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ANAEMIA, VITAMIN-A DEFICIENCY, ANTHROPOMETRIC NUTRITIONAL STATUS AND ASSOCIATED FACTORS AMONG YOUNG SCHOOL CHILDREN IN KODZOBI, GHANA, A PERI-URBAN COMMUNITY

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ABSTRACT

Anaemia, vitamin-A deficiency and under nutrition are prevalent among children at levels of public health significance in developing countries of which Ghana is no exception. The objective of this study was to assess the anaemia, low vitamin-A level and anthropometric nutritional status of 162 randomly selected young Ghanaian school children 4 – 8 years in Kodzobi, a peri-urban community and establish associated factors. Questionnaires were used to collect background data from parents of study participants. Vitamin-A and haemoglobin concentrations were determined using High Performance Liquid Chromatography and Haemocue hemoglobinometer, respectively. Malaria parasitaemia was examined by the Giemsa staining technique. Weight and height measurements were taken according to WHO's standard procedures to assess participants' nutritional status. The mean haemoglobin and serum retinol concentrations were 11.6 ± 1.1 g/dl and 22.8 ± 6.5 μg/dl, respectively. Prevalence of anaemia and vitamin-A deficiency among study participants were 38.3 % and 24.0 %, respectively. The prevalence of underweight, stunting, thinness and overweight were 9.3 %, 9.9 %, 4.3 % and 3.7 %, respectively. Haemoglobin correlated positively and significantly with weight, weight-for-age and body mass index-for-age z scores. Child's sex, vitamin-A status and parental monthly income associated with anaemia status. Females had a higher risk of being anaemic compared to males (OR = 2.519; 95 % CI: 0.965 - 6.580; p = 0.049). Participants with normal vitamin-A concentration were at lower risk of being anaemic (OR = 0.302; 95 % CI: 0.109 - 0.840; p = 0.022) than those with low vitamin-A concentration. Anaemia and young child age negatively associated with vitamin-A status, at p = 0.039 and p = 0.037, respectively. Anaemia and vitamin-A deficiency are issues of public health importance among school-aged children in Ghana. There is, therefore, the need to invest in actions that prevent their occurrence and management especially among children of school going age.

Key words: Anaemia, vitamin-A deficiency, nutritional status, retinol, haemoglobin, school children, peri-urban

INTRODUCTION

Anaemia, Vitamin-A deficiency (VAD) and under nutrition are prevalent among children and are issues of public health interest in developing countries. Approximately 25.4 % of school-aged children in the world are anaemic with 40 % residing in developing countries [1]. In Ghana, a cross-sectional study conducted among a group of school children 2 - 10 years old indicated 36 % prevalence of anaemia [2]. Similar studies reported 66 % and 63 % prevalence of anaemia among children less than 5 years and between 5 to 12 years old respectively [3, 4]. Specifically, iron deficiency anaemia was prevalent among school children in the southern and northern parts of Ghana [3, 5]. Anaemia was the fourth cause of both hospital admissions and mortality for children under 5 years in Ghana [6]. There are a number of factors that are both nutritional and non-nutritional that cause anaemia. Nutritional anaemia is credited to deficiencies in iron, vitamin-A, vitamin-B_{12}, folate, zinc and ascorbic acid [7]. There had been attempts and there are still strategies to minimize the burden of anaemia among Ghanaian children. Most of these strategies include food fortification, dietary modification and diversification, access to and use of mosquito treated bed nets and nutrition education programs.

Nutritional status of school children has important implications for their physical, emotional and mental development. It also affects their school performance and academic achievements [8].

In Ghana, national surveys on the average have reported a downward trend in prevalence of stunting (35 % in 2003, 28 % in 2008 and 19 % in 2014), underweight (18 % in 2003, 14 % in 2008 and 11 % in 2014) and anaemia (78 % in 2008 and 66 % in 2014) for children under five years [3]. Another study reported 52 % and 47 % for prevalence of stunting and underweight, respectively [9]. A recent study on nutrient intake and nutritional status of school aged children in Ghana, reported that 67% of them had at least one nutritional deficit (anaemia, stunting, or thinness) [10].

Vitamin-A deficiency (VAD) is the most essential cause of avoidable childhood blindness and is a major contributor to morbidity and mortality from infections [11]. Vitamin-A deficiency and anaemia often co-exist as VAD may contribute to anaemia through its effects on iron metabolism, haematopoiesis and increased susceptibility to infections [12]. Gamble *et al.* found severe VAD was associated with anaemia among preschool children [13]. This implies that severe VAD may be a risk factor for anaemia and may have contributed to the pathogenesis of anaemia among those cohorts of preschool children investigated [13]. It is a fact that anaemia prevalence reduced repeatedly during simultaneous vitamin-A and iron supplementation [14, 15]. It has also been shown that both vitamin-A and iron supplementation had positive impact on vitamin-A and anaemia status in older children [14]. Anaemia and VAD are associated with high mortality rates (especially) in children under five years of age and in school-aged children [16]. Although nutritional deficiencies (like VAD), hookworm infection, and haemoglobinopathies [17, 18] may predispose children to the development of anaemia, evidence suggests that, malaria is one of the most important factors [16]. Other predisposing factors include increased pathogenic profile in the gut, inflammations,

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inhibitory food compounds and infections [19, 20]. Ghanaian school children are confronted with adverse effect of anaemia: low physical activity and low attention span, which can lead to poor academic achievement. Vitamin-A deficiency results in poor vision and increased susceptibility to infections. The consequences of these are poor growth, developmental and reproductive challenges.

The objective of the present study was to assess the prevalence of anaemia, vitamin-A deficiency and anthropometric nutritional status and associated factors in young school children 4 – 8 years in Kodzobi, a peri-urban community. The findings would form a basis for nutrition program planning, education and inform policy.

MATERIALS AND METHODS

Study Design and setting

This was a cross-sectional study that assessed anaemia, vitamin-A, and anthropometric nutritional status (underweight, stunting and thinness) of school children 4 – 8 years in Kodzobi, Volta Region a peri-urban Ghanaian community. The study setting was selected by simple random sampling. It is a subsistence crop farming area with savannah vegetation, and patches of forest zones. Initial observations based on the current study showed that inhabitants are subsistence farmers cultivating mainly cassava, cowpea and groundnut for consumption and livelihood.

The age range (4 – 8 years) was considered because among this group of children, severe micronutrient deficiencies have been demonstrated to cause growth faltering with adverse effect on cognitive development [21]. The current study presents baseline data collected with the intention of carrying out a future nutrition intervention to improve the haemoglobin and serum vitamin-A concentrations of the study participants. A sample size of 172 children was estimated based on a standardized effect size of 0.5, with expected effect size and standard deviation from a previous pre and post intervention study in the community using 80 % power and 0.05 confidence level plus 20 % expected fall out rate [22]. Children participating in an existing Ghana government school feeding program were randomly sampled to participate in this study.

Data collection

Interviews were used to collect data on background characteristics (sex, age, occupation, education and monthly income) from parents of the study participants using open-ended and semi-structured questionnaires.

Anthropometric assessment

The weight and height measurements of each participant were taken in triplicates to the nearest 0.1 kg and 0.1 cm with the Precision Health Scale UC-300 (from A and D Company Limited, Higashi-Ikebukuro, Toshima-Ku, Japan) and a standardized stadiometer (Model HM200P Chander, USA), according to World Health Organization standard procedures, respectively [23]. The average of each triplicate measurement was considered as the actual weight and height of each participant.

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Biochemical assessment

A qualified phlebotomist collected 2 ml of fasting venous blood by venepuncture from each participant early in the morning before breakfast meal. Venous blood samples collected were transported on ice packs to the central laboratory of the Volta Regional Hospital (commonly known as TRAFALGA). Each blood sample was centrifuged at 2,500 rpm for 15 minutes and aliquots of serum, pipetted into 1.5 ml Eppendorf tubes, transported on ice-chips to Noguchi Memorial Institute for Medical Research (NMIMR) and stored at -800 ºC until analysed.

Haemoglobin concentration for each participant was determined immediately after sampling in duplicates with the Haemocue Hemoglobinometer-Hb-201 (HemoCue AB Angelhom, Sweden). The average readings were taken as the actual haemoglobin concentration for each participant.

Serum samples were analysed for retinol concentration according to NMIMR retinol analysis protocol [25]. One milligram of retinol standard (from Sigma Aldrich) in ethanol with 0.1 % (w/v) Butylated Hydroxytoluene was dissolved in 1 ml methanol. Six serial dilutions in the range of 0.016 – 0.50 mg/ml were made from the 1 mg/ml stock with 500 µl of methanol. One hundred and twenty microliters of each serial dilution of the reference vitamin-A standard was injected into the HPLC system. The resultant peaks were plotted against their respective concentrations to establish a standard calibration curve. The operation wavelength was 350 nm at a flow rate of 1ml per minute with a retention time of six minutes. Serum retinol concentrations were determined from the calibration curve using the respective peak areas.

Parasitological examination

While in the field, thick and thin blood smears were prepared from the blood sample of each participant in duplicates using the Giemsa staining technique [24]. The Giemsa stained microscopic slides were examined by microscopy for presence or absence of Plasmodium falciparium parasites.

Data analysis

Data collected on each participant were doubly entered into the computer with Epi Info™ 7, cleaned, exported to the Statistical Package for Social Sciences (SPSS version 23) for analyses. Data on height, weight, age and sex were used to calculate Z-score nutritional indices. Children were classified as underweight, stunted or thin when their calculated weight-for-age, height-for-age, and body mass index-for-age Z-scores, were ≤ –2 standard deviations.

Participants were identified with anaemia using age specific cut-off point for haemoglobin (Hb) concentrations: Hb concentrations < 11.0 g/dl for children 0 to 59 months and < 11.5 g/dl for children 5 – 11 years [26]. Serum retinol concentrations: < 20 µg/dl (< 0.70 µmol/l), 10 - 20 µg/dl (0.35 - 0.70 µmol/l) and < 10 µg/dl (< 0.35 µmol/l) were considered as low vitamin-A, moderate vitamin-A, and severe vitamin-A deficiency respectively [27]. All measured variables were checked for normality. Haemoglobin, serum retinol, weight and height values were normally distributed.

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Summary data are presented as means plus or minus standard deviations or otherwise as proportions. Data comparison between male and female sexes was done for differences in anthropometric measures, haematological and biochemical variables using paired t-tests. Between groups, significant differences for continuous variables were carried out using independent t-test. Chi-square test was used to establish significant differences in percentages or proportions for categorical variables (anaemia, VAD, stunting, underweight, thinness, malaria).

Ethical approval

Ethical approval to carry out this research was obtained from the Institutional Review Board (IRB) of Noguchi Memorial Institute for Medical Research, College of Health Sciences, University of Ghana, Legon. The District Directorate of Education, the chief and elders of Kodzobi as well as the Head teacher of Adaklu Kodzobi basic school gave permission for the study to be executed. Both parents and children gave their consent after the study protocol was thoroughly explained to them.

RESULTS AND DISCUSSION

This study assessed the anaemia, vitamin-A, anthropometric nutritional status, malaria parasitaemia and hookworm status of school children 4 - 8 years old in Kodzobi, a peri-urban community in Ghana and established factors linked to anaemia and vitamin-A status. One hundred and sixty-two children out of 172 parents and children who consented to participate in the study provided biological (blood and stools) samples. Ten participants did not provide biological samples because of health, cultural or religious reasons. Data from the 162 participants were, thus, analysed and presented in this paper.

Characteristics of the study participants

Fifty one percent and forty nine percent of participants were male and female, respectively (Table 1). The mean age of the participants was 7.17 ± 1.67 years. Ninety five percent of participants' households were registered with the National Health Insurance Scheme. Most of the parents of the study participants (90.7 %) were peasant farmers and traders engaged in petty-trading respectively. Most of the parents (95.7 %) earned from 280 to 498 Ghana cedis equivalent to 62 to 110 United States dollars (UDS) monthly (Table 1).

Anaemia and vitamin-A status

The mean haemoglobin concentration was 11.6 ± 1.1 g/dl (Table 1). The females had a significantly higher prevalence of anaemia (43.0 %) than males (34.0 %), p= 0.047 (Table 2). A previous study among urban school children aged between 5 and 15 years also recorded a significantly higher prevalence of anaemia in females compared to males [2]. This could be due to the fact that generally females tend to be more anaemic because of their biological make up. Females also often have lower overall dietary intake and, in turn, iron intake compared to males [28]. Probably males were meeting requirements out of home because they are more exploratory in nature and may have access to other iron rich fruits and vegetables. Malaria was more prevalent among females than males in this study and that could also have contributed to the higher anaemia prevalence in the females. Conditions such as iron, folate, vitamin-B_{12} and vitamin-C deficiencies, malaria, hookworm infections and inflammations are documented to cause anaemia even though the study did not investigate all these variables [29].

The mean serum retinol concentration of the participants was 22.8 ± 6.5 µg/dl (Table 2). The prevalence of vitamin-A deficiency: serum retinol < 20 µg/dl was 24.0 % (Table 2). The prevalence of vitamin-A deficiency (VAD) in the current study was lower than reported in a study conducted among children 2 to 10 years old in Eastern Region of Ghana [30]. The prevalence of VAD reported among children in Benin City (29.6 %) [31], was similar to that of the present study. The present finding shows that VAD is still of public health concern among children in the study community as shown by serum retinol concentration cut offs [32].

The prevalence of malaria parasitaemia and hookworm infestation were 30.9 % and 0.6 %, respectively. Ghana is a malaria prone country and studies have indicated that approximately 20,000 children die from malaria every year [33]. Malaria in turn causes intravascular haemolysis with subsequent blood loss and poor immune response, which suppresses erythropoietin and erythropoiesis [34]. Studies have shown that the levels of low vitamin-A status and malaria parasitaemia observed among the female participants may partly be responsible for the high prevalence of anaemia among them compared to their male counterparts in this study. Inadequate intakes and poor bioavailability of haematopoietic nutrients such as iron, folic acid, vitamin-B_{12} and vitamin-A may also contribute to anaemia.

Data gathered from food frequency questionnaire interviews and focus group discussions indicated that vegetables, fruits, meat and meat products consumption, were scarce at household level (thirty percent of participants consumed meat, vegetables and fruits at most twice in a week during the data collection period). Non-haem iron absorption is enhanced by vitamin-C which is largely found in fruits. Cereal, roots and tubers were the staple plant-based foods available to the study participants and their household members (all participants reported consuming fish, cereals, legumes roots and tubers daily during the data collection period). Anti-nutritional factors such as polyphenols, phytic acid in whole grains, oxalates and tannins found mostly in plant-based foods, are able to reduce bioavailability of non-haem iron [35]. Thus, consumption of plant staple foods might have partly contributed to nutritional anaemia among the participants.

Nutritional status

Nutritional status of children could be implicated as an important indicator of their health status. The trend of underweight, stunting, thinness and over nutrition (overweight plus obesity) were 9.3 %, 9.9 %, 4.3 % and 3.7 %, respectively with no significant gender differences observed, $p<0.05$, (Table 2). The level of undernutrition observed among the study children was lower than that reported in previous studies among other children in Ghana [9, 10]. Stunting, which is an indicator of chronic malnutrition, reflects failure to receive adequate nutrition over a long period. It represents the long-term effects of undernutrition in a population. It is not sensitive to recent, short-term changes in dietary intake. Stunting could be promoted by recurrent and chronic illness as well as socio-economic factors. For these reasons, wide variations in the prevalence of stunting have been observed in different countries [8, 36, 37].

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The prevalence of stunting in this study was lower than that reported in the 2014 Ghana Demographic Health Survey [3] and in an earlier study in the Ashanti Region of Ghana where prevalence of stunting was 52 % [9]. Contrary to the present findings where more girls were stunted (11.0 %) than boys (8.0 %), a systematic review showed that boys were more stunted than girls in sub-Saharan Africa [38]. Unlike this study, the systematic review recruited children from 10 different countries, while this study's participants were more homogenous, living in the same community and sharing the same resources. Other factors that could affect height of school-age children are genetic, ethnicity, hormonal changes and pubertal growth spurt [37].

Low educational level of parents could negatively influence parents' capacity to show health-related behaviour or provide high-quality care [39]. Parents with low education tend to receive low income, resulting in household food insecurity. Both low-quality care and household food insecurity can result in undernutrition of children [39]. Except for height and height-for-age Z score, haemoglobin correlated positively and significantly with all the anthropometric variables in this study (Table 3).

Factors associated with vitamin-A and anaemia status

Gender, vitamin-A status and parental monthly income levels were the factors significantly associated with anaemia status of the participants (Table 4). The female participants were at a higher risk of being anaemic than the male participants (OR = 2.519; 95 % CI: 0.965 - 6.580; p = 0.049). Participants with normal vitamin-A status were at lower risk of becoming anaemic compared to those with low vitamin-A status (OR = 0.302; 95 % CI: 0.109 - 0.840; p = 0.022) (Table 4). Results from this study showed that absence of anaemia (OR = 0.355; 95 % CI: 0.120 - 0.935; p = 0.037) and child age (OR = 1.305; 95 % CI: 1.013 - 1.680; p = 0.039) were the factors significantly associated with vitamin-A status (Table 5). In addition, the findings indicated that participants with low vitamin-A status were three-fold more likely to develop anaemia compared to those with normal status. It can be inferred that normal vitamin-A concentration or the factors that lead to it protected against nutritional anaemia in the study participants. On the other hand, study participants with normal haemoglobin levels (> 110 g/L for 0-59 month and > 115 g/L for 5 - 11 years old) had a lower risk of being vitamin-A deficient.

Studies have shown that vitamin-A deficiency may contribute to anaemia through its effects on iron metabolism, haematopoiesis and increased susceptibility to infections [13]. The two conditions often co-exist, as has been reported in school-aged children [8, 17]. The present study is a confirmation of the evidence in school children. The result (**Table 4**) indicated that participants whose parents had monthly income less than GH₵ 500.00 (110.00 USD), were about six times more likely to be anaemic (OR= 5.731; 95 % CI: 1.106 - 9.550; p = 0.042). Studies in Ghana and elsewhere in Africa point to the fact that the various socio-economic status indicators such as parental income level and family assets were associated with children's nutritional status [39, 40]. The lower the income, the less likely the family may be able to afford iron rich foods, especially animal-based foods which are rich in haem iron. Many Ghanaian households consume mainly

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staple plant-based foods that even though contain appreciable levels of non-haem iron, are poorly bioavailable for absorption.

CONCLUSION

Anaemia and vitamin-A deficiency exist as issues of public health importance among the study participants. The various factors observed to be associated with anaemia (child's sex, vitamin-A status and parental monthly income) and vitamin-A status (child age and anaemia) of the participants could be considered in designing target interventions to improve their nutrition and health status.

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Table1: Background characteristics of study participants

Variable	Males (n=82)	Females (n=80)	Total (n=162)
Mean age	7.31 ± 1.69	7.02 ± 1.66	7.17 ± 1.67
Household NHI status			
Registered members	93.8	95.6	95.1
Non-registered members	6.2	4.4	5.6
Parental ages (years)			
≤ 20 – 30	89.0	88.8	88.9
31 – 40	2.4	6.2	4.3
41 – 50	6.1	3.7	4.9
51 – 60	2.4	1.2	1.9
Parental occupation			
Formal sector employment	12.5	8.9	10.5
Informal sector employment	87.5	91.1	90.7
Parental education			
Formal education	92.0	95.6	93.8
Informal education	8	4.4	6.8
Parental monthly income GH₵ (USD)			
GH₵280 - 498 (62 – 110USD)	97.9	93.3	95.7
GH₵499 - 720 (111 – 160USD)	2.1	6.7	4.3

Values are mean plus or minus standard deviations, otherwise percentages
NHIS-National Health Insurance
GH₵: Ghana Cedi
USD: United States Dollars (1USD = 4.5 GH₵)

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Table 2: Biochemical and anthropometric indices of male and female study participants

Variable	Males (n=82)	Females (n=80)	Total (n=162)	Pv
Haemoglobin (g/dl)	11.6 ± 1.1	11.7 ± 1.2	11.6 ± 1.1	0.751
Anaemic, Hb <11.5 g/dl (%)	34.0	43.0	38.3	0.047
Serum retinol (ug/dl)	21.7 ± 7.1	23.9 ± 5.7	22.8 ± 6.5	0.095
Low retinol <20 µg/dl (%)	30	18	24	0.056
Mean weight (kg)	22.5 ± 4.2	22.0 ± 4.6	22.3 ± 4.4	0.607
Mean WAZ Score	-0.554 ± 0.944	-0.496 ± 0.993	-0.526 ± 0.964	0.772
Underweight, WAZ Score<-2SD (%)	10.0	9.0	9.3	0.574
Mean height (cm)	120.7 ± 10.9	119.7 ± 11.5	120.2 ± 11.1	0.680
Mean HAZ Score	-0.599 ± 1.166	-0.542 ± 1.168	-0.571 ± 1.161	0.815
Stunting, HAZ Score<-2SD (%)	8.0	11.0	9.9	0.574
Mean BMIAZ Score	-0.240 ± 0.913	-0.218 ± 0.937	-0.229 ± 0.920	0.911
Thinness, BMIAZ Score<-2SD (%)	3.0	5.0	4.3	0.469
Overweight (%)	3.0	2.0	2.5	0.751
Obese (%)	2.0	0.0	1.2	0.660
Malaria parasitaemia (%)	29.0	32.0	30.9	0.404

Values are mean plus or minus standard deviations, otherwise percentages
Pv statistical significance levels were determined using independent t-test or otherwise Chi-Square test.
P values were set at $p<0.05$. Abbreviations: (Hb) haemoglobin; (WAZ) Weight-for-Age-Z Score; (HAZ) Height-for-Age-Z Score; (BMIAZ) Body Mass Index-for-Age-Z Score

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Table 3: Correlation between measured variables in the study participants

	Weight	Height	WAZ	HAZ	BMIAZ	HB
Weight	1					
Height	0.834**	1				
WAZ	0.474**	0.283**	1			
HAZ	0.438**	0.540**	0.767**	1		
BMIAZ	0.203	-0.193	0.629**	0.027	1	
HB	0.274**	0.179	0.287**	0.199	0.207*	1

Person correlation * p < 0.005: **p < 0.001. Abbreviations: (Hb) haemoglobin; (WAZ) Weight-for-Age-Z Score; (HAZ) Height-for-Age-Z Score; (BMIAZ) Body Mass Index-for-Age-Z Score

Table 4: Factors associated with Anaemia status among the participants

Factor	Odds ratio	95% CI	P value
Child sex			
Female	2.519	0.965 – 6.580	0.049*
Male (r)			
Vitamin-A status			
Normal vitamin-A status	0.302	0.109 – 0.840	0.022*
Low vitamin-A status (r)			
Malaria status			
Malaria parasitaemia absent	0.591	0.219 – 1.596	0.299
Malaria parasitaemia present (r)			
Parental monthly income			
GH₵280 - 498	5.731	1.106 – 9.550	0.042*
GH₵499 - 720 (r)			
Parental marital status			
Divorced/unmarried	1.253	0.461 – 3.404	0.658
Married (r)			
Parental educational status			
Formal education	0.347	0.059 – 2.035	0.241
No formal education (r)			
Age	1.105	0.099 – 1.236	0.935
Age group			
4 – ≤ 5 years	0.896	0.167 – 4.677	0.715
> 5 – 8 years (r)			

*Factors whose association with anaemia was significant at p < 0.05
Abbreviations: (CI) Confidence Interval; (r) Reference category
USD: United States Dollars (1USD = 4.5 GH₵)

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Table 5: Factors associated with vitamin A deficiency among the participants

Factor	Odds ratio	95% CI	P value
Child age	1.305	1.013 – 1.680	0.039*
Anaemia status			
Non-anaemic	0.335	0.120 – 0.935	0.037*
Anaemic(r)			
Parental marital status			
Married	0.430	0.159 – 1.164	0.097
Divorced or unmarried (r)			
Malaria status			
Malaria Parasitaemia present	1.593	0.544 – 4.663	0.395
Malaria Parasitaemia absent (r)			
Parental monthly income			
GH₵280 - 498	0.736	0.137 – 3.960	0.721
GH₵499 - 720 (r)			
Child sex			
Male	0.378	0.133 – 1.075	0.068
Female (r)			
Age group			
4 – ≤ 5 years	2.794	0.826 – 9.441	0.099
> 5 – 8 years (r)			

*Factors' whose association with vitamin A status was significant at $p < 0.05$
Abbreviations: (CI) Confidence Interval; (r) Reference category
USD: United States Dollars (1USD = 4.5 GH₵)

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