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Influence of malaria on anemia levels among children less than 60 months of age

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Abstract

This study aimed at determining the influence of malaria on anemia levels among children less than 60 months of age. An ordered logistic regression model was adopted using secondary data from the Uganda Malaria Indicator Survey. A child's anemia level was significantly affected by malaria status, child's age, child's sex, mother's education, region and wealth quintile. The risk of anemia in children increased among those suffering from malaria (OR=3.68, p=0.00). The risk of anemia reduced with; increase in a child's age, being female, increase in mother's education, residing in the Western region and increase in wealth quintile. The study recommended emphasis on the fight against malaria through interventions to reduce malaria transmission such as utilization of long lasting insecticide treated nets, indoor residual spraying and chemoprevention in children in addition to promoting uptake of nutritious foods rich in iron and other minerals essential for proper growth in children.

Keywords: anemia, malaria, children, Uganda

1. Introduction

Anemia defined as a low level of functional hemoglobin in the blood, decreases the amount of oxygen reaching the tissues and organs of the body [18]. Anemia in childhood is defined as a hemoglobin (Hb) concentration below cut off levels established by the World Health Organization: <11 g/dl in children aged 6–59 months, <11.5 g/dl in children aged 5–11 years and 12 g/dl in older children aged 12–14 [16, 20]. Anemia in children can lead to severe health consequences including impaired cognitive and motor development, stunted growth and increased morbidity from infectious diseases, with inadequate intake of iron, folate, vitamin B12 or other nutrients accounting for the majority of cases of anemia in many populations [16, 18].

In areas where malaria is endemic, malaria usually accounts for a significant proportion of anemia in children under age five while in areas of stable malaria transmission, anemia has been used to monitor the impact of malaria control interventions [18]. Because anemia is a major cause of morbidity and mortality associated with malaria, prevention and treatment of malaria among children and pregnant women is essential for reduction of the anemia burden [18] with some studies indicating that malaria control effectively reduces the prevalence of childhood anemia [4, 8]. Studies in East Africa have shown that P. falciparum malaria and iron deficiency account for much of the anemia seen in young children with a randomized study concluding that approximately 60% of anemia in infancy could be prevented by antimalarial chemoprophylaxis, illustrating the importance of malaria as a cause of anemia [13].

According to WHO, Africa has the highest anemia prevalence overall for pre-school aged children with global prevalence in the 0–5 year-old age group rising to 47.4 % [7, 11]. The results of the 2014-15 Uganda Malaria Indicator Survey (UMIS) show that 5 percent of Ugandan children under five are severely anemic with the prevalence of severe anemia being highest among children aged 9-11 months (16 percent) and lowest among children 48-59 months (2 percent) indicating a reduction in prevalence of anemia with age [18]. Because childhood anemia and iron deficiency have a significant impact on life-long health, it is important to identify determinants of this condition early in the child's life to avoid compromising on their physical growth, learning ability, work efficiency and immune functioning [3]. Anemia can occur at any time and at all stages of the life cycle [11, 19] but young children and pregnant women are the most at risk segment of the community [1, 19]. The current study seeks to investigate the risk factors for anemia with special emphasis on the effect of a child's malaria status.

2. Materials and Methods

2.1 Data source

The data used in this study was from the Uganda Malaria Indicator Survey [18]. A nationally representative sample of 5,802 households in 210 census enumeration areas was used. The sample was selected using a stratified two-stage cluster design consisting of 210 clusters with 44 in urban areas and 166 in rural areas. In the first stage, 20 sampling strata were created and clusters were selected independently from each stratum by a probability-proportional-to-size selection. In the second stage of the selection process, 28 households were selected in each cluster by equal probability systematic sampling. All children aged 0-59 months living in the households selected for the 2014-15 UMIS were eligible for anemia and malaria testing using finger- or heel-prick blood samples. Test results for anemia (using the HemoCue portable machine) and malaria (using the SD Bioline Ag *P.f* Rapid Diagnostic Test) were made available immediately and provided to the child's parent or guardian. Ninety seven percent of eligible children were tested for anemia, 96 percent were tested for malaria with RDTs and 97 percent were tested for malaria with microscopy

2.2 Data analysis

Data was analyzed using STATA Version 13.0 at three stages. Firstly, a descriptive summary of all plausible independent variables was done using frequency distributions. Secondly, using the Pearson's chi-square test association between anemia level and plausible independent variables was tested. Variables that were significant ($p \leq 0.05$) at this level were considered for further analysis at the multivariate level.

$$\chi^2 = \sum_{i=1}^{k}\sum_{j=1}^{n}\frac{(O_{ij}-E_{ij})^2}{E_{ij}} \quad (1)$$

where O_{ij} is the number of individuals observed in the i^{th} row and j^{th} column cell, E_{ij} is the number of individuals expected in the i^{th} row and j^{th} column cell.

Thirdly, since the dependent variable was treated as an ordinal outcome, that is, a child's anemic level is either, not anemic, mild, moderate or severe; the ordinal logistic regression model was fitted to determine the significant determinants of a child's anemic level.

$$\log\left(\frac{Pr(y_i \leq j)}{Pr(y_i > j)}\right) = \alpha_j + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + \epsilon_{ij} \quad (2)$$

where $\alpha_1 < \alpha_2 < \cdots < \alpha_{k-1}$, $\beta_{j1} \dots \beta_{jk}$ are partial slope coefficients, $X_{11} \dots X_{ki}$ are plausible independent variables and ϵ_{ij} is the error term.

3. Results

3.1 Description of respondents

Table 1 provides a summarize description of the characteristics of children who were involved in the study with regards to their anemia level, malaria status, age, sex, mother's education level, sex of the household head, region, residence (rural/urban), wealth quintile and source of drinking water.

Table 1: Description of respondents

Variables	Frequency	Percent
Anemia level		
Not anemic	2,311	46.78
Mild	1,185	23.99
Moderate	1,341	27.15
Severe	103	2.09
Malaria status		
Negative	3,958	80.28
Positive	972	19.72
Child's age		
0-23	1,845	37.35
24-47	2,093	42.37
48-59	1,002	20.28
Child's sex		
Male	2,407	48.72
Female	2,533	51.28
Mother's education		
No education	952	22.93
Primary	2,424	58.4
Secondary	642	15.47
Higher	133	3.2
Sex of household head		
Male	3,903	79.01
Female	1,037	20.99
Region		
Central	945	19.13
Northern	2,112	42.75
Western	975	19.74
Eastern	908	18.38
Residence		
Urban	736	14.9
Rural	4,204	85.1
Wealth quintile		
Poorest	1,547	31.32
Poorer	1,060	21.46
Middle	872	17.65
Richer	764	15.47
Richest	697	14.11
Water source		
Unimproved	1,328	26.92
Improved	3,605	73.08

From table 1, the highest proportion of children less than 60 months were not anemic (46.78%) with the rest reported to either have mild (23.99%), moderate (27.15%) or severe (2.09%) anemia. Majority of the children; tested negative

(80.28%) for malaria, were female (51.28%) and were aged 24-47 months (42.37%). Majority of the children belonged to; male headed households (79.01%) located in rural areas (85.1%) with access to improved water sources (73.08%). Majority of the children's mothers had attained primary level (58.4%) education with a few attaining higher education (3.2%). The highest proportion of respondents; resided in households from the Northern region (42.75%) and were in the poorest (31.32%) wealth quintile.

3.2 Plausible independent variables and anemia level

Table 2 provides a summary of the association between the plausible independent variables and anemia level. Apart from the sex of the household head, the rest of the plausible independent variables were significantly ($p \leq 0.05$) associated with anemia level.

Table 2: Association between plausible independent variables and anemia level

Variable		Not anemic	Mild	Moderate	Severe
Malaria status	Negative	51.92	23.65	23.19	1.24
	Positive	26.03	25.21	43.21	5.56
		Chi2(3) = 297.3603 Pr = 0.000			
Child's age	0-23	32.79	26.67	37.29	3.25
	24-47	52.65	22.31	23.65	1.39
	48-59	60.28	22.55	15.77	1.40
		Chi2(6) = 286.8359 Pr = 0.000			
Child's sex	Male	44.83	23.97	28.87	2.33
	Female	48.64	24.00	25.50	1.86
		Chi2(3) = 10.3102 Pr = 0.016			
Mother's education	No education	42.54	24.05	30.78	2.63
	Primary	44.93	24.88	27.93	2.27
	Secondary	47.51	24.30	27.10	1.09
	Higher	66.17	15.04	18.80	0.00
		Chi2(9) = 34.3885 Pr = 0.000			
Sex of household head	Male	46.27	23.70	27.75	2.28
	Female	48.70	25.07	24.88	1.35
		Chi2(3) = 7.5581 Pr = 0.056			
Region	Central	50.05	24.44	23.92	1.59
	Northern	45.55	25.05	27.23	2.18
	Western	57.95	20.72	20.10	1.23
	Eastern	34.25	24.56	37.89	3.30
		Chi2(9) = 135.9824 Pr = 0.000			
Residence	Urban	55.98	21.06	21.33	1.63
	Rural	45.17	24.50	28.16	2.16
		Chi2(3) = 30.3554 Pr = 0.000			
Wealth quintile	Poorest	42.15	25.79	29.61	2.46
	Poorer	44.62	23.58	29.15	2.64
	Middle	45.87	25.00	26.83	2.29
	Richer	52.09	22.25	24.61	1.05
	Richest	55.67	21.23	21.81	1.29
		Chi2(12) = 53.4085 Pr = 0.000			
Water source	Unimproved	46.08	26.36	26.20	1.36
	Improved	47.02	23.13	27.49	2.36
		Chi2(3) = 9.6363 Pr = 0.022			

Based on Table 2 above, the highest proportion of children who tested positive for malaria had moderate anemia (43.21%) followed by those who were not anemic (26.03%), mildly anemic (25.21%) and lastly severely anemic (5.56%). Children aged 0-23 months had the highest proportion with severe anemia (3.25%), moderate anemia (37.29%) and mild anemia (26.67%) compared to other age groups. Females had the highest proportion with mild anemia (24%) whereas males had the highest proportion with both moderate (28.87%) and severe (2.33%) anemia. Majority of mothers with higher education had non-anemic (66.17%) children whereas mothers with no education had the highest proportion of children with moderate (30.78%) and severe (2.63%) anemia. The highest proportion of children with severe anemia were; from the Eastern (3.3%) and Northern (2.18%) regions and resided in rural areas (2.16%). Majority of children from households in the richer (52.09%) and richest (55.67%) wealth quintiles had no anemia with severe anemia reported highest in the poorer (2.64%), poorest (2.46%) and middle (2.29%) wealth quintiles. Children from households using improved water sources had the highest proportion of children with moderate (27.49%) and severe (2.36%) anemia.

3.3 Determinants of anemia levels among children less than 60 months of age

Table 3 below provides a summary of the significant determinants of a child's anemia level. Apart from residence (rural/urban) and water source for drinking, the rest of the plausible independent variables had a significant effect ($p \leq 0.05$) on a child's anemia level.

Table 3: Determinants of anemia level

Variables		Odds Ratio	Z	P>|z|	95% C.I	
Malaria status	Negative	1.00				
	Positive	3.68	16.08	0.00	3.14	4.31
Child's age	0-23	1.00				
	24-47	0.38	-14.29	0.00	0.33	0.44
	48-59	0.25	-15.23	0.00	0.21	0.30
Child's sex	Male	1.00				
	Female	0.83	-3.16	0.00	0.74	0.93
Mother's education	No education	1.00				
	Primary	0.96	-0.48	0.63	0.83	1.12
	Secondary	0.93	-0.62	0.53	0.75	1.16
	Higher	0.59	-2.45	0.01	0.39	0.90
Region	Central	1.00				
	Northern	0.87	-1.32	0.19	0.71	1.07
	Western	0.67	-3.73	0.00	0.55	0.83
	Eastern	1.66	4.73	0.00	1.34	2.04
Residence	Urban	1.00				
	Rural	1.05	0.44	0.66	0.85	1.30
Wealth quintile	Poorest	1.00				
	Poorer	0.95	-0.57	0.57	0.80	1.13
	Middle	0.81	-2.02	0.04	0.66	0.99
	Richer	0.74	-2.79	0.01	0.59	0.91
	Richest	0.76	-1.84	0.07	0.57	1.02
Water source	Unimproved	1.00				
	Improved	0.97	-0.41	0.68	0.85	1.12

For children who tested positive for malaria, the odds of having severe anemia versus the combined moderate, mild and no anemia were 3.68 times higher than for children who tested negative for anemia given the other variables are held constant.

Pertaining to the child's age, for children aged 24-47 months, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.38 times lower compared to children aged 0-23 months other factors constant. As for children aged 48-59 months, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.25 times lower compared to children aged 0-23 months other factors constant.

As for sex of the child, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.83 times lower for females compared to males other factors constant.

Regarding mother's education level, for children of mothers with higher education, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.59 times lower compared to children of mothers with no education other factors constant.

With regards to region, for children coming from households located in the Western region, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.67 times lower compared to children from households located in the Central region other factors constant. As for children from the Eastern region, the odds of having severe anemia versus the combined moderate, mild and no anemia were 1.66 times higher compared to children from households located in the Central region other factors constant.

Concerning wealth quintile, for children coming from households in the middle wealth quintile, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.81 times lower compared to children from households in the poorest wealth quintile other factors constant. As for children coming from households in the richer wealth quintile, the odds of having severe anemia versus the combined moderate, mild and no anemia were 0.74 times lower compared to children from households in the poorest wealth quintile other factors constant.

4. Discussion

The study findings indicate a significantly increased risk of anemia in children suffering from malaria. This is consistent with studies by [4, 6, 14, 12]. This can be attributed to the fact that malaria causes profound disturbances in physiological iron distribution and utilization, through mechanisms that include hemolysis, release of heme, dyserythropoiesis, anemia, deposition of iron in macrophages and inhibition of dietary iron absorption [17]. Regarding the significance of a child's age and the increased risk among younger children less than 24 months, similar findings were reported by [2, 4, 9, 14, 21]. The increased risk of anemia in the males as opposed to females is in agreement with findings by [14, 10, 19]. Mother education significantly reduced the risk of anemia in children whose mothers had attained higher education although [14] reported a significant effect even for secondary level. The risk was highest for children whose mothers had no education [5, 19, 21]. Regional differences in the risk of anemia were significant for the Western and Eastern regions and this could be attributed to variations in staple foods consumed. In the Western region, there is high consumption of bananas and milk consumption all highly rich in iron leading to a reduced risk of anemia in children. Significant regional differences were also reported by [10]. Risk of anemia reduced for children in households in the middle and richer wealth quintiles compared to the poorest wealth quintile due to their increased ability to provide children with well-balanced nutritious meals. Similar findings were reported by [5, 7, 10, 15, 21].

4. Conclusion

This study focused on determining the influence of malaria on anemia levels among children less than 60 months of age. Furthermore, the study also looked at the influence of other plausible factors on the anemia level of a child. Based on the study findings, the risk of anemia in children increased with; suffering from malaria (OR=3.68, p=0.00) and residing in the Eastern region (OR=1.66, p=0.00). The risk of anemia in children reduced with; increase in a child's age, being female, increase in mother's education, residing in the Western region and rise in wealth quintile. Therefore the study recommends emphasis on the fight against malaria which is not only one of the leading causes of mortality among children but also a risk factor for anemia. Anemia has detrimental outcomes to the health and physical development of children and further increases the risk of mortality and morbidity from infectious diseases. Interventions to reduce malaria transmission such as utilization of long lasting insecticide treated nets, indoor residual spraying and chemoprevention in children are highly encouraged. These interventions should be in addition to promoting uptake of nutritious foods rich in iron and other minerals essential for proper growth in children. This can be achieved through provision of vital nutrient supplements to children and breast feeding mothers, running sensitization campaigns to educate the people about healthy eating habits as well as boosting household agriculture to enable families meet their basic food requirements.

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