

ANALYSIS OF RISK FACTORS AFFECTING PREVALENCE OF ANEMIA IN NIGERIA ADARABIOYO. M. I¹ AND OLAYINKA. J. N²

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ABSTRACT

This research is aimed at modelling risk factors affecting anemia caused by malaria among children in Nigeria and determine the goodness of fit of the model and thereby proffering useful suggestions and recommendations. Ordinal logistic regression was used as a tool to model the risk factors affecting severity of anemia (i.e no anemia, mild and severe) among children with respect to maternal ages, region, place of residence, sex, educational level of mother, use of mosquito net, wealth index, had malaria two weeks before the survey and age in months of child. The data was obtained from NDHS dataset on malaria 2008. The study showed that severity of anemia is greatly affected by socio-economic variables, such as region, place of residence, educational level of mothers, gender, and wealth index. The study also revealed that age of mothers does not affect severity of anemia.

Key works: Pregnancy, ordinal logistic regression, probability, anemia,

INTRODUCTION

Anemia (hemoglobin level < 11 g/dL) remains one of the most intractable public health problems in malaria-endemic countries particularly in Africa with worsening health con. It affects more than half of all pregnant women and children less than five years old,^{1,2} and has serious consequences since severe anemia (hemoglobin level < 5 g/dL) is associated with an increased risk of death,³ while iron deficiency and anemia may impair cognitive and motor de-development,⁴⁻⁶ growth,⁷ immune function,⁸ and physical work capacity.⁹ The insidious nature of its presentation means, however, that mild-to-moderate degrees of anemia frequently remain undetected and untreated by health care workers and in the community,^{10,11} while blood transfusion for severe anemia may be prescribed on the basis of inaccurate hemoglobin measurement,¹² thus exposing the patient unnecessarily to the risk of infection with human immunodeficiency virus (HIV) and other blood-borne pathogens.¹³ Prevention is clearly of critical importance, yet current coverage with anti-malarial interventions and micronutrient supplementation is poor in many African countries.¹⁴ In these settings, the targeted delivery of interventions against anemia to high-risk groups (pregnant women and young children) may be an appropriate use of limited economic and human resources.

Measurement of hemoglobin on capillary blood using the HemoCue hemoglobinometer (HemoCue AB, Angelholm, Sweden) has been recently introduced as part of nationally representative household-level Demographic and Health Surveys (DHS) (ORC Macro. <http://www.measuredhs.com>). To date, hemoglobin measurement has been or is currently included in surveys from 13 countries in tropical Africa. Data on children less than five years old from surveys conducted in Benin (n=2,568), Uganda (n= 6,003), Mali (n =3,192), and Madagascar (n= 2,272), is shown in Figure 1 (courtesy of Dr. E. Korenromp, Roll Back Malaria Department, World Health Organization, Geneva, Switzerland). The proportion of the population exposed to four or more months of malaria transmission per year ranges from 55.5% (Madagascar) to 86.4% or higher (Uganda, Mali, and Benin).¹⁵ Figure 1a shows that hemoglobin levels continue to decline after the physiologic decrease that normally occurs in the first 2–3 months of life, reaching a nadir towards the end of the first year. Data from Benin and Uganda (Figure 1b) demonstrate that more than 80% of infants 10 months of age are anemic, and approximately one-third have hemoglobin levels less than 8 g/dL. Strikingly similar patterns have been reported from community cross-sectional and cohort studies conducted in areas of stable, perennial malaria transmission in Tanzania,^{11,16} Kenya,¹⁷⁻¹⁹ (Figure 2), and Malawi.²⁰

However, anemia is usually multi-factorial in origin, and although malaria plays a key etiologic role in endemic countries like Nigeria, it is clear that poor nutritional status, micronutrient deficiencies, intestinal helminths, HIV infection, and

hemoglobinopathies make important additional contributions. A number of factors account for the progressive fall in hemoglobin that is observed during the first year of life in areas of stable malaria transmission. Antenatal factors. Placental malaria. Sequestration of malaria parasites in the placenta, a consequence of infection with *Plasmodium falciparum* during pregnancy, is associated with an increased risk of intrauterine growth retardation (IUGR), premature delivery, maternal and infant anemia, and infant mortality.^{19,21} Poor maternal nutrition and micronutrient deficiencies. Poor nutritional status in pregnancy has adverse consequences that can persist from one generation to the next, since women who are underweight or stunted are at risk of delivering premature or low birth weight infants, who are themselves at risk of poor growth and development and anemia in childhood and adolescence. Iron deficiency is a common cause of anemia in pregnant women in malaria-endemic areas, and a recent study from Malawi demonstrated an absence of stainable iron in bone marrow aspirate, the most definitive method for determining iron status, in 44% of pregnant women with a hemoglobin levels less than < 10.5 g/dL. Multiple micronutrient deficiencies contribute to anemia in pregnancy, and deficiencies of vitamin A, folate, and vitamin B-12 were found in approximately 40%, 30%, and 25%, respectively, of pregnant Malawian women with anemia.

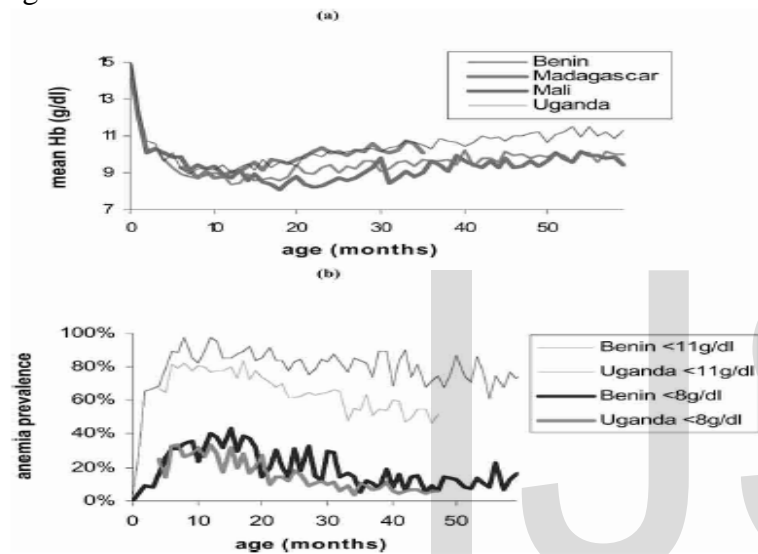


FIGURE 1. Age patterns of anemia in Demographic and Health Surveys (DHS). a. mean hemoglobin (Hb) concentration (g/dL). b. prevalence of an Hb concentration less than 11 g/dL and 8 g/dL.

Source: AM. J. TROP. Med. Hyg. 71 (Suppl 2), 2004, pp25-34

METHODS AND DATA

Among the different regression models, logistic regression plays a particular and important role. The base concept, however, is universal. In a statistical investigation, several variables are defined and their values are determined for a set of objects. Some of these variables are a priori considered to be dependent on others within the same framework. Others are thought to be exclusively dependent on exterior and not quantified (or not quantifiable) aspects, but not on further variables inside the same model. The main aim of a regression analysis is to reveal and specify the impact of the so-called independent or exogenous explanatory variables on the dependent or endogenous response. The prevalent linear regression model is (under certain hypotheses) in many circumstances a valuable tool for quantifying the effects of several exogenous on one dependent continuous variable. For situations where the dependent variable is qualitative, however, other methods had to be developed. One of these is the logistic regression model which specifically covers the case of a binary (dichotomous) response.

In this research work, two procedures were used to determine the relationship between anemia level among children under-five mortality and some other socio-economic and demographic covariates. The cross-tabulation was explored to determine which of the covariates directly contribute to anemia level among children under-five years. In addition to this a multivariate ordinal logistic regression model was fitted to determine the level of contribution of the covariates by determining the odds of the fitted parameters. The model was compared with a Multivariate linear regression model. Some of the covariates which are likely to correlate with anemia level and were considered for this study includes; educational level of mothers, age of mothers, place of residence, sex of child, region, wealth index, had fever in the last

two weeks before the survey, child ever slept under treated mosquito net, the blood smear test and rapid test and age of children. Some categorical levels were collapsed together and recoded to avoid some cells having zero counts. The age of mothers was collapsed as 1(<30years), 2(30-39 years) and 3(40-49years); Wealth index was recoded as 1(poor), 2(middle) and 3(rich).

We consider a binary random variable y having a Bernoulli distribution,

$$y \sim B(1, \pi(x)),$$

i.e. the variable y takes either the value 1 or 0 with probabilities $\pi(x)$ or $1-\pi(x)$ respectively. $x \in R^P$ is a vector of p exogenous variables and $\pi: R^P \rightarrow [0, 1]$ a real-valued function. In fact, $\pi(x)$ represents the conditional probability $P(y=1|x)$ of $y=1$ given x

Let $r := y - \pi(x)$, which allows us to rewrite our model as

$$y = \pi(x) + r,$$

Where r has an expectation of

$$E(r) = E(y - \pi(x)) = \pi(x) - \pi(x) = 0$$

And a variance of

$$Var(r) = Var(y) = \pi(x)(1 - \pi(x))$$

For the purpose of this study, we define logistic transformation $\sigma_{LR}: R \rightarrow [0,1]$ by

$$\sigma_{LR}(Z) := \frac{Exp(z)}{1+Exp(z)} = \frac{1}{1+exp-z}$$

. which allows us to specify the probability function of

$$\pi \text{ as } \pi(x) := \sigma_{LR}(x^T \beta),$$

with a vector $\beta \in R^P$ of unknown parameters. This specification yields the logistic regression model with parameter β .

If we denote the inverse function of σ_{LR} , which is called logit transformation by

$$\text{logit } \pi = \ln \frac{\pi}{1 - \pi},$$

We can write our regression model as

$$\text{logit } \pi(x) = x^T \beta$$

However, data for this study is a secondary data from Demography and Health Surveys (DHS). Since 1984, the DHS program has provided technical assistance to more than 300 Surveys in over 900 countries, advancing global understanding of health and population trends in developing Countries. The program is funded by U. S Agency for International Development (USAID). The DHS programs supports a range of data collection options that can be tailored to fit specific monitoring and evaluation need of host countries. DHS has developed standard procedures, methodologies and manuals to guide the survey process. Many steps are therefore required to ensure that the data properly reflect the situations they are intended to describe and that data are comparable across countries.

Demographic and health surveys are nationally representative household surveys that provide data for wide range of monitoring and impact evaluation indicators in the areas of population, health and nutrition. In a standard DHS surveys the sample sizes range between 5000 and 30000 households and is being conducted every 5 years, to allow for comparison over time. The Interim DHS surveys focuses on collection of information on key performance monitoring indicators but may not include data for all impact evaluation measures such as mortality rates. They are conducted between rounds of DHS surveys and have shorter questionnaires that the standard DHS surveys. Information available in DHS dataset ranges from prevalence of anemia, iron supplementation, female genital cutting, fertility and fertility preference, household respondent characteristics, infant and child mortality, malaria and maternal health and mortality, nutrition, tobacco use, wealth among others.

This study focus on risk factors affecting prevalence of anemia cause by malaria among children

RESULTS AND DISCUSSION

From table 4 children in the North Central have the highest risk of being anemic. The region is 4 times likely to have anemic condition compare to other regions while the North East is 3 times likely to have anemia when compare to other regions while the North West has the least odds. The results also indicate that children in urban areas are 1.5 times likely

to have anemic condition compare to children in the rural areas. The study also shows that male children are 0.8 times more likely to have anemia compare to female children. Children whose mothers have secondary education are 1.1 times likely to have anemia condition when compare to others. Mothers of different age group are equally likely to have anemic children with odds values as 1.1 and 1.1 for age groups <30 and 30-39 respectively. The wealth index reveals that the poor category is 0.79 times likely to have anemia compare to middle class which is 0.66 times likely to have anemia. Also those who have no fever in the last two weeks before the survey are 2.8 times likely to have anemia while those who have fever are 2.9 times likely to have anemia. The study also shows that the odds is against children in the age group 36-47 months old are 1.05 likely to have anemia compare to others.

The estimated coefficients represent the change in the log odds for one unit increase in the corresponding independent variable. For example under place of residence we expect 0.437 increase in the ordered log odds of being in a higher level of response variable given that all other variables in the model are held constant. In education we would expect -0.733 decrease in the ordered log odds of being in a lower level of the response given that all other variables are held constant. In the children whose mothers are in the age <30 and 30-39 years, we expect a 0.091 and 0.066 increase in the ordered log odds of being in a higher level of the response variable given that all other variables are held constant. In the wealth index, a -0.233 decrease in the log odds of being in the lower level of the response category given that all other variables are held constant.

With the wald's statistic, we are able to find which of the predictors are significant to the outcomes of the anemia. The wald's statistic is square of the ratio of the coefficient to its standard error based on the small observed significance level. We can reject the null hypothesis that is zero. It follows a chi-square distribution with degree of freedom $\alpha = 0.05$. The result shows that Region, Sex and fever in the last two weeks have their walds statistic values greater than the critical chi-square values. With the chi-square tabulated with $p=0.00 < 0.05$, we reject the hypothesis that the model without predictors is as good as model with predictors. The fitted model can be used to predict the different probabilities of the possible outcomes of any anemia to certain degree given the conditions of the child involved. The multivariate ordinal logistic regression models show that between the rapid test and blood smear test, the odds is in favour of the rapid test. The children tested using the rapid test is 7.0 times likely to be confirmed having anemia compare to children tested on blood smear.

CONCLUSION

Anemia (hemoglobin level < 11 g/dL) remains one of the most intractable public health problems in malaria-endemic countries of Africa. It affects more than half of all pregnant women and children less than five years old. This study has linked anemia to some socio-economic conditions of the affected families. Level of education of the family, wealth index, place of residence and geopolitical region of the affected families greatly contributed to anemia status of the children. In order to nip it at the bud, education of the girl-child must be given proper consideration. Also there must be equitable distribution of wealth so that children will not be malnourished as deficiency in iron and other vital nutrients pose risk to the health and wellbeing of the children.

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Table1: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1800.653			
Final	1656.247	144.406	19	.000

Link function: Logit.

Table 2: Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	1841.581	1925	.912
Deviance	1540.229	1925	1.000

Link function: Logit.

Table 3:Pseudo R-Square

Cox and Snell	.166
Nagelkerke	.182
McFadden	.074

Link function: Logit.

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Table4: Parameter Estimates

	Estimate	Std. Error	Wald	Odds	df	Sig.	95% Confidence Interval		
							Lower Bound	Upper Bound	
Threshold D	[Anemia = severe(1)]	-2.451	.681	12.971	0.086207	1	.000	-3.785	-1.117
	[Anemia: moderat(2)]	.453	.669	.459	1.573024	1	.498	-.858	1.763
	[Anemia = mild(3)]	1.438	.670	4.601	4.212263	1	.032	.124	2.752
Location	[Region=(north central(1))]	1.474	.277	28.411	4.366667	1	.000	.932	2.016

[Region=north east(2)]	1.105	.297	13.844	3.019224	1	.000	.523	1.687
[Region=north west(3)]	.242	.272	.790	1.273794	1	.374	-.292	.775
[Region=south east(4)]	0 ^a	.	.		0	.	.	.
[Residence=urban(1)]	.437	.168	6.782	1.548056	1	.009	.108	.765
[Residence=rural(2)]	0 ^a	.	.		0	.	.	.
[Sex=male(1)]	-.337	.136	6.141	0.713909	1	.013	-.603	-.070
[Sex=female(2)]	0 ^a	.	.		0	.	.	.
[Education=no edu(0)]	-.733	.375	3.831	0.480465	1	.050	-1.468	.001
[Education=Primary(1)]	-.289	.390	.550	0.749012	1	.458	-1.055	.476
[Education=secondary(2)]	.074	.381	.038	1.076807	1	.845	-.673	.821
[Education=tertiary(3)]	0 ^a	.	.		0	.	.	.
[Net=No mosquito(0)]	-.092	.144	.412	0.912105	1	.521	-.374	.190
[Net=use mosquito net(1)]	0 ^a	.	.		0	.	.	.
[Age of mothers=<30years(1)]	.091	.234	.150	1.095269	1	.699	-.368	.550
[Age of mothers =30-39 years (2)]	.066	.238	.077	1.068227	1	.782	-.401	.533
[Age of mothers =40-49 years (3)]	0 ^a	.	.		0	.	.	.
[Wealth_index=poor(1)]	-.233	.180	1.677	0.792154	1	.195	-.585	.119
[Wealth_index=middle(2)]	-.422	.193	4.801	0.655734	1	.028	-.799	-.045
[Wealth_index=rich(3)]	0 ^a	.	.		0	.	.	.
[Fever=No(0)]	1.040	.509	4.171	2.829217	1	.041	.042	2.039
[Fever=Yes(1)]	.884	.517	2.926	2.420563	1	.087	-.129	1.897
[Fever=Not sure(2)]	0 ^a	.	.		0	.	.	.
[Age_of_children=6-11(1)]	-.364	.244	2.238	0.694891	1	.135	-.842	.113
[Age_of_children=12-23(2)]	-1.016	.203	25.113	0.36204	1	.000	-1.413	-.619
[Age_of_children=24-35(3)]	-.319	.208	2.351	0.726876	1	.125	-.727	.089
[Age_of_children=36-47(4)]	.058	.199	.085	1.059715	1	.771	-.333	.449

[Age_of_children=48-59(5)]	0 ^a	.	.	0	.	.	.
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Link function: Logit.

- a. This parameter is set to zero because it is redundant.

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