Determinants of anemia in children under five years in Angola, Malawi and Senegal: A comparative study

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Determinants of anemia in children under five years in Angola, Malawi and Senegal: A comparative study

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Abstract

Background: Anemia is defined as a condition where there is an insufficient quantity of homoglobin, hematocrit or red cell in the human body [1, 2]. Unicef (2017) report urged all countries to reduce under five years mortality by 2030, thereof there is a need of understanding and determining factors contributing to child mortality. The significance of this study underpins the improvement in collaboration among the three countries and recommend to government the area to invest in order to meet the SDG target.
Method: The current study used demographic health survey data from Angola (2016), Malawi (2016) and Senegal (2016). The African continent is a developing continent with limited resources, hence studying three countries will result in distributing scarce resources across countries and enhance collaboration. Using World Health Organisation (WHO) classification guidelines of anemia, the ordinal dependent variable was developed. The three categories of anemia condition used in this study are Mild (10.0 - 10.9 g/dl), Moderate (7.0 - 9.9 g/dl) and severe (<7 g/dl).
Results: Gamma measure and chi-square test of independence was conducted to explore the association between anemia status and factors. The score test and Brant test were used to test the proportional odds model assumption and it was satisfied. Results from ordinal survey logistic regression model found place of residence, age of the child, wealth index, mother level of education and nutritional status to be significant factors associated with anemic condition of under five year children in all three countries.
Discussion: The health institutions of Angola, Malawi and Senegal need to monitor under five years children that are suffering from malnutrition condition. The study showed that there is a high chance for under five years children to suffer from both malnutrition and anemia condition. This finding is similar to the results of the study that was conducted in Bangladesh and Burma [27, 28].
Conclusion: The study identified place of residence, age of the child, wealth index, mother level of education and nutritional status as common factors associated with anemia in Angola, Malawi and Senegal. This finding is in agreement with that of the studies conducted by [27, 26, 36]. The results showed the necessity of collaboration between Angola, Malawi and Senegal in order to achieve the SGD target.
Keywords: anemia, homoglobin, gamma measure, chi-square test, proportional odds model

1 Background

Anemia is defined as a condition where there is an insufficient quantity of homoglobin, hematocrit or red cell in the human body [1, 2]. This condition affect mostly pregnant women and children less than 2 years of age [3, 4]. According to World Health Organisation (WHO), the population is classified as being normal when the prevalence is below 2.5%, and the prevalence above 5% raise health concerns.

Approximately half of the children between the age of 0-5 years globally are are anemic and one third of pregnant women are anemic [5]. Mild anemia, moderate anemia and severe anemia are the three types of anamia. Mild anemia is associated with the level of homoglobin concentration in the interval of 10.0 - 10.9 g/dl.

Moderate anemia is associated with the level of homoglobin concentration in the interval of 7.0 - 9.9 g/dl, whereas severe anemia corresponds to the level of homoglobin concentration that is less than 7.0 g/dl. This individual classification apply to both pregnant women and children under five years.

3.3% of children age 6-59 months in Africa are suffering from severe anemai, this estimate is two times the global estimate of children suffering of anemia [6] . In addition, 1.4 % of pregnant women suffer from severe anemia. The global percentage of pregnant women suffering from severe anemia is 1.1. This indicates that pregnant women and young children in African are most affected by anemia, hence there is a need to understand and address this health concern in the African region.

Current literature reveals that improving parent level of education and household income reduces child risk of suffering from anemia [1, 7, 2, 4]. Age of the child, household size and being exposed to malaria conditions increase the chances of suffering from anemia [19, 13, 17].

A study conducted by [22] showed that the Malawian policy makers and government need to address poverty, maternal anemia and malnutrition challenges in attempt to reduce the risk of exposing children to anemia condition. In addition, the research by [23] revealed that improving malaria and anemia control in pregnancy will reduce child's risk of suffering from anemic condition. Whereas, a study by [8] showed that mother level of education, household wealth status, child experiencing fever and stunting are positively associated with anemia for Malawian children less that five years.

In Angola, anemia and malaria are the most contributing diseases to under five/ pre-school aged children. Approximately 60% and 19 % of pre-school aged children are suffering from anemia and malaria respectively in Angola [24]. A study conducted by [9] defined anemia as a severe public health problem for children less that five years in Angola. The results of the study identified age group and sex of the child as key determinant of anemia

Results from the study conducted by [25] in Senegal showed that improving mother level of literacy, consumption of animal protein (meat, fish and eggs) reduces child's risk of suffering from iron deficiency. Whereas, a study conducted by [11] showed that malaria parasitaemia, sickle cell disorders, alpha-thalassemia, stunting, age ranged from 2 to 4 years and age greater than 5 years are significantly associated with anemia for children less that 10 years in Senegal. The conclusion of the study highlighted that malaria, stunting, haemoglobin genetic disorders as major causes of children anemia condition.In addition, A study reviewing observational studies of 15 countries including Malawi and Senegal by [12] concluded that covariates such as age, type of residence, socioeconomic status and maternal education tend to be associated with anemia.

The statistical report released by [6] shows that Angola, Malawi and Senegal level of public health significance for children less than 59 months is severe. This findings indicate health concerns which can lead to economic problems, sustainability of the country and increase in mortality rate.

Anemia is one of many causes of under five mortality. Statistics released by UNICEF (2018) revealed that the under five mortality rate has declined by more that half since 1990. However, sub-Saharan Africa still contribute the highest rate.

The projections released by UNICEF (2018) indicate that under five mortality in Africa in 2030 will be 54 deaths per 1000 live births.

One of the Sustainable Development Goal (SDG) target is to reduce under five mortality to 25 deaths per 1000 live births by 2030 [10]. Based on the projections, Africa will be more than half of the SDG target by 2030. Mayotte, Reunion, Seychelles and Egypt are the only African countries that current have under five mortality below the SDG 2030 target.

Angola is situated in the middle of Africa with the population of approximate 25 million people. The 2016 under five mortality is 82.5 deaths per 1000 live births. Whereas, 15 million populated Senegalese country has under five mortality of 47.1 deaths per 1000 live birth. Malawi under five mortality rate is estimated to be 55.1 deaths per 1000 live births and has a population of 18 million.

Angola, Malawi and Senegal are expected to reduce their under five mortality rate by at least half of their current mortality rate [10]. This requires serious interventions and targeting significant causes of under five mortality. Hence, the aim of this paper is to assess anemia, identify its determinant and propose significant recommendations to meet 2030 SDG target in Angola, Malawi and Senegal.

The significance of this study underpins the improvement in collaboration among the three countries and recommend to government the area to invest in order to meet the SDG target. Further, this strategy may be regarded as one of many cost-effective ideas as these studied countries can share the resources on their disposal.

2 Methods

2.1 Data source

This study employed a national representative data from three African countries, the Angola Demographic and Health Survey (ADHS, 2016), Malawi Demographic and Heath Survey (MDHS, 2016) and Senegal Demographic and Health Survey (SDHS, 2016). There was no ethical approval required since the study employed the secondary data obtained from Micro International. However, a written request was submitted to

DHS Micro for approval.

2.1.1 ADHS, 2016

ADHS, 2016 was implemented jointly by the Angola National Institute of Statistics (INE), the Ministry of Health (MINSA) and the Ministry of Planning and Territory Development (MPDT). The objective of the survey, which was collected from October 2015 through March 2016 was to provide insightful information with regard to the demographic and health situation of women, men and children including fertility levels, marriages, sexual activity, fertility preferences, family planning methods, childhood and maternal mortality, maternal and child health, breast feeding practices, nutrition, malaria, HIV/ AIDS, domestic violence and child well being.

A sample of 16,109 households was selected, where 14,379 women age 15-49 and 5,684 men age 15-54 participated. The response rate for women and men was 96% and 94% respectively. The sample design enable to provide estimates at the national, provincial and place of residence level.

2.1.2 MDHS, 2016

The 2015-2016 MDHS data was stratified and selected in two stages. On the first stage, 850 standard enumeration areas (SEAs) including 173 SEAs in urban areas and 677 in rural areas were selected with the probability proportional to the SEA size and with independence selection in each sampling stratum. On the second stage, a fixed number of 30 households per urban cluster and 33 per rural cluster were selected with an equal probability systematic selection from the newly created household listing.

A total sample of 27,516 households were selected. 26,564 of the the total sample were occupied and successfully interview households were 26,361. This yielded a response rate of 99%.

2.1.3 SDHS, 2016

SDHS 2016 was implemented by the National Agency of Statistics and Demographic (ANSD) in collaboration with the Ministry of Health and Social Action (MSAS). One of the objective of the survey was to respond to ongoing data needs for planning, monitoring and evaluating health and safety programs population.

A total sample of 4,437 households were selected. 8,865 women age 15-49 and 3,527 men age 15-59 were interviewed successfully. 5,722 children under five years were measured and weighted to determine their nutritional status, 5,239 children aged 6-59 months were tested for anemia and 5,237 were tested from the exam microscopic for malaria parasitaemia. The sample is designed to provide results at national, provincial and place of residence level.

2.2 Variables

2.2.1 Response variable

World Health Organisation anemia classification allowed the study to divide anemia status into three ordinal categories and employ as response variable in this study. The three categories of anemia condition are Mild (10.0 - 10.9 g/dl), Moderate (7.0 - 9.9 g/dl) and severe (<7 g/dl). Similar categories were used in studies by [21, 26, 29].

2.2.2 Explanatory variables

Socioeconomic, demographic, health and environmental elements of living are known to be the contributing factors into anemia status. The above mentioned logic have been used in studies [20, 19, 26]. Hence the variables of this paper were chosen from this framework. Mother's level of education (Primary, Secondary or Higher), type of resident (Rural or Urban), household size (0-5, 6-10, 11-15 or 15), child's age in months (< 12, 12-23, 24-35, 36-47 or 48-59), sex of household head (Male or Female), sex of child (Male or Female), wealth index (Poor, Middle or Not poor), birth interval (<24, 24-47 or > 470, birth order (2-3, 4-5 or > 5), marital status (unmarried, divorced, married), child nutritional status were the variable considered for analysis.

The Gamma measure and chi-square test of independence was carried out to identify variables to be included in the multivariate analysis. This analysis allows to identify the association and the significance between two variables. The results of the variables included in the multivariate analysis are displayed in Table 1, Table 2 and Table 3. These variables are mother's level of education (Primary, Secondary or Higher), type of resident (Rural or Urban), household size (0-5, 6-10, 11-15 or 15), child's age in months (< 12, 12-23, 24-35, 36-47 or 48-59), sex of household head (Male or Female), sex of child (Male or Female), wealth index (Poor, Middle or Not poor) and nutritional status (severe, moderate or mild).

Fewer studies have been conducted to understand children under five mortality in Angola, Malawi and Senegal. Thereof, this study will be adding to the current studies that the government and policy makers of these countries are using to allocate resources. A study conducted by [22] in Malawi excluded child nutritional status as covariate, this covariate have been identify by literatures as a significant factor associated to under five mortality. In addition, [25] conducted a study that focused more on child's food consumption variables in Senegal. Therefore, the novelty of this study include employing malnutrition status variable and socio-economic characteristics.

2.3 Statistical Analysis

2.3.1 Test of Association and Proportional odds model (POM)

Chi-square and gamma measure were employed to measure the strength of association. If the covariates were in ordinal scale, the gamma measure was used to determine the strength of association. Whereas, if the covariates were in nominal scale, the chi-square was used to determine the strength of association. The estimator of gamma ($\hat{\gamma}$) is given by [18],

$$\hat{\gamma} = \frac{C - D}{C + D} \tag{1}$$

where C is the total number of concardant pairs and D is the total number of discordant pairs. Chi-square has the form,

$$\chi^2 = \sum \frac{(O - E)}{E} \tag{2}$$

where O represents the observed frequency and E is the expected frequency under the null hypothesis. E is calculated as follow,

$$E = \frac{rowtotal - columntotal}{samplesize} \tag{3}$$

The association measure use the fact that the statistic, $gam\hat{m}a$ follows a normal distribution with mean $= \gamma$ and standard error (SE) calculated from the delta method. Chi-square use the the fact that it follows a chi-square distribution with (r-1)(c-1) degrees of freedom (df), where r is the number of categories of the covariates and c is the number of categories of response variable.

Proportional odds model is the commonly used model to examine the adjusted effect of covariates on nutritional health status of children. Proportional odds model is valid when original continuous response variable is grouped and assumption holds. Literatures shows that there are cases where proportional odds assumption do not hold, therefore partial proportional odds model is considered. This type of modelling relaxes the assumption of proportional odds model.

Suppose $y_i = (i = 1, 2, 3, ..., n)$ is the response variable with ordinal categories 1,2,3,...,j,...,c and $x_i = (x_{i1}, x_{i2}, x_{i3}, ..., x_{ip})$ is the vector of p covariates related to y_i. The function form of the proportional odds model is given by [35],

$$\begin{aligned} \eta(X) &= ln\left[\frac{Pr(Y \leq j|x_1, x_2, ..., x_p)}{Pr(Y > j|x_1, x_2, ..., x_p)}\right] \\ &= \theta_j + \beta_1 x_1 + ... + \beta_p x_p \end{aligned} \tag{4}$$

and the function form of partial proportional odds model is given by,

$$\begin{aligned} \eta(X) &= ln\left[\frac{Pr(Y \leq j|x_1, x_2, ..., x_p)}{Pr(Y > j|x_1, x_2, ..., x_p)}\right] \\ &= \theta_j + (\beta_1 + \alpha_{j1})x_1 + ... + \beta_p x_p \end{aligned} \tag{5}$$

where $\beta_1, \beta_2, ..., \beta_p$ are regression parameters and θ_j represent the intercept of the j^{th} cumulative logit.

Partial proportional odds model is used when the assumption of proportional odds model is not satisfied.

2.3.2 Generalized Linear Model (GLM)

2.3.3 GLM definition

Wickens [30] define GLM as synthesis and extension of regression models given by

$$E(Y) = \mu = X'\beta. \tag{6}$$

Further, GLM model is made up of the linear predictors [30]

$$\eta_i = \beta_0 + \beta_1 X_{1i} + ... + \beta_p X_{pi} \tag{7}$$

and two functions (link and variance function). The special case of GLM is logistic regression. This type of regression is increasingly employed in many disciplines including medical research [31].

2.3.4 Survey Logistic Regression

Commonly used regression model when the research do not want to handle the sample design into the analysis is simply logistic regression [33]. In contrast, when a researcher wants to incorporate the sample design into the analysis the survey logistic regression is employed.

The survey logistic regression model is written as

$$ln\left[\frac{\eta_{ij}}{1 - \eta_{ij}}\right] = \beta_0 + \beta_1 X_{1ij} + ... + \beta_p X_{pij}. \tag{8}$$

Studies by [33, 15, 16] also used used survey logistic regression.

3 Results

3.1 Test of Association

The test of association between dependent and independent variable was conducted through Chi-square and gamma measure. The test of association results between anemia status and factors from Angola, Malawi and Senegal are shown in Table 1, Table 2 and Table 3 respectively. The interaction terms were included in the analysis, however they were found no significant and were thereof excluded for further analysis.

Table 1 show that there is a significant association between anemia and place of residence, child's age, mother level of education, household size, household wealth status, child birth order and malnutrition status. Angola rural areas have a higher prevalence of under five children suffering from severe anemia compared to children in urban areas (2.5% and 2.1% respectively).

There is 30.1% of under five children in rural areas that are suffering from moderate anemia compared to 26.1% children in urban areas. This finding reveal that there is higher prevalence of under five children suffering from severe and moderate anemia in rural areas of Angola then in urban areas. The prevalence of under five children suffering from severe anemia in the age group less 24 months and age group between 24-35 was found to be higher as compared to other child's age group.

Improving mother's level of education is found to be positively correlated with the reduction in child risk of suffering from severe and moderate anemia. Household wealth status is observed to be associated with anemia status. Improvement on the wealth status of the household reduces child's risk of suffering from moderate anemia with 28.3% and 22.6% for middle

Table 1: Assessing the association between selected factors and anemia status of under five children using gamma and chi-square test, Angola data.

Factors	Severe (%)	Moderate (%)	Mild (%)	$\hat{\gamma}(p-value)$	$\chi^2(p-value)$
Resident					
Rural	51 (2.5%)	610 (30.1%)	1366 (67.4%)	0.003	-
Urban	51 (2.1%)	647 (26.5%)	1745 (71.4%)		
Sex of household head					
Male	66 (2.3%)	808 (27.9%)	2022 (69.8%)	-	0.904
Female	36 (2.3%)	449 (28.5%)	1089 (69.2%)		
Child's age (months)					
<12	8 (3.1%)	116 (45.1%)	133 (51.8%)	0.000	-
12-23	18 (2.8%)	248 (39.1%)	369 (58.1%)		
24-35	29 (3.1%)	278 (29.5%)	634 (67.4%)		
36-47	33 (2.5%)	340 (25.9%)	938 (71.5%)		
48-59	14 (1.1%)	275 (20.7%)	1037 (78.2%)		
Sex of child					
Male	55 (2.5%)	655 (29.4%)	1518 (68.1%)	-	0.099
Female	47 (2.1%)	602 (26.9%)	1593 (71.1%)		
Mother level of education					
Primary	86 (2.9%)	879 (29.7%)	1998 (67.4%)	0.000	-
Secondary	14 (1.4%)	262 (25.4%)	755 (73.2%)		
Higher	2 (2.2%)	17 (18.3%)	74 (79.6%)		
Birth interval					
<24	9 (2.0%)	112 (25.4%)	320 (72.6%)	0.076	-
24-47	34 (2.2%)	406 (26.2%)	1112 (71.6%)		
>47	37 (2.4%)	430 (28.4%)	1047 (69.2%)		
Household size					
0-5	56 (2.6%)	688 (32.2%)	1395 (65.2%)	0.000	-
6-10	42 (2.0%)	515 (24.3%)	1560 (73.7%)		
11-15	4 (2.0%)	53 (26.5%)	143 (71.5%)		
>15	0 (0.0%)	1 (7.1%)	13 (92.9%)		
Wealth index					
Poor	74 (3.2%)	708 (30.6%)	1530 (66.2%)	0.000	-
Middle	14 (1.3%)	303 (28.3%)	753 (70.4%)		
Not poor	14 (1.3%)	246 (22.6%)	828 (76.1%)		
Birth order					
2-3	38 (2.8%)	384 (28.7%)	917 (68.5%)	0.021	-
4-5	23 (3.0%)	193 (25.2%)	550 (71.8%)		
>5	80 (1.4%)	372 (26.5%)	1014 (72.2%)		
Malnutrition					
Severe	6 (3.0%)	85 (42.1%)	111 (55.0%)	0.000	-
Moderate	18 (3.1%)	179 (30.5%)	389 (66.4%)		
Mild	78 (2.1%)	993 (27.0%)	2611 (70.9%)		
Marital status					
Married	16 (2.2%)	205 (27.9%)	515 (70.0%)	-	0.959
Not married	78 (2.3%)	930 (27.9%)	2326 (69.8%)		
Widowed	6 (2.2%)	81 (30.0%)	183 (67.8%)		

Table 2: Assessing the association between selected factors and anemia status of under five children using gamma and chi-square test, Malawi data.

Factors	Severe (%)	Moderate (%)	Mild (%)	$\hat{\gamma}(p-value)$	$\chi^2(p-value)$
Resident					
Rural	59 (1.7%)	1120 (31.7%)	2355 (66.6%)	0.002	-
Urban	4 (0.6%)	190 (27.3%)	501 (72.1%)		
Sex of household head					
Male	49 (1.6%)	938 (30.7%)	2067 (67.7%)	-	0.535
Female	14 (1.2%)	372 (31.7%)	789 (67.1%)		
Child's age (months)					
< 12	11 (3.7%)	171 (57.2%)	117 (39.1%)	0.000	
12-23	16 (2.2%)	312 (43.3%)	392 (54.4%)		
24-35	10 (1.0%)	302 (31.2%)	656 (67.8%)		
36-47	17 (1.5%)	283 (24.9%)	835 (73.6%)		
48-59	9 (0.8%)	242 (21.9%)	856 (77.3%)		
Sex of child					
Male	44 (2.1%)	661 (31.6%)	1387 (66.3%)	-	0.003
Female	19 (0.9%)	649 (30.4%)	1469 (68.7%)		
Mother level of education					
Primary	45 (1.5%)	968 (32.5%)	1968 (66.0%)	0.003	-
Secondary	11 (1.3%)	231 (27.9%)	585 (70.7%)		
Higher	2 (1.5%)	12 (19.0%)	49 (77.8%)		
Birth interval					
< 24	6 (3.0%)	53 (26.4%)	142 (70.6%)	0.783	-
24-47	16 (1.3%)	392 (30.7%)	869 (68.1%)		
> 47	11 (1.0%)	354 (31.0%)	776 (68.0%)		
Household size					
0-5	44 (1.8%)	780 (31.1%)	1682 (67.1%)	0.452	-
6-10	18 (1.1%)	509 (30.6%)	1135 (68.3%)		
11-15	1 (1.7%)	20 (33.9%)	38 (64.4%)		
> 15	0 (0.0%)	1 (50.0%)	1 (50.0%)		
Wealth index					
Poor	38 (2.1%)	619 (34.2%)	1151 (63.7%)	0.000	-
Middle	14 (1.7%)	236 (28.2%)	587 (70.1%)		
Not poor	11 (0.7%)	455 (28.7%)	1118 (70.6%)		
Birth order					
2-3	22 (1.6%)	406 (29.7%)	938 (68.7%)	0.699	-
4-5	7 (0.8%)	269 (31.9%)	567 (67.3%)		
> 5	12 (1.2%)	284 (29.2%)	676 (69.5%)		
Malnutrition					
Severe	4 (3.9%)	38 (36.9%)	61 (59.2%)	0.048	-
Moderate	14 (3.2%)	136 (31.3%)	285 (65.5%)		
Nourished	45 (1.2%)	1136 (30.8%)	2510 (68.0%)		
Marital status					
Married	0 (0.0%)	9 (31.0%)	20 (69.0%)	-	0.974
Not married	53 (1.5%)	1092 (30.9%)	2387 (67.6%)		
Widowed	10 (1.5%)	208 (31.4%)	445 (67.1%)		

Table 3: Assessing the association between selected factors and anemia status of under five children using gamma and chi-square test, Senegal data.

Factors	Severe (%)	Moderate (%)	Mild (%)	$\hat{\gamma}(p-value)$	$\chi^2(p-value)$
Resident					
Rural	70 (3.6%)	666 (34.4%)	1202 (62.0%)	0.000	-
Urban	6 (0.7%)	235 (25.5%)	679 (73.8%)		
Sex of household head					
Male	64 (3.0%)	676 (31.8%)	1385 (65.2%)	-	0.100
Female	12 (1.6%)	225 (30.7%)	496 (67.7%)		
Child's age (months)					
< 12	3 (2.1%)	61 (42.7%)	79 (55.2%)	0.000	-
12-23	16 (4.1%)	209 (53.5%)	166 (42.5%)		
24-35	21 (3.7%)	220 (38.5%)	330 (57.8%)		
36-47	21 (2.5%)	237 (27.8%)	593 (69.7%)		
48-59	15 (1.7%)	174 (19.3%)	713 (70.0%)	-	0.001
Sex of child					
Male	48 (3.2%)	515 (34.1%)	946 (62.7%)	-	0.001
Female	28 (2.1%)	386 (28.6%)	935 (69.3%)		
Mother level of education					
Primary	68 (2.9%)	768 (32.4%)	1532 (64.7%)	0.039	-
Secondary	4 (1.3%)	86 (28.6%)	211 (70.1%)		
Higher	0 (0.0%)	0 (0.0%)	0 (0.0%)		

Birth interval					
< 24	5 (2.3%)	59 (27.1%)	154 (70.6%)	0.039	-
24-47	35 (3.0%)	373 (31.6%)	774 (65.5%)		
> 47	13 (2.1%)	218 (35.6%)	381 (62.3%)	-	0.001
Household size					
0-5	11 (2.9%)	130 (34.0%)	241 (63.1%)	0.904	-
6-10	29 (2.4%)	362 (30.5%)	795 (67.0%)		
11-15	24 (3.3%)	223 (30.9%)	474 (65.7%)		
> 15	12 (2.1%)	186 (32.7%)	371 (65.2%)		
Wealth index					
Poor	66 (4.0%)	594 (35.8%)	999 (60.2%)	0.000	-
Middle	7 (1.2%)	162 (28.5%)	399 (70.2%)		
Not poor	3 (0.5%)	145 (23.0%)	483 (76.5%)		
Birth order					
2-3	12 (1.6%)	234 (31.8%)	489 (66.5%)	0.192	-
4-5	24 (3.8%)	196 (31.2%)	408 (65.0%)		
> 5	17 (2.6%)	220 (33.9%)	412 (63.5%)		
Malnutrition					
Severe	4 (5.3%)	26 (34.2%)	46 (60.5%)	0.000	-
Moderate	17 (5.0%)	128 (37.6%)	195 (57.4%)		
Mild	55 (2.3%)	747 (30.6%)	1640 (67.2%)		
Marital status					
Married	0 (0.0%)	5 (27.8%)	13 (70.0%)	-	0.805
Not married	69 (2.6%)	833 (31.8%)	1719 (65.6%)		
Widowed	7 (3.2%)	63 (28.9%)	148 (67.9%)		

and not poor households respectively.

There is a 3.0% of under five children suffering from severe anemia and severe malnutrition. Whereas, 3.1% of under five children are suffering from severe anemia and moderate malnutrition.

Table 2 show that there is association between under five anemia status and place of residence, child's age, sex of the child, mother's level of education, household wealh status and malnutrition status.

There is 1.7% under five children suffering from severe anemia in rural areas of Malawi compared to 0.6% of under five children in urban areas. The results also show that improving mother's level of education and household status reduces the child's risk of suffering from anemia.

The prevalence of under five children suffering from severe anemia and severe malnutrition is 3.9%, whereas the prevalence of under five children suffering from moderate anemia and severe malnutrition is 36.9%.

Table 3 show that place of residence, child's age, sex of the child, mother level of education, household status, birth interval and malnutrition status are all associated with anemia in Senegal. There is 3.6% of under five children suffering from severe anemia in rural areas of Senegal compared to 0.7% of under five children in urban areas. It was also found that improving mother's level of education and household wealth reduces the child's risk of suffering from anemia.

There is a higher prevalence of under five children suffering from severe anemia and severe malnutrition (5.3%) compared to those suffering from mild malnutrition and severe anemia (2.3%).

3.2 Survey logistic regression application

The survey logistic regression model that was used in this study is given by

$$\begin{aligned} ln\left[\frac{\eta_{ij}}{1-\eta_{ij}}\right] &= \beta_0 + \beta_1 X_{1ij} + ... + \beta_7 X_{7ij} \\ &= \beta_0 + \beta_1 Resident + \beta_2 Mothereducation \\ &+ \beta_3 Sexofchild + \beta_4 Childage + \\ &\beta_5 Wealthindex + \beta_6 Nutritionstatus + \\ &\beta_7 Householdsize \end{aligned} \tag{9}$$

SAS software command PROC SURVEYLOGISTIC for ordinal logistic regression was used in order to handle sampling design when analysing the data.

The test of proportional odds assumption was found to be not significant at 5% level of significant. Hence, the proportional odd assumption is satisfied. This means the interpretation of results for severe/moderate anemia versus mild anemia are the same as the interpretation of anemia versus not anemia [21].

There results from Table 4 revealed that under five children residing in rural area of Angola are 1.1320 times more likely to be in the worse condition of anemia than those residing in the urban areas of Angola. This result is in line with the findings of the study conducted by [34]. Whereas, under five children in rural areas of Malawi and Senegal are found to be 0.8370 and 0.7310 less likely to be in the worse condition of anemia compared the children residing in the urban areas.

The likelihood of a under five child from not poor household in Angola, Malawi and Senegal is found to be 1.5530, 1.2090 and 2.0750 more times to be on the worse anemia condition compared to the counterpart.

Table 4: Coefficients and odds ratios

	Angola			Malawi			Senegal		
Factors	Coeff.	OR	P-Value	Coeff.	OR	P-Value	Coeff.	OR	P-Value
Intercept 1	0.9739		0.0002	-0.0971		0.5825	0.5204		0.0002
Intercept 2	3.9023		0.0001	3.4976		0.0001	3.6529		0.0001
Resident									
Ref :Urban									
Rural	0.0619	1.132	0.2428	-0.0888	0.8370	0.1312	-0.1569	0.7310	0.0275
Mother education									
Ref :Secondary									
Primary	-0.1974	0.7950	0.0661	-0.2389	0.7970	0.0388	-0.0092	0.9820	0.8912
Higher	0.1649	1.1410	0.3740	0.2503	1.2990	0.2376	-0.1070	0.8070	0.1501
Sex of child									
Ref :Male									
Female	0.0829	1.1800	0.0234	0.0645	1.1380	0.0695	0.1425	1.3300	0.0011
Child's age									
Ref : $<$ 12 months									
12-13	-0.3127	1.3050	0.0001	-0.3888	1.9200	0.0001	-0.3138	0.6070	0.0001
24-35	0.0427	1.8610	0.5146	0.1855	3.4100	0.0072	-0.1638	1.1640	0.0645
36-47	0.2329	2.2510	0.0002	0.5292	4.8090	0.0001	0.3663	1.9770	0.0001
48-59	0.6157	3.3010	0.0001	0.7153	5.7930	0.0001	0.9265	3.4610	0.0001
Wealth index									
Ref :Poor									
Middle	0.0073	1.2600	0.8975	0.1262	1.3280	0.0510	0.0640	1.5870	0.4505
Not poor	0.2164	1.5530	0.0014	0.0317	1.2090	0.5874	0.3338	2.0780	0.0005
Nutritional Status									
Ref :Severe									
Moderate	0.0815	1.4880	0.3139	0.0086	1.2260	0.9353	-0.2190	0.7920	0.0631
Nourished	0.2344	1.7340	0.0002	0.1867	1.4640	0.0336	0.2048	1.2100	0.0588
Household size									
Ref : $>$ 15 months									
0-5	-0.4051	0.2580	0.0927	0.7929	17.369	0.0001	-0.0605	0.9870	0.5587
6-10	-0.1578	0.3300	0.5126	0.7234	16.2270	0.0001	0.1084	1.1690	0.0990
11-15	-0.3875	0.2620	0.1391	0.5470	13.6040	0.0251	0.0027	1.0490	0.9997

Under five female children from Angola, Malawi and Senegal are found to be suffering from worse anemia condition as compared to male under five children.

The results show that the likelihood for under five children to suffer from worse anemic condition increase directly proportional to child's age. Children in the age interval of 48-59 months have higher chance of suffering from worse anemia condition than any other child outside of that age group. The study conducted by [32] had a different finding with the under five Pakistan children. The 36-59 children were found to be less likely to suffer from anemic condition as compared to other age groups.

Under five children suffering from moderate malnutrition in Angola and Malawi are 1.4880 and 1.2260 times more likely to be in the worse condition of anemia. Whereas, the under five children suffering from moderate malnutrition in Senegal are 0.7920 less likely to suffer from worse condition of anemia. Under five children with nourished nutritional status are 1.7340, 1.4640 and 1.2100 time more likely to suffer from severe anemia in Angola, Malawi and Senegal respectively.

Under five children residing in the households of size 0-5 members in Senegal are 0.9870 less likely to suffer from severe anemia as compared to households of bigger size. Senegalese households of size 6-10 and 11-15 members expose under five children to severe anamia.

4 Discussion

Survey logistic regression which is a special case of Generalized Linear Model (GLM) was employed in the study for analysis. From the results, the test of proportional odds assumption was found to be not significant at 5% level of significant. Hence, the proportional odd assumption is satisfied. This means the interpretation of results for severe/moderate anemia versus mild anemia are the same as the interpretation of anemia versus not anemia.

Results further revealed that sex of children under five years in Angola, Malawi and Senegal is significantly associated with anemia. Under five year old female child was found to be more likely to suffer from anemic condition as compared to under five year old male child.

Place of residence is another factor that the government of Angola needs to look at in attempt to reduce the under five year old mortality induced by anemia. Children under five years residing in rural areas of Angola were found to be more likely to be exposed to anemia as compared to under five years children residing in urban areas. This indicate that the is a gap in the services that are provided to rural and urban areas of Angola

Results also revealed that children under five years residing in rural areas of Malawi and Senegal were less likely to suffer from severe anemia condition. This indicates that the government of Malawi and Senegal is equally distributing the necessary services to both rural and urban areas. Hence, there is a need for Angola government and policy makers to work closely with Malawian and Senegalese stakeholders to discuss and brainstorm on how to close the gap of service delivery between rural and urban setting in Angola.

Household size factor was identified as a significant determinant of anemia for children under five years in Malawi and Senegal. Household of bigger size increases the probability of having a young child exposed to anemia in Malawi and Senegal. Thereof, the government of Malawi and Senegal needs to educate the population on the impact induced by increasing the household size. Also, apart from educating the population the government can create financial structures that will be supporting families of size more than five members.

The health institutions of Angola, Malawi and Senegal need to monitor under five years children that are suffering from malnutrition condition. The study showed that there is a high chance for under five years children to suffer from both malnutrition and anemia condition. This finding is similar to the results of the study that was conducted in Bangladesh and Burma [27, 28], hence this risk factor can be observed as a risk factor that is affecting all developing countries globally.

5 Conclusions

The study identified place of residence, age of the child, wealth index, mother level of education and nutritional status as common factors associated with anemia in Angola, Malawi and Senegal. This finding is in agreement with that of the studies conducted by [27, 26, 36]. The results showed the necessity of collaboration between Angola, Malawi and Senegal in order to achieve the SGD target.

The government of Angola needs to ensure that financial, health and educational structures supporting urban areas are also distributed equally to rural areas. Another area of focus from the studied countries is availability and accessibility of health institutions. It is challenging for rural setting to accessing health institutions based on logistics required, hence it is pivotal for government of Angola, Malawi and Senegal to make available the mobile clinics or health support to rural settings. The government needs to also ensure that the well-being of pregnant women until giving birth is taken of and supported by medical assistance

Addressing anemia independent will not assist in reducing the mortality rate of under five children. Thereof, there is also a need to take in consideration malnutrition, malaria and other factors. The strategic proposal from three countries should be drawn with all the possible causes addressed. That will ensue to SGD target achievement.

Limitation of the study include modelling common factors across Angola, Malawi and Senegal. This reasoning resulted in excluding variables that are found by literatures to be significant in defining mortality of under five years.

Future study should focus on incorporate mother's BMI, mother anemic status, mother age at first birth etc. This will ensue better understanding of under five year anemia causes. It is also suggested that similar study should be carried out with more than three countries. This will speak to the distribution of services aiming at reducing under five mortality across African continent and a better collaboration among Africa countries.

Abbreviations

World Health Organisation (WHO), Sustainable Development Goal (SDG), Ministry of Planning and Territory Development (MPDT), standard enumeration areas (SEAs), standard error (SE), Generalized Linear Model (GLM)

Declaration

Ethical approval and consent to participate

Ethical approval was granted by the Ethics Committee of the National Statistical Office of Angola for Angola DHS Data; Malawi for Malawi DHS Data; and Senegal for Senegal DHS Data. The 2016 DHS data are available to the general public by request from the Measure DHS website. We submitted a request to the Measure DHS by describing the purpose and objectives of the study and thereafter received permission to download the children's dataset.

Consent for publication

Not applicable

Availability of data and materials

The dataset analysed during this study is not publicly available but data is available from the corresponding author on reasonable request. Additionally, further information about the data and conditions for access are available upon registration and request to DHS program- http://dhsprogram.com.

Competing interest

The author declare they have no competing interests

Funding

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Authors' contributions

CK: Designed the study, analyse the data, interpret the results and writes the manuscript. SR: Revised the manuscript critically, edited the final draft and supervised the research.

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