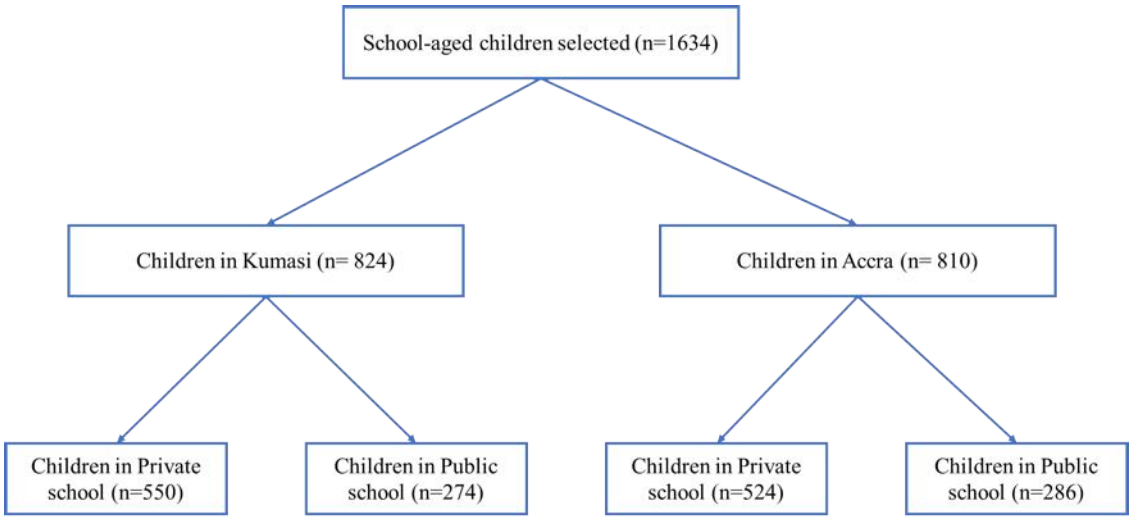

Figure 1: Participant flow diagram of study

Statistical analyses

Body mass index (BMI)-for-age z-score was calculated using the 2007 World Health Organization (WHO/MGRS) BMI-for-age standards [14]. Hemoglobin data were used to determine anemia levels, based on WHO age- and sex-standardized thresholds for children as follows: non-anemic (hemoglobin ≥ 11.5 g/dL for 9-11 years, ≥12.0 g/dL for 12-14 years, ≥ 12.0 g/dL for girls 15 years or older, and ≥ 13.0 g/dL for boys 15 years or older); mild anemia (hemoglobin 11.0-11.4 g/dL for 9-11 years, 11.0-11.9 g/dL for 12-14 years, 11.0-11.9 g/dL for girls 15 years or older, and 11.0-12.9 g/dL for boys 15 years or older); moderate anemia (hemoglobin 8.0-10.9 g/dL for 9 years or older); and severe anemia (hemoglobin <8.0 g/dL for 9 years or older). Data collected were analyzed using IBM SPSS Statistic 23.

The relationship between hemoglobin levels and sociodemographic variables as well as predictors of hemoglobin levels were determined using the Chi-square test statistic and binary logistic regression modelling. Socioeconomic status (SES) was determined as a composite wealth index by scoring parental educational level, occupation, possession of car(s), vehicle(s), television, electric stove, refrigerator, freezer, and type of household income. The index was divided by tertiles and reported as low, middle, or high. Statistical significance was set at p-value < 0.05.

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RESULTS AND DISCUSSION

Sociodemographic characteristics

A total of 1,634 SAC in Kumasi and Accra were included in this analysis. There were significant differences across children from private and public school with respect to sex, socioeconomic status, household size, and the marital status of their parents/caregiver (Table 1). The public school sample had a slightly higher percentage (6%) of female students and a lower percent (8 percentage points) of the highest wealth tertile, than the private sector (both $p<0.05$).

Hemoglobin concentration

There were significant differences in the mean hemoglobin concentrations of the study participants for most of the variables assessed: city of residence, household SES indicators, and SAC demographic characteristics and dietary behaviors (Table 2). The overall prevalence of anemia among SAC was 20.4% (Table 3). Prevalence of mild, moderate and severe anemia cases were 13.6%, 6.6%, and 0.2%, respectively. The prevalence of anemia in SAC in public schools was 1.4-fold higher than in private schools. About one-quarter (26.3%) of SAC in Accra were anemic; the prevalence in Kumasi was far less (15.0%) than that for Accra at $p < 0.05$. The prevalence of anemia among female SAC was 11.0% lower than that of the males ($p < 0.05$). The level of anemia in the 12–15 years old was 11.0% higher than the 9–11 years old SAC ($p < 0.05$). Anemia prevalence was highest among the thin SAC (BMI < 18.5 kg/m^2). Mild anemia was the most prevalent among the three forms of anemia (mild, moderate and severe). The prevalence of severe anemia was very low among the study participants.

In the multivariable analysis, several factors were associated with anemia status. Being a resident in Accra and being stunted increased the likelihood of anemia by 1.7- and 1.9-fold (Table 4). While being thin increased the odds by 2.6-fold, being overweight decreased it by 40%. Having a large household size (10 or more members) and being male did not reach significance with anemia among SAC.

The mean hemoglobin concentration for urban Ghanaian schoolchildren in this study was 12.8±1.2 g/dL. This was a little less than the value (13.6 g/dL) reported for schoolchildren in similar settings in the Kilimanjaro Region of Tanzania [15]. Similarly, the prevalence of anemia (20.4%) observed in the SAC in the current study was lower than the prevalence (23.1%) in the Tanzanian study [16]. The prevalence of anemia in these Ghanaian SAC was less than half the prevalence of 48% in children 5-14 years of age reported for schoolchildren in other developing countries [17].

The relatively lower prevalence of anemia among the SAC in the current study, compared to the levels reported for other similar countries, may partly be explained by the free distribution of treated mosquito nets and education on their usage as part of the malaria eradication programs. Evidence exists for the impact of Insecticide Treated Nets (ITNs) ownership and usage on prevalence of malaria and anemia in children in Hohoe municipality, Ghana [18, 19, 20] and Biako Island, Equatorial Guinea [21]. There are other factors beyond the scope of this paper (presence of hookworm, cancers, hemoglobinopathies [22, 23], and consumption of anti-nutritional factors (phytate,

polyphenols and tannins)) that influence anemia in SAC. However, these were not measured in the current study.

Based on WHO classification, anemia prevalence above 5% is a Public Health Problem. Anemia prevalence of 5.0% to 19.9% is considered a mild Public Health Problem and 20.0% to 39.9% is accepted as moderate Public Health Problem. Anemia prevalence at or above 40.0%, is referred to as Severe Public Health Problem [7]. The 20.4% reported in this study confirms the existence of a moderate public health problem of anemia in the study area. Assefa et al. in 2014 [5] found anemia of moderate public health concern among Ethiopian schoolchildren in Jimma township. Even moderate anemia is associated with depressed mental and motor development in children and may not be reversible [24]. Thus, these data on the anemia situation of schoolchildren in urban settings in Ghana is critical for any national policy on anemia control among schoolchildren.

Our indicators of socioeconomic status were not associated with anemia among the study participants. A previous cross-sectional study among SAC in a rural setting in Ghana [14] found that low parental monthly income, linked to low socioeconomic status, was significantly associated with anemia. The majority of the participants in the current study attending public sector schools in both Accra and Kumasi came from poor households and presented with higher levels of anemia and lower concentrations of mean hemoglobin than those from the private sector schools. Thus, the type of school is likely a useful predictor of socioeconomic status in the analysis.

The SAC in Accra were more likely to be anemic compared to those in Kumasi. Kumasi is located in a forest belt where meat, fruits and vegetables are readily available and affordable compared to Accra, possibly providing a diet higher in iron, vitamin A, pro-vitamin A (beta-carotene), folic acid, vitamin C and zinc to minimize the prevalence of nutritional anemia. In contrast, Accra is a coastal urban setting where meat, fruits and vegetables are more expensive, and not easily affordable to the schoolchildren of poor SES households.

In this study, the prevalence of anemia was significantly higher in males than in females in only the unadjusted analysis. The findings of systematic review and meta-analysis of data on school-age children in Ethiopia [14], eight countries of Asia and Africa [25] showed a similar trend in prevalence of anemia being higher in males than in females. Some other studies in Ghana [10, 26-28], and Egypt [29] reported findings on anemia prevalence in male and female SAC, compared to the present study where the prevalence of anemia in females were higher compared to the prevalence in males. The high prevalence of anemia between male and female SAC in Sub-Saharan Africa may be attributable to various nutritional and environmental factors such as inadequate nutrition, unhealthy food habits, and parasitic infections as had been reported in a previous study in children under five years of age [5].

This is the first study conducted in the two urban settings (Accra and Kumasi) in two different regions (geographical locations) in Ghana among schoolchildren 9-15 years to compare the prevalence of anemia and determine its associated factors. The study was

limited to SAC and the findings do not apply to younger children. The study did not cover infections like malaria parasitaemia and helminths known to cause anemia. Since the study focused on schoolchildren, findings do not cover urban children older than five years who are not attending school. The limitation to the study was that, it was cross-sectional in nature and the findings relate to associations rather than causal effects.

CONCLUSION

Anemia among the study participants can be classified as a moderate public health concern in the two largest cities (Accra and Kumasi) in Ghana. Anemia was more prevalent among thinner and stunted adolescents as well as those residing in Accra. Policies on strategies to control anemia should take into account factors associated with higher anemia prevalence rates.

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Data availability

Data is available upon request.

Author contributions

Conceptualization: Anna Lartey, Helena Nti, Grace Marquis
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Competing interest

Authors have no conflict of interest

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Table 1: Sociodemographic characteristics of study participants by school type (N=1634)

Variables	Private n=1074	Public n=560	P-value
City of residence			
Accra	524 (49)	286 (51)	0.381
Kumasi	550 (51)	274 (49)	
Age (years)	12.0±1.6	12.7±1.7	0.001
Sex			
Male	476 (44)	215 (38)	0.021
Female	598 (56)	345 (62)	
Household SES¥			
Low	601 (56)	426 (76)	0.001
Middle	363 (34)	123 (22)	
High	110 (10)	11 (2)	
Marital status of responding caregiver			
Single	360 (34)	238 (43)	0.001
Married/Co-habitating	617 (57)	247 (44)	
Separated/Divorced	57 (5)	46 (8)	
Widowed	40 (4)	29 (5)	
Household size (#)			
3-9	956 (89)	462 (82)	0.001
10-22	118 (11)	98 (18)	

Values are n (%) or mean ± standard deviation.
SES¥: socioeconomic status. High implies (1) having formal education; (2) office worker; (3) earning monthly salary or allowance or both; (4) possession of car(s), television, air-conditioner, fridge or freezer (or both) at home. Middle implies at least two of the four categories (1), (2), (3) and (4). Low implies none of the four categories

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Table 2: Hemoglobin concentration (g/dL) of study participants estimated across observed characteristics (N=1630)

Variables	(Mean ± SD)	P-value
City of residence		
Accra	12.6 ± 1.2	0.001
Kumasi	13.1 ± 1.3	
School type		
Private	12.9 ± 1.3	0.052
Public	12.8 ± 1.3	
Household socioeconomic status		
Electric stove ownership		
Yes	12.9 ± 1.3	0.039
No	12.7 ± 1.3	
Television ownership		
Yes	12.9 ± 1.3	0.042
No	12.5 ± 1.2	
Sex		
Male	12.8 ± 1.4	0.002
Female	13.0 ± 1.2	
Age (years)		
9-11	12.7 ± 1.2	0.001
12-15	12.9 ± 1.4	
Eating Pattern		
Two meals per day	12.8 ± 1.3	0.039
Three meals per day	13.0 ± 1.3	
Frequent Meat/fish intake (2-3 times a day)		
Yes	12.9 ± 1.3	0.043
No	12.7 ± 1.2	
Supplement intake[1]		
Yes	12.9 ± 1.2	0.001
No	12.7 ± 1.3	

$P < 0.05$ is considered statistically significant as determined by independent Student's t-test.
[1]Supplement refers to iron, folic acid, B12, vitamin A or zinc supplements

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Table 3: Anemia status of school children in Kumasi and Accra (n=1634)

Characteristics	Anemia Status				All anemia (n=333) n (%)
	Normal (n=1301) n (%)	Mild (n=222) n (%)	Moderate (n=108) n (%)	Severe (n=3) n (%)	
Level of anemia (%)	968 (74.4)	222 (13.6)[a]	108 (6.6)[b]	3 (0.2)[c]	333 (20.4)
School type					
Private	879 (69.0)	129 (12.0)[a]	65 (6.1)	1 (negl)	195 (18.2)[a]
Public	422 (75.4)	93 (16.6)[b]	43 (7.7)	2 (negl)	138 (24.6)[b]
City of residence					
Accra	597 (73.7)	148 (18.3)[a]	63 (7.8)	2 (negl)	213 (26.3)[a]
Kumasi	704 (85.4)	74 (9.0)[b]	45 (5.5)	1 (negl)	120 (14.6)[b]
Sex					
Males	508 (73.5)	137 (19.8)[a]	45 (6.5)	1 (negl)	183 (26.5)[a]
Females	793 (84.1)	85 (9.0)[b]	63 (6.7)	2 (negl)	150 (15.9)[b]
Age (years)					
9-11	512 (86.5)	44 (7.4)[a]	36 (6.1)	0(0.0)	80 (13.5)[a]
12-15	789 (75.7)	178 (17.1)[b]	72 (6.9)	3(negl)	253 (24.3)[b]
Nutritional status					
Normal	905 (78.0)	165(14.2)[a]	88 (7.6)[a]	2 (negl)	255 (22.0)[a]
Thinness	22 (64.7)	7 (20.6)[b]	4 (11.8)[b]	1 (2.9)	12 (35.3)[b]
Overweight	250 (84.5)	35 (11.8)	11 (3.7)	0 (0.0)	46 (15.5)
Obesity	124 (86.1)	15 (10.4)	5 (3.5)	0 (0.0)	20 (13.9)

Hemoglobin levels used to diagnose anemia among the study children by age or sex are: non-anemic (hemoglobin ≥ 11.5 g/dL for 9-11 y, ≥ 12.0 g/dL for 12-14 y, ≥ 12.0 g/dL for girls 15 y or older, and ≥ 13.0 g/dL for boys 15 y or older); mild anemia (hemoglobin 11.0-11.4 g/dL for 9-11 y, 11.0-11.9 g/dL for 12-14 y, 11.0-11.9 g/dL for girls 15 y or older, and 11.0-12.9 g/dL for boys 15 y or older); moderate anemia (hemoglobin 8.0-10.9 g/dL for 9 y or older); and severe anemia (hemoglobin <8.0 g/dL for 9 y or older).Values in same column with different superscript are significantly different at $p<0.05$. negl: negligible (<0.5%)

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Table 4: Multivariable logistic regression analysis for the risk of anemia among SAC in Accra and Kumasi

Predictor variable	P-value	OR	95% CI
Age (years)			
12–15 [(a)]	-	-	-
9–11	0.972	1.01	0.74 - 1.38
City			
Kumasi[(a)]	-	-	-
Accra	0.002	1.65	1.44 – 1.83
BMI-for-age category			
Normal[(a)]	-	-	-
Underweight	0.021	2.60	1.11 – 5.75
Overweight	0.031	0.60	0.36 – 0.94
Obesity	0.270	0.70	0.36 – 1.27
Household size			
3 – 9[(a)]	-	-	-
10 – 22	0.055	1.90	0.95 – 3.56
Stunting status			
Normal[(a)]	-	-	-
Stunted	0.045	1.85	1.19 -3.10
Sex			
Female[(a)]	-	-	-
Male	0.072	0.75	0.54 – 1.02
Father's employment status			
Employed[(a)]	-	-	-
Unemployed	0.960	1.02	0.34 – 2.47
Mother's employment status			
Employed[(a)]	-	-	-
Unemployed	0.197	0.61	0.25-1.18

[a] Reference category

BMI: body mass index: underweight (≤ -2SD); normal (-2SD ≤ x ≤ +1SD); overweight (+1SD ≤ x ≤ +2SD); obese (≥ +2SD); Stunted: Height-for-age ≤ -2 Z score

REFERENCES

1. **Assefa S, Mossie A and L Hamza** Prevalence and severity of anaemia among schoolchildren in Jimma Town, Southwest Ethiopia. *BMC Hematology* 2014; 14:3.

2. **World Health Organization**. Hemoglobin concentrations for the diagnosis of anemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization, 2011 (WHO/NMH/NHD/MNM/11.1). Accessed January 2021 at (http://www.who.int/vmnis/indicators/haemoglobin.pdf).

3. **World Health Organization**. The Global Prevalence of Anemia. Geneva; 2015.

4. **Sharp P** Minerals and trace elements In: Geissler C and H Powers (Eds). Human Nutrition and Dietetics, 11 edn. London: Churchhill Livingstone, 2005; 241-244.

5. **Haas JD and T Brownlie** Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. *Journal of Nutrition* 2001; **131**: 676S-688S.

6. **De Benoist B, Erin M, Egli I and M Cogswell** Worldwide prevalence of anaemia 1993-2005. WHO Global Database on Anaemia. 2008; 1-51.

7. **Koukounari A, Estambale BBA, Njagi JK, Cundill B, Ajanga A, Crudder C, Otido J, Jukes MCH, Clarke SE and S Brooker** Relationships between anemia and parasitic infections in Kenyan schoolchildren: A Bayesian hierarchical modelling approach. *International Journal of Parasitology* 2008; **38(14-4):** 1663-1671.

8. **Ghana Demographic Health Survey (GDHS) 2014.** Ghana Statistical Service (GSS), Ghana Health Service (GHS) Accra, Ghana DHS Program ICF International, Rockville, Maryland, USA, October 2015.

9. **Egbi G, Steiner-Asiedu M, Saalia FK, Ayi I, Ofosu W, Setorglo J, Klobodu SS and M Armar-Klemesu** Anemia among schoolchildren older than five years in the Volta Region of Ghana. *Pan African Medical Journal* 2014; 17(Supp 1):10.

10. **Tohouenou MM, Egbi G, Ohemeng A and M Steiner-Asiedu** Anemia, Vitamin-A deficiency, Anthropometric Nutritional Status and Associated Factors among School Children in Kodzobi, Ghana, a Peri-urban Community. *African Journal of Food Agriculture Nutrition and Development* 2019; **19(2)**:14483-14499.

11. **Lartey A, Marquis GS, Aryeetey R and H Nti** Lipid profile and dyslipidemia among school-age children in urban Ghana. *BMC Public Health* 2018; 18:320.

12. **World Health Organization Growth Standards**; Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for- Age: Methods and Development. Geneva;2006. Available at http://www.who.int/childgrowth/standards (Accessed January 2021).

13. **Azupogo F, Aurino E, Gelli A, Bosompem KM, Ayi I, Osendarp SJM, Brouwer ID and G Folson** Agro-ecological zone and farm diversity are factors associated with haemoglobin and anemia among rural school-aged children and adolescents Ghana. *Maternal and child Nutrition* 22019;15:e12643. https://doi.org/10.1111/mcn.12643

14. **Tesfaye M, Yemane T, Adisu W, Asres Y and L Gedefaw** Anemia and iron deficiency among school adolescents: Burden, severity, and determinant factors in southwest Ethiopia. *Adolescent Health, Medicine and Therapeutics* 2015; **6**: 189–196.

15. **Calista N, Haikael DM, Neema K, Athanasia OM and J Kimiywe** Dietary practice, nutrient adequacy, and nutrition status among adolescents in boarding high school in the Kilimanjaro Region, Tanzania. *Journal of Nutrition and Metabolism* 2020; volume 2020, Article ID 3592813: 14. https://doi.org/10.1155/2020/3592813

16. **Baker RD and FR Greer** Committee on Nutrition American Academy of Pediatrics. Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0-3 years of age). *Pediatrics* 2010; **126(5):** 1040-50.

17. **Kweku M, Appiah EK, Enuameh Y, Adjuik M, Takramah W, Tarkang E and J Gyapong** The impact of malaria control intervention on malaria and anemia in children under five after ten years of implementation in the Hohoe Municipality. *Advances in Infectious Diseases* 2017; **7**: 93-105. https://doi.org/104236/aid.2017.73010

18. **Kweku M, Appiah EK, Takramah W, Enuameh Y, Norman I and F Binka** Effect of a malaria control program on the prevalence of malaria, fever and anemia in under five years in the Hohoe Municipality of Ghana: A Comparative Analysis of Cross-Sectional Surveys. *Advances in Infectious Diseases* 2015; **5**: 180-188. http://dx.doi.org/10.4236/aid.2015.54023

19. **Parbey PA, Tarkang E, Manu E, Amu H, Ayanore MA, Aku FY, Ziema SA, Bosoka SA, Adjuik M and M Kweku** Risk factors of anemia among children under five years in the Hohoe municipality, Ghana: A case control study. *Hindawi Anemia* 2019; Volume 2019 Article ID 2139717:9.

20. **Pardo G, Descalzo MA, Molina L, Custodia E, Lwanga M, Mangue C, Obono J, Nchama A, Roche J, Benito A and J Cano** Impact of different strategies to control plasmodium infection and anemia on the Island Biako (Equitorial Guinea). *Malaria Journal* 2006; 5:10. http://dx.doi.org/10.1186/1475-2875-5-10

21. **Obse N, Mossie A T Gobena** Magnitude of Anemia and associated risk factors among pregnant women attending antenatal care in Shella Woreda, West Arsi Zone, Oromia Region, Ethiopia. *Ethiopian Journal of Health Science* 2013; **23(2):** 165–73.

22. **International Institute for Population Sciences**: Nutritional Status of Children and Prevalence of Anemia among Children, Adolescents Girls and Pregnant Women. Munbai India, 2006.

23. **Kelley MV, Ofosu A, Kennedy A and DM Denno** Pediatric anemia in rural Ghana: A cross-sectional study of prevalence and risk factors. *Journal of Tropical Pediatrics* 2014; 60(4):308-317.

24. **Tezera R, Sahile Z, Yilma D, Misganaw E and E Mulu** Prevalence of anemia among school-age children in Ethiopia: a systematic review and meta-analysis. *Systematic Reviews* 2018; 7:80. https://doi.org/10.1186/s13643-018-0741-6

25. **Hall A, Bobrow EE, Brooker S, Jukes MCH, Nokes K, Lambo JK and ND Toan** Anemia in schoolchildren in eight countries in Africa and Asia. *Public Health Nutrition* 2009; **4(3):** 749.

26. **Abizari AR, Buxton C, Kwara L, Mensah-Homiah J, Armar-Klemesu M and ID Brouwer** School feeding contributes to micronutrient adequacy of Ghanaian schoolchildren. *British Journal of Nutrition* 2014; **112**: 1019–1033. https://doi.org/10.1017/S0007114514001585

27. **Abizari A, Moretti D, Zimmermann MB, Armar-klemesu M and ID Brouwer** Whole cowpea meal fortified with NaFeEDTA reduces iron deficiency among Ghanaian school children in a malaria endemic area. *Journal of Nutrition* 2012; **142**: 1836–1842. https://doi.org/10.3945/jn.112.165753

28. **Egbi G** Prevalence of vitamin A, zinc, iodine deficiency and anemia among 2–10 year- old Ghanaian children. *African Journal Food Agriculture Nutrition and Development* 2012; **12(2):** 5946–5958.

29. **Salama RA and MR Labib** Prevalence of anemia among informal primary school children: A community based study in rural Upper Egypt. *Epidemiology Biostatistics and Public Health* 2016; **13(1):** 1–7.