Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.2, 2014

Factors Associated with Haemoglobin Prevalence among Ghanaian Children Aged 6 – 59 months.

Michael Ofori Fosu[1*] Frank Osei Frimpong[2] Michael Ofori Arthur[3]

1. Lecturer, Department of Mathematics and Statistics, P.O Box 854, Kumasi Polytechnic, Ghana
2. Lecturer, Department of Mathematics and Statistics, P.O Box 854, Kumasi Polytechnic, Ghana
3. National Service Personnel, Department of Mathematics and Statistics, P.O Box 854, Kumasi Polytechnic, Ghana

*E-mail: mikeoffos@yahoo.com

Abstract

This study was undertaken to assess the prevalence of anaemia and to investigate various factors associated with haemoglobin (Hb) prevalence in children aged 6–59 months in Ghana. The data set used was based on a longitudinal study from the fourth round Multiple Indicator Cluster Survey (MICS). This was a national survey conducted by Ghana Statistical Service (GSS) to monitor the progress of women and children. A sample of 7,626 children under-five years across the country between 2009 and 2011 were selected for the survey.

Multiple logistic regression and bootstrap technique for parameter estimates were used to determine the relationship of biological, socio-economic, nutritional and other factors associated with Hb concentration. The prevalence of anaemia among children between 6 – 59 months in Ghana found in this study was 64.7% which is quite high even though lower than the 2008 GDHS rate of 78%. This is so because it is still higher than the WHO cut-off point of 40% making it a serious public health concern. The highest rate of 36.2% occurs within the 6 – 23 months. The factors observed to be highly significantly associated with anaemia among these children included malaria prevalence (p-value=0.000), age of the child (p-value=0.000), household economic status (0.000), region of residence (p-value=0.000), mothers educational level (p-value=0.000) and sex of the child (p-value=0.000). All other factors considered such as area of residence and ethnicity were not significant (p-values > 0.05).

In a nutshell, children who are born to more advantaged women who have high educational levels, economically sound, live in areas that are not infested with malaria, live in the southern part of Ghana and are females have low probability of becoming anaemic than their counterparts who are disadvantaged and live in malaria prone environment.

Keywords: Haemoglobin, Prevalence rate, Anaemia, Malaria, Socio-Economic

1. Introduction

More than 100 million African children are thought to be anaemic (DeMaeyer E and Adiels-Tegman M 1985), and community-based estimates of anaemia prevalence (blood haemoglobin concentration (Hb) <11 g/dl) in children in settings where malaria is endemic range between 49% and 76% (DeMaeyer E et al 1985; Premji Z et al 1995; Muhe L et al 1999; McElroy PD et al 2000 and May J et al 2000). The consequences, in terms of years of life lost, of such a high level of anaemia are hard to quantify, although the burden of malaria-associated anaemia has been estimated at 190,000–974,000 deaths per year in children-under 5 years of age (Murphy SC and Breman JG 2000). Certainly, children admitted to hospital with severe anaemia (Hb <8 g/dl) are more likely to die than children admitted without anaemia, and anaemia is one of the largest killers of children admitted to hospital in sub-Saharan Africa (Schellenberg D et al 1999; Marsh K et al 1995; Slutsker L et al 1994). Even where blood transfusions are available there is a significant case fatality rate of 6–18% (Schellenberg D et al 1999; Lackritz EM et al 2003; Bojang KA et al 1997). However, most children at high risk of severe anaemia live beyond the easy reach of a hospital, the most common type of health facility that can perform blood transfusions.

The causes of anaemia are often multifactorial and are interrelated in a complex way. First, the relative importance of each factor — for example, hookworm or malaria — varies in different settings (Rawlins SC et al 1991; Hall A et al 1982). Anaemia may be chronic — for example, secondary to iron deficiency, infection with human immunodeficiency virus (HIV), or intestinal worms — or it may be acute, owing to a sickle-cell crisis or *Plasmodium falciparum* infection, or chronic anaemia may be acutely exacerbated. The situation is complicated further because anaemia in childhood can result not only from events in childhood but also from maternal iron deficiency and anaemia, which are associated with impaired fetal development and iron-deficient and anaemic babies (Sweet DG et al 2001; Singla PN et al 1996; Jaime-Perez JC et al 2000; Menendez C et al 1997).

Socioeconomic status may also affect the risk of anaemia by affecting nutritional status, family size, and birth interval, as well as intensifying problems of affordability and accessibility of preventive and curative measures. Studies in East Africa have shown that *P. falciparum* malaria and iron deficiency account for much of the anaemia seen in young children (Menendez C et al 1997; Newton CRJC et al 1997). One randomized study concluded that approximately 60% of anaemia in infancy could be prevented by antimalarial chemoprophylaxis, illustrating the importance of malaria as a cause of anaemia in this setting (Menendez C et al 1997).The same study also found that iron supplementation reduced the incidence of anaemia by about 30%. In the same area, the prevalence of helminths in children under 5 was only 2% (Gascon J et al 2001), and genetic causes of anaemia, such as sickle-cell disease, were present, but at relatively low prevalence (Menendez C et al 1997; Clegg JB et al 1999). The public health importance of anaemia resulting from HIV infection is not yet clear and is difficult to quantify. The control of anaemia depends largely on the diagnosis and treatment of anaemia cases, rather than on the prevention of anaemia. However, clinical examination for detecting anaemia in young children is only moderately sensitive (24–74% for an Hb <11 g/dl and 37–81% for an Hb <8 g/dl) (Weber MW et al 1997; Van den Broek NR et al 1999; Muhe L et al 2000) and may be particularly problematic in very young children examined by relatively poorly trained staff in the primary care setting (4–20%) (Stoltzfus RJ et al 1999).Various diagnostic tests exist but all reliable approaches require some equipment that is not readily available in many settings. In terms of prevention, insecticide-treated mosquito nets (ITNs) have been shown to improve haemoglobin concentration in children living in malaria endemic areas (Lengeler C et al 2003), but only recently has a potentially sustainable approach to the distribution of ITNs been shown to have similar effects (Abdulla S et al 2001). It will take some considerable time before systems for the delivery of ITNs are functional on a large scale. The WHO/UNICEF (United Nations Children's Fund) iron supplementation policy recommends daily iron supplements starting at age 6 months for most children and continuing up to 2 years (Stoltzfus R et al 1998). However, this policy is rarely implemented due to the non-availability of a liquid ferrous sulphate preparation and the absence of a mechanism to deliver supplements to the target group.

Iron deficiency and anaemia continue to be two important public-health problems in developing counties. An estimated more than two billion people suffer from iron-deficiency anaemia worldwide (UNICEF, 1998). Young children and pregnant women are most affected around the world (WHO and UNICEF, 2001). Anaemia is defined as a low haemoglobin (Hb) concentration, and the cut-off value of 11 g/dl for children aged 6–59 months usually applied (De Pee S et al 2002) in settings where malaria is endemic ranges from 49% to 76% (UNICEF 2001, McElroy PD et al 2000, May J et al 2000). Anaemia has been shown to affect cognitive development, shorten attention span, and cause irritability, fatigue, difficulty with concentration, lethargy, increased mortality, and susceptibility to infection. Consequently, anaemic children tend to perform poorly on vocabulary, reading and other tests (Parker L, 1989). However, with appropriate preventive programmes, many cases of anaemia, including iron-deficiency anaemia, can be prevented in children.

Associated factors for Hb concentration among children aged 6–59 months in past studies included iron supplementations, home-prepared vegetable puree meal, intake of iron from meat, sex differences, age of child, bioavailability of iron in the diet, serum retinol concentration, diarrhoea, supply of clean water, environmental sanitation, and low birth weight (Aikawa R et al 2006, Osório MM et al 2004, Engelmann MD et al 1998, Wieringa FT et al 2007, Domellöf M et al 2002).

The 2011 Multiple Indicator Cluster Survey (MICS) (GSS, 2011) report indicated that the overall prevalence of anaemia among Ghanaian children less than five years (adjusted Hb less than 11 g/dl) was 57%, a significant decline compared to 78% in the 2008 Demographic and Health Survey (DHS) (GSS/MOH, 2008) Children aged 12 – 23 months had much higher levels at 71%, compared to the rest in the group, whilst the prevalence in the 48 – 59 months old group was 48%. It also showed some variations among disadvantaged children and the privileged ones. Although there has been a notable improvement since 2008, these rates are still above 40% which is the WHO cut-off point for a severe public health problem. The report further indicates massive regional variations which call for studies to find out why these differentials exist in order to prefer solutions to them.

Adequate planning of child health and nutrition programmes in Ghana requires the availability of recent data from population-based surveys, including information on growth and other nutritional deficiencies. Thus, knowledge about factors associated with Hb. concentration in children is essential for building effective prevention programmes. Identification of risk factors would assist targeting children who are at a heightened risk of low Hb concentration. However, very few studies have been reported from Ghana that analysed some factors associated with Hb concentration among children aged 6–59 months. Documenting the epidemiology of anaemia in as African communities a whole and Ghana in particular may offer fresh insights into potential control strategies. With this in mind we explore possible reasons for this high prevalence by building a multiple regression model of biological, socio-economic, nutritional and other factors associated with Hb concentration in a representative sample of children aged 6 – 59 months in Ghana.

2. Data

The 2011 Multiple Indicator Cluster Survey data was used in this study. This is a fourth round of the survey which is conducted every five years to monitor the situation of children and women in Ghana. In this survey about 10,963 women who were within the reproductive age (15 – 49 years) were selected across the ten Regions of Ghana. The subjects were interviewed reference to two years preceding the survey. The selection procedure was based on a representative probability sample of households nationwide from a frame of Ghana 2010 Population and Housing Census Enumeration Areas (EA's). For comparability, the MICS used an internationally standardized sampling of two-stage stratified sample design. At the first stage, a number of EA's were selected from the regions which were considered as clusters. The households in each region were then selected using systematic sampling with probability proportional to size in the second stage. Of the 12,150 households selected for the sample, 11, 925 households were contacted and duly interviewed. In the households interviewed, 10,963 women aged 15 – 49 years were identified for interview.

3. Methodology

This paper uses a data set based on the 2011 MICS. The survey was carried out on a sample of 11,925 households from a selected household of 11,970 in all the ten administrative regions of Ghana giving about 100% response rate. The households were selected due to the sizes of the regions. The survey used both qualitative and quantitative methods of data collection aimed at providing basic data for measuring the progress of children and women in the country. Data used for analysis in this paper was based on information on the 7626 under-five children who were interviewed in the survey. Out of this number 4609 (60.4%) availed themselves for the Hb testing and were subsequently drawn into our analysis. However, 4516 (59.2%) of these children underwent the malaria rapid test. Statistical package for social scientists (SPSS version 20) and SAS system version 9.2 were used for extraction and the eventual analysis of data. Descriptive statistics and frequencies of the background characteristics of the mothers and the respective households the children belong to were generated. The association between the independent and dependent variable was established using chi-square analysis procedures. The dependent variable selected was the outcome of the results of the haemoglobin (Hb) test that was carried among the under-five children in the survey whether a child's Hb level was normal or otherwise. Our distinction was based on the WHO/UNICEF/INACG 1998 definition of anaemia among 6 months to five years children which is Hb below 11 g/dL or 33% Hematocrit. In our analysis, we used 0 for Hb < 11 g/dL and 1 for Hb ≥ 11 g/dL. The independent variables included sex of the child, rapid malaria test results, age of the child, region, area of residence, economic status of the child's household and mothers' characteristics including; education, ethnicity and age. A critical level of significance of 5 percent ($p<0.05$) was used to identify the most statistically significant determinants of under-five anaemia at the household level

3.1 Model Specification

The following generalized linear logistic model was used

$$\pi = \log\left(\frac{u}{1-u}\right) = \chi\beta + \mathcal{E} \qquad (1)$$

Where π links the linear function to $\log\left(\frac{u}{1-u}\right)$. The link is not a linear function, μ is the probability of being anaemic and χ is the model matrix including child's age, mothers' educational level, economic status of household, location of child, malaria prevalence, and sex of baby. The matrix also includes geographical location, such as region of origin and whether the respondent is from rural or urban environment; β is the vector of parameters, and $\mathcal{E}$ is the vector of residuals. The Fisher scoring method was applied (SAS, 2007) to obtain Maximum Likelihood estimates of β. The overall goodness of fit is derived from the Likelihood Ratio Test of the hypothesis $H_{0:}$ $c(\beta) = 0$ where a comparison is made between the full model and the model that contains only the intercept (Hilbe and Greene, 2008). Therefore it is a test for global null hypothesis of the elements of the solution vector.

The odd of an event is the probability that it would happen to the probability that it would not occur and the likely number of times. In this paper it is the probability that a child will be anaemic to the probability that the child would not be anaemic. This means that the outcome variables in the logistic regression should be discrete and dichotomous. Logistic regression was found fit to be used because the outcome variable was in binary form that is a child within 6 – 59 months is anaemic or otherwise non anaemic. In addition, there were no assumptions to be made about the distributions of the explanatory variables as they did not have to be linear or equal in variance within the group. The model suggests that the likelihood of a particular household having an anaemic child varies across all the independent variables to be studied. After fitting the model, the outcomes were used to interpret the existing relationships between ones' child being anaemic, household structure and mothers' characteristics.

2.2 Goodness of fit test

For basic inference about coefficients in the model the standard trinity of Likelihood-based tests, Likelihood ratio, Wald and Lagrange Multiplier (LM), are easily computed. For testing a hypothesis, linear or nonlinear, of the form;

$$H_{0:}\, c(\beta)=0 \qquad (2)$$

The likelihood-ratio statistic is the obvious choice. This requires estimation of β subject to the restrictions of the null hypothesis, for example subject to the exclusions of a null hypothesis that states that certain variables should have zero coefficients. That is, they should not appear in the model. Then the likelihood-ratio statistic;

$$X^2\,[J] = 2(logL - logL_0) \qquad (3)$$

where $logL$ is the log-likelihood computed using the full or *unrestricted* estimator, $logL_0$ is the counterpart based on the restricted estimator and the degrees of freedom J, the number of restrictions. Each predictor, including the constant, can have a calculated Wald Statistic defined as

$$[\beta_j / SE(\beta_j)]^2, \qquad (4)$$

which is distributed a X^2. $[\beta_j / SE(\beta_j)]^2$ defines both the z or t statistic, respectively distributed as t or normal. For computation of Wald Statistics, one needs the asymptotic covariance matrix of the coefficients.

4. Results

The anaemia prevalence among under-five children in this study was 64.7% (from our sample of non-missing weights). This figure is quite staggering and indicates a public health concern as it is way higher than the minimum threshold of 40%. Table 1 provides a descriptive view of the different categories. Male sex according to the findings tends to be more anaemic than their female counterparts (about 52% versus 48%). At the regional levels, the three northern regions have high rates compared to other regions. The highest coming from northern region with about 26.1% followed Upper West with about 15.2%. Central region follows fourth with a prevalence of 9.0%. Eastern region has the least prevalence rate of about 4.7% in the country. Children from rural households, those from the poorest households and those whose mothers have no education or a maximum of middle/JHS school education are more likely than more advantaged children to become anaemic. For example, the proportion of anaemic children whose mothers have a maximum of middle/JHS education is 94.5%, compared to 5.5% of children whose mothers have a minimum of secondary school education. Children from rural households are likely to have anaemia compared to those in urban households (75.6% versus 24.4%). Children born in wealthiest households are more likely to have normal Hb levels compared to children from poorest households. The possibility of a child becoming anaemic is higher among children under two years and reduces as they age to their fifth year. For example more children were found to be more anaemic during their second year birth than even the first year. The prevalence of anaemia among under-five children is more pervasive among those who have malaria parasites in their blood stream than those found not to be infected with any malaria parasites. About 44% of the children who tested Positive for both falciparum and OMV were found to be anaemic.

Table 2 and table 3 depict the results of multivariate logistic analysis and the bootstrap parameter estimates of the factors associated with anaemia respectively. The factors observed to be highly significantly associated with anaemia included malaria prevalence (p-value=0.000), age of the child (p-value=0.000), household economic status (0.000), region of residence (p-value=0.000), mothers educational level (p-value=0.000) and sex of the child (p-value=0.000). Table 3 confirms the significance or otherwise of the variables understudied as evidenced by the two-tailed test and biases associated with it. Confounder control by multiple logistic regression analysis revealed that significance factors (in order of odds ratio) were child's age, malaria prevalence, economic status, region of residence, mothers' educational level and child's sex.

5. Discussion

The 64.7% prevalence of anaemia among children between 6 – 59 months in Ghana found in this study is quite high even though lower than the 2008 GDHS rate of 78%. This is so because it is still higher than the WHO cut-off point of 40% making it a serious public health concern. The highest rate of 36.2% occurs within the 6 – 23 months. The descriptive statistics show that children born in rural areas tend to be more anaemic than urban children. Again, women who have higher education tend to have children with normal Hb levels than women who are not educated or have low levels of education. Households whose economic status is high also bear children with normal Hb levels than those who live below the poverty line. Female children stands a chance of not being anaemic compared with their male counterparts (about 52% versus 48%). The age of a child determines the Hb concentration among Ghanaian children. Those under two years stand a higher risk of having anaemia than those close to five years. Malaria prevalence is a major determining factor for anaemia among under-five children. The association of the variables especially malaria prevalence, economic status and mothers educational level observed in this study has also been reported from other developed and developing countries. The anaemia prevalence of 64.7% which is higher than the WHO threshold is a source of worry to the nation as it indicates a public health problem. The risk of a child becoming anaemic was higher among households with poor economic status, children born of women with no or low education, born a male child, living in a malaria endemic environment, living in the northern part of the country or under two years of age.

6. Conclusion

The results of this study suggest that for reducing anaemia, the strategy needs to focus on nutrition education to facilitate better weight gain during pregnancy focusing more on the girl child education, regular antenatal and post-natal care visits, sleeping under treated mosquito nets always, exclusive breastfeeding, intake of iron food supplements during pregnancy and formulating policies that will reduce poverty among rural women. The girl child education policy, the distribution of free treated insecticide mosquito nets across the country must be pursued with all the seriousness it deserves. Children between 0 – 59 months must also be given food rich in iron and vitamin A as well as de-wormers. This is important in order that we can avoid the consequences such as child mortality, perinatal mortality and impaired neurocognitive function in children among others.

The main limitation that needs to be considered when interpreting the results of this study is that a number of confounding variables, such as child weight at birth, iron intake by mothers and children, diarrhoea that may influence Hb concentration in children were not included in our analysis. Within the limits of this study however, age of the child, malaria prevalence, economic status, region of residence, mothers' educational level and the sex of the child contributed significantly in predicting anaemia among children aged 6 – 59 months in Ghana.

Table 1. Descriptive statistics of the study population

Variable	Haemoglobin level					
	<11 g/dL (anaemic)		≥11 g/dL (non- anaemic)		Total	
	N	(%)	N	(%)	N	(%)
Hb prevalence	**2983**	**(64.7)**	**1626**	**(35.3)**	**4609**	**(100)**
Childs' sex						
Male	1541	(51.7)	757	(46.6)	2298	(49.9)
Female	1442	(48.3)	869	(53.4)	2311	(50.1)
Total	***2983***	***(100)***	***1626***	***(100)***	***4609***	***(100)***
Area/Residence						
Urban	729	(24.4)	720	(44.3)	1449	(31.4)
Rural	2254	(75.6)	906	(55.7)	3160	(68.6)
Total	***2983***	***(100)***	***1626***	***(100)***	***4609***	***(100)***
Region						
Western	204	(6.8)	164	(10.1)	368	(8.0)
Central	267	(9.0)	204	(12.5)	471	(10.2)
Greater Accra	156	(5.2)	199	(12.2)	355	(7.7)
Volta	214	(7.2)	147	(9.0)	361	(7.8)

Eastern	139 (4.7)	161 (9.9)	300 (6.5)
Ashanti	182 (6.1)	233 (14.3)	415 (9.0)
Brong Ahafo	227 (7.6)	132 (8.1)	359 (7.8)
Northern	778 (26.1)	182 (11.2)	960 (20.8)
Upper East	362 (12.1)	102 (6.3)	464 (10.1)
Upper West	454 (15.2)	102 (6.3)	556 (12.1)
Total	***2983 (100)***	***1626 (100)***	***4609 (100)***
Childs' age in months			
6 – 11	339 (11.4)	139 (8.5)	478 (10.4)
12 – 23	741 (24.8)	246 (15.1)	987 (21.4)
24 – 35	675 (22.6)	363 (22.3)	1038 (22.5)
36 – 47	663 (22.2)	447 (27.5)	1110 (24.1)
48 – 59	565 (18.9)	431 (26.5)	996 (21.6)
Total	***2983 (100)***	***1626 (100)***	***4609 (100)***
Wealth index quintiles			
Poorest	1464 (49.1)	400 (24.6)	1864 (40.4)
Second	658 (22.1)	324 (19.9)	982 (21.3)
Middle	406 (13.6)	275 (16.9)	681 (14.8)
Fourth	283 (9.5)	307 (18.9)	590 (12.8)
Richest	172 (5.8)	320 (19.7)	492 (10.7)
Total	***2983 (100)***	***1626 (100)***	***4609 (100)***
Mothers' education			
None	1696 (56.9)	546 (33.6)	2242 (48.6)
Primary	545 (18.3)	321 (19.7)	866 (18.8)
Middle/JHS	577 (19.3)	534 (32.8)	1111 (24.1)
Secondary+	165 (5.5)	225 (13.8)	390 (8.5)
Total	***2983 (100)***	***1626 (100)***	***4609 (100)***
Malaria rapid test results			
Positive, falciparum only (PF)	779 (26.1)	295 (19.2)	1074 (23.8)
Positive, Other species (O,M,V)	41 (1.4)	17 (1.1)	58 (1.3)
Positive, both falciparum and OMV	1304 (43.7)	232 (15.1)	1536 (34.0)
Negative	849 (28.5)	986 (64.3)	1835 (40.6)
Other	9 (0.3)	4 (0.3)	13 (0.3)
Total	***2982 (100)***	***1534 (100)***	***4516 (100)***

Table 2. Factors Associated with Anaemia - Multiple logistic regression model

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.494	.3211	2.864	4.123	118.351	1	.000
Childs' age	-.306	.0271	-.359	-.253	127.346	1	.000
Childs' sex	-.243	.0680	-.376	-.110	12.763	1	.000
Region	.083	.0132	.058	.109	40.036	1	.000
Wealth index quintiles	-.264	.0379	-.338	-.189	48.390	1	.000
Mothers educational level	-.177	.0411	-.257	-.096	18.430	1	.000
Malaria rapid test	-.233	.0322	-.297	-.170	52.637	1	.000
Area/Residence	.041	.0919	-.139	.221	.197	1	.657
(Scale)	1[a]						

Table 3 Bootstrap for Parameter Estimates

Parameter	B	Bootstrap[a]				
		Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
					Lower	Upper
(Intercept)	3.494	.002	.326	.001	2.875	4.159
Childs' age	-.306	-.001	.027	.001	-.356	-.254
Childs' sex	-.243	-.003	.069	.001	-.380	-.109
Region	.083	.001	.013	.001	.059	.110
Wealth index quintiles	-.264	.001	.038	.001	-.335	-.186
Mothers educational level	-.177	-.001	.042	.001	-.257	-.093
Malaria rapid test	-.233	.000	.035	.001	-.303	-.166
Area/Residence	.041	.003	.095	.683	-.144	.226
(Scale)	1	0	0		1	1

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

References

Abdulla S, Schellenberg JA, Nathan R, Mukasa O, Marchant T, Smith T, et al. (2001) Impact on malaria morbidity of a programme supplying insecticide treated nets in children aged under 2 years in Tanzania: community cross sectional study. BMJ; 322:270-3.

Aikawa R, Ngyen CK, Sasaki S, Binns CW. (2006) Risk factors for iron-deficiency anaemia among pregnant women living in rural Vietnam. J Public Health Nutr; 9:443–8.

Alasfoor D, Traissac P, Gartner A, Delpeuch F. (2007) Determinants of persistent underweight among children, aged 6–35 months, after huge economic development and improvements in health services in Oman. J Health Popul Nutr.; 25:359–69.

Assis AM, Gaudenzi EN, Gomes G, Ribeiro Rde C, Szarfarc SC, Souza SB (2004) Hemoglobin concentration, breastfeeding and complementary feeding in the first year of life. Rev Saude Publica.; 38:543–51.

Bojang KA, Palmer A, Boele van Hensbroek M, Banya WA (1997) Greenwood BM. Management of severe malarial anaemia in Gambian children. Transactions of the Royal Society of Tropical Medicine and Hygiene; 91:557-61.

Carneiro IA, Drakeley CJ, Owusu-Agyei S, Mmbando B, Chandramohan D (2007) Haemoglobin and haematocrit: is the threefold conversion valid for assessing anaemia in malaria-endemic settings? Malar J; 6:67.

Clegg JB,Weatherall DJ. (1999) Thalassemia and malaria: new insights into an old problem. Proceedings of the Association of American Physicians; 111:278-82.

DeMaeyer E, Adiels-Tegman M. (1985) The prevalence of anaemia in the world. World Health Statistics Quarterly; 38:302-16.

De Pee S, Bloem Sari MW, Kiess L, Yip R, Kosen S. (2002) The high prevalence of low haemoglobin concentration among Indonesia infants aged 3–5 months is related to maternal anaemia. Am Soc Nutr Sci.:2216–21.

Domellöf M, Dewey KG, Lönnerdal B, Cohen RJ, Hernell O (2002) The diagnostic criteria for iron deficiency in infants should be reevaluated. J Nutr. 132:3680–6.

Ekunwe EO (1997) Predictive value of conjunctival pallor in the diagnosis of anaemia. West African Journal of Medicine; 16:246-50.

Engelmann MD, Davidsson L, Sandstrwm B, Walczyk T, Hurrel RF, Michaelsen KF. The influence of meat on nonheme iron absorption in infants. Pediatr Res. 1998; 43:768–73.

Engelmann MD, Sandström B, Michaelsen KF (1998) Meat intake and iron status in late infancy: an intervention study. J Pediatr Gastroenterol Nutr.; 26:26–33.

Filmer D, Pritchett LH (2001) Estimating wealth effects without expenditure data - or tears: an application to educational enrolments in states of India. Demography; 38:115–32.

Gascon J, Vargas M, Schellenberg D, Urassa H, Casals C, Kahigwa E, et al. Diarrhoea in children under 5 years of age from Ifakara, Tanzania: a case-control study. Journal of Clinical Microbiology 2001; 38:4459-62

Ghana Statistical Service and Ghana Health Service (2008) Demographic and Health Survey

Ghana Statistical Service (2011) Multiple Indicator Cluster Survey with biomarker

Hall A, Latham MC, Crompton DW, Stephenson LS,Wolgemuth JC (1982) Intestinal parasitic infections of men in four regions of rural Kenya. Transactions of the Royal Society of Tropical Medicine and Hygiene; 76:728-33.

Jaime-Perez JC, Herrera-Garza JL, Gomez-Almaguer D (2000) Relationship between gestational iron deficiency and iron deficiency in the newborn; erythrocytes. Hematology; 5:257-62.
Kalter HD, Burnham G, Kolstad PR, Hossain M, Schillinger JA, Khan NZ, et al. (1997) Evaluation of clinical signs to diagnose anaemia in Uganda and Bangladesh, in areas with and without malaria. Bulletin of the World Health Organization; 75 Suppl. 1:103-11.
Krenzischeck DA, Tanseco FV (1996) Comparative study of bedside and laboratory measurements of haemoglobin. Am J Crit Care 5:427–32.
Lackritz EM, Campbell CC, Ruebush TK, 2nd, Hightower AW,Wakube W, Steketee RW, et al. (2003) Effect of blood transfusion on survival among children in a Kenyan hospital. Lancet 1992; 340:524-8. Bulletin of the World Health Organization 81 (8)
Lengeler C (2003) Insecticide-treated bednets and curtains for preventing malaria. Cochrane Database of Systematic Reviews ;(2):CD000363.
Luby SP, Kazembe PN, Redd SC, Ziba C, Nwanyanwu OC, Hightower AW, et al. (1995) Using clinical signs to diagnose anaemia in African children. Bulletin of the World Health Organization; 73:477-82.
May J, Falusi AG, Mockenhaupt FP, Ademowo OG, Olumese PE, Bienzle U, et al. (2000) Impact of subpatent multi-species and multi-clonal plasmodial infections on anaemia in children from Nigeria. Trans R Soc Trop Med Hyg; 94:399–403.
Marsh K, Forster D,Waruiru C, Mwangi I, Winstanley M, Marsh V, et al. (1995) Indicators of life-threatening malaria in African children. New England Journal of Medicine; 332:1399-404.
McNulty SE, Torjman M, Grodecki W, Marr A, Schieren H (1995) A comparison of four bedside methods of haemoglobin assessment during cardiac survey. Anesthesia Analgesic. 81:1197–202.
McElroy PD, ter Kuile FO, Lal AA, Bloland PB, Hawley WA, Oloo AJ, et al. (2000) Effect of *Plasmodium falciparum* parasitemia density on hemoglobin concentrations among full-term, normal birth weight children in western Kenya, IV. The Asembo Bay Cohort Project. Am J Trop Med Hyg.; 62:504–12.
Menendez C, Kahigwa E, Hirt R, Vounatsou P, Aponte JJ, Font F, et al. (1997) Randomised placebo-controlled trial of iron supplementation and malaria chemoprophylaxis for prevention of severe anaemia and malaria in Tanzanian infants. Lancet; 350:844-9.
Moˆnica M. Oso´rio et al (2004) Factors associated with Hb concentration in children aged 6–59 months in the State of Pernambuco, Brazil; British Journal of Nutrition (2004), 91, 307–314
Muhe L, Oljira B, Degefu H, Enquesellassie F,Weber MW (1999) Clinical algorithm for malaria during low and high transmission seasons. Archives of Disease in Childhood; 81:216-20.
Muhe L, Oljira B, Degefu H, Jaffar S,Weber MW (2000) Evaluation of clinical pallor in the identification and treatment of children with moderate and severe anaemia. Tropical Medicine and International Health; 5:805-10
Muniz PT, Castro TG, Araújo TS, Nunes NB, da Silva-Nunes M, Hoffmann EH, et al. (2007) Child health and nutrition in the Western Brazilian Amazon: population-based surveys in two counties in Acre State. Cad Saude Publica.; 23:1283–93.
Murphy SC, Breman JG. (2001) Gaps in the childhood malaria burden in Africa: cerebral malaria, neurological sequelae, anemia, respiratory distress, hypoglycemia, and complications of pregnancy. American Journal of Tropical Medicine and Hygiene; 64(1-2 Suppl.): 57-67.
Musaiger AO (2002) Iron deficiency anaemia among children and pregnant women in the Arab Gulf countries: the need for action. Nutr Health.; 16:161–71.
Nestel P. Washington, DC: (2002) International Nutritional Anaemia Consultative Group, ILSI Human Nutrition Institute; Adjusting haemoglobin values in program surveys; pp. 2–4
Newton CRJC,Warn PA,Winstanley PA, Peshu N, Snow RW, Pasvol G, et al. (1997) Severe anaemia in children living in a malaria endemic area of Kenya. Tropical Medicine and International Health; 2:165-78.
Osório MM, Lira PI, Ashworth A (2004) Factors associated with Hb concentration in children aged 6–59 months in the state of Pernambuco, Brazil. Br J Nutr.; 91:307–14.
Parker L. Washington, DC (1989) National Education Association;. The relationship between nutrition and learning: a school employee's guide to information and action; pp. 10–35
Premji Z, Hamisi Y, Shiff C, Minjas J, Lubega P, Makwaya C. (1995) Anaemia and Plasmodium falciparum infections among young children in an holoendemic area, Bagamoyo, Tanzania. Acta Tropica; 59:55-64.
Rawlins SC, Campbell M, Fox K, Bennett F, Gibbs WN, Greene M (1991) Parasitic infections in young Jamaicans in different ecological zones of the island. Tropical and Geographical Medicine; 43:136-41.
Sari M, de Pee S, Martini E, Herman S, Sugiatmi Bloem MW, et al. (2001) Estimating the prevalence of anaemia: a comparison of three methods. Bull World Health Organ.; 79:506–11

Schellenberg D, Menendez C, Kahigwa E, Font F, Galindo C, Acosta C et al. (1999) African children with malaria in an area of intense Plasmodium falciparum transmission: features on admission to hospital and risk factors for death. American Journal of Tropical Medicine and Hygiene; 61:431-8.
Schellenberg D et al. (2003) The silent burden of anaemia in Tanzanian children: a community-based study Bulletin of the World Health Organization; 81:581-590
Senarath U, Dibley MJ, Agho KE. Breast-feeding practices and associated factors among children under 24 months of age in Timor-Leste. (2007) Eur J Clin Nutr.; 61:387–97.
Singla PN, Tyagi M, Shankar R, Dash D, Kumar A (1996) Fetal iron status in maternal anemia. Acta Paediatrica; 85:1327-30.
Singla PN, Tyagi M, Kumar A, Dash D, Shankar R (1997) Fetal growth in maternal anaemia. Journal of Tropical Pediatrics; 43:89-92.
Slutsker L, Taylor TE, Wirima JJ, Steketee RW (1994) In-hospital morbidity and mortality due to malaria-associated severe anaemia in two areas of Malawi with different patterns of malaria infection. Transactions of the Royal Society of Tropical Medicine and Hygiene; 88:548-51.
Stoltzfus R, Dreyfuss M. (1998) Guidelines for the use of iron supplements to prevent and treat iron deficiency anaemia. Washington: ILSI Press
Stoltzfus RJ, Edward-Raj A, Dreyfuss ML, Albonico M, Montresor A, Dhoj Thapa M, et al. (1999) Clinical pallor is useful to detect severe anemia in populations where anemia is prevalent and severe. The Journal of Nutrition; 129:1675-81.
Sweet DG, Savage G, Tubman TR, Lappin TR, Halliday HL (2001) Study of maternal influences on fetal iron status at term using cord blood transferrin receptors. Archives of Disease in Childhood. Fetal and Neonatal Edition; 84:F40-3.
Tabachnick BG, Fidel LS. New York, NY: Harper Collins; (1996). Using multivariate statistics; pp. 709–811.
Timor-Leste demographic and health survey. (2003) Newcastle: University of Newcastle;. Timor-Leste. Ministry of Health; pp. 217–24.
Thaver IH, Baig L (1994) Anaemia in children: Part I. Can simple observations by primary care provider help in diagnosis? Journal of the Pakistan Medical Association;44:282-4.
UNICEF (1998) The state of the world's children 1998 New York, NY: United Nations Children's Fund; United Nations Children's Fund; p. 131.
Van den Broek NR, Ntonya C, Mhango E, White SA (1999) Diagnosing anaemia in pregnancy in rural clinics: assessing the potential of the Haemoglobin Colour Scale. Bulletin of the World Health Organization; 77:15-21.
Viteri FE, de Tuna V, Guzman MA (1972) Normal haematological values in Central American population. Br J Haematol; 23:189–204.
Waterlow JC, Buzina R, Keller W, Lane JM, Nichaman MZ, Tanner JM (1977). The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. Bull World Health Organ; 55:489–98.
Waters H, Saadah F, Surbakti S, Heywood P. (1992–1999) Weight-for-age malnutrition in Indonesian children,. Int J Epidemiol. 2004; 33:589–95.
Weber MW, Kellingray SD, Palmer A, Jaffar S, Mulholland EK, Greenwood BM. (1997) Pallor as a clinical sign of severe anaemia in children: an investigation in the Gambia. Bulletin of the World Health Organization; 75; Suppl. 1:113-8.
Wieringa FT, Berger J, Dijkhuizen MA, Hidayat A, Ninh NX, Utomo B, et al. (2007) Sex differences in prevalence of anaemia and iron deficiency in infancy in a large multi-country trial in South-East Asia. Br J Nutr.; 98:1070–6.
WHO (2001) Iron deficiency anaemia: assessment, prevention and control. A guide for programme managers. Geneva: World Health Organization; United Nations Children's Fund; pp. 11–43. (WHO/NHD/01.3)
WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age—methods and development. Vol.13. Geneva: World Health Organization; 2006 World Health Organization Multicenter Growth Reference Study Group; p. 301.
Zucker JR, Perkins BA, Jafari H, Otieno J, Obonyo C, Campbell CC (1997) Clinical signs for the recognition of children with moderate or severe anaemia in western Kenya. Bulletin of the World Health Organization 75; Suppl. 1:97-102.