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Determinants of normal haemoglobin concentration among under-five children in Sub-Saharan Africa: a Positive deviance inquiry using cross-sectional study design

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ABSTRACT

Background Low haemoglobin level in children is linked with short-term and long-term consequences including developmental delay. Globally, over half of the children under the age of five years had low haemoglobin concentration. However, there is limited research on the prevalence and determinants of normal haemoglobin concentration among under-five children in sub-Saharan Africa.

Objective To assess determinants of normal haemoglobin concentration among under-five children in SSA.

Design Cross-sectional study design using a positive deviance approach

Setting 33 SSA countries.

Participants 129 408 children aged 6–59 months

Primary and secondary outcome measures A multilevel Poisson regression model with robust variance was fitted to identify determinants of normal haemoglobin concentration. An adjusted prevalence ratio with a 95% CI was reported to declare the statistical significance.

Result The pooled prevalence of normal haemoglobin concentration among under-five children in SSA was 34.9% (95% CI: 34.6% to 35.1%). High maternal education, middle and rich household wealth, female child, frequent antenatal care visits, non-anaemic mothers, taking anthelmintic drugs and normal nutritional status were associated with increased odds of normal haemoglobin concentration. On the other hand, higher birth order, having fever and diarrhoea, rural residence were associated with lower odds of normal haemoglobin levels.

Conclusion According to our finding, only four out of 10 under-five children in SSA had a normal haemoglobin level. This finding proved that anaemia among children in SSA remains a serious public health concern. Therefore, improving maternal education, provision of drugs for an intestinal parasite and early detection and treatment of maternal anaemia, febrile illness and diarrhoeal disease is important.

STRENGTHS AND LIMITATIONS OF THE STUDY

⇒ This study was based on a pooled nationally representative Demographic and Health Survey (DHS) of the 33 sub-Saharan African countries, which made the observed associations more robust and enhanced the generalisability of the findings.
⇒ The haemoglobin concentration was objectively measured, which helps to reduce potential misclassification.
⇒ We are unable to draw cause-and-effect relationships because of the cross-sectional nature of DHS data.
⇒ Because these variables were not available in DHS, we did not consider important predictors such as visceral leishmaniosis, hookworm and congenital infections.

BACKGROUND

The world Health Organasation (WHO) defines anaemia among under-five children as a haemoglobin (Hb) concentration below 11 g/dl.[1] Anaemia is a medical disorder that is defined by a deficiency in the amount of healthy red blood cells, which frequently coincides with decreased haemoglobin levels or abnormal shape of blood cells, preventing blood from providing oxygen to the tissues of the body.[2 3]

Anaemia is a major public health concern around the world, primarily affecting young children and pregnant women.[4 5] According to the WHO, an estimated 269 million under-five children worldwide are anaemic, with a prevalence of 39.8%.[6] The African region has the highest prevalence of anaemia among children under the age of five, with 60.2%.[7]

The most common causes of anaemia in children are haemoglobinopathies, dietary deficiencies (such as iron, folate, vitamins

B_{12} and A) and infectious illnesses such as malaria, tuberculosis, HIV and hookworm.[8–10] Anaemia has serious short-term and long-term consequences for children's health. It harms children's health by causing developmental delays, lower cognitive development, low immunity, weariness, difficulties to focus, lethargy, increased mortality and infection susceptibility.[11] Furthermore, anaemia in childhood is linked to a decrease in ability to combat illnesses, which leads to substantial morbidity and death in children.[12]

Given the consequences, effective and efficient public health strategies to address childhood anaemia are urgently needed. In order to design effective interventions, it is critical to have a clear understanding about the factors that have the potential to prevent children from developing anaemia. The current study aims to shed light on these factors by focusing on children with normal Hb concentrations (ie, children who do not have any form of anaemia). The study will provide a comprehensive understanding of the factors that promote normal Hb concentration as opposed to the risk factors for low Hb concentration (anaemia). Indeed, understanding the factors that contribute for normal Hb concentration in children, which is currently lacking in sub-Saharan Africa (SSA), is critical for developing effective anaemia prevention programmes.

The analytical strategy of the present study was positive deviance (PD), a resource-based approach. The concept of PD is preceded by the statement that 'in every community there are some individuals or groups whose unusual behaviors and strategies enable them to find better solutions to problems than their peers, despite having access to the same resources and facing similar or worse challenges'.[13 14] The PD concept aims to study the behaviours and characteristics of those who achieve better results on a given health outcome than their peers who reside in the same community.[15] It is an established concept that can be studied using a statistical approach and is often quantified as those who do not experience a negative outcome of interest compared with their peers in the same settings.[15] In the past, the PD method was used to investigate neonatal care, childhood anaemia, child nutrition, safe sex practices, malaria control, health service delivery and educational outcomes in a variety of settings.[16–19] Indeed, almost all of these PD studies were conducted outside SSA except a study conducted in Ghana.[20] In SSA countries, the application of PD in investigating child health outcomes is relatively rare. This suggests the need for more research using the PD approach in SSA.

The PD approach is unique in that it focuses on the 'positive' aspects of an outcome rather than the 'negative' and it can identify potential points of intervention. Positive deviants in the current study were children who lived in anemia-endemic SSA countries but had normal Hb concentrations (not anaemic) compared with their counterparts who lived in the same countries but were anaemic. The primary goal of this study is to investigate the factors that influence normal Hb concentration among children living in SSA countries. Identifying these determinants would serve as the foundation for developing programmes aimed at children in SSA countries who are at risk of having low Hb concentrations. It is important to note that the current study's resource-focused approach differs from the dominant risk model approach, in which the focus is typically on children with poor health and the associated risk factors.

METHODS

Data source and sampling procedure

This study was based on the most recent Demographic and Health Survey (DHS) of 33 SSA countries. The DHS is conducted every 5 years to generate updated health and health-related indicators. The study subjects were chosen using a two-stage stratified sampling technique. Enumeration areas were chosen at random in the first stage, and households were chosen in the second. Children in the chosen households underwent haemoglobin testing using the HemoCue rapid testing methodology to determine their anaemia status. A drop of capillary blood was drawn from the kids' fingertip or heel for the test, and the haemoglobin concentration was measured using a photometer. DHS has a variety of data sets, and we used the Kids Record (KR) file for this study. Based on reviewed literatures, we extracted the data from the KR data set and then appended it using the STATA command 'append using'. Combining separate data sets from each SSA country into a single data set through the process of data set appending is a common practice in data analysis. By doing so, we create a unified data set that allows for more efficient management and analysis within STATA. This study's final sample size was 129 408 children aged 6–59 months (table 1). Detailed information about DHS methodology can be found from the official database https://dhsprogram.com/Methodology/index.cfm.

Study variables and measurements

Dependent variable

The response variable was Hb concentration of children. The Hb data were categorised into mild anaemia (haemoglobin level 10.0–10.9 g/dL, moderate anaemia (haemoglobin level 7.0–9.9 g/dL), severe anaemia (haemoglobin level<7.0 g/dL) and no anaemia (hemoglobin≥11.0 g/dL).[21] In this study, mild, moderate and severe anaemia were recoded as 'anaemic or low Hb concentration' and assigned a value of '0' (referenced category), while children who did not have any form of anaemia were assigned a value of '1' (non-anaemic or normal Hb concentration) (outcome of interest). Because PD is the analytic lens, children with normal Hb concentrations were classified as positive deviants.

Independent variables

Given the hierarchical structure of the DHS data, where mothers and children were nested within the cluster, and in accordance with the study's objectives, two levels of

Table 1 The prevalence of mild, moderate and severe anaemia (along with normal haemoglobin) across the 33 countries studied

Country	Year of survey	Severe anaemia (%)	Mild anaemia (%)	Moderate anaemia (%)	No anaemia (%)
Angola	2015–2016	2.12	30.00	32.00	35.88
Burkina Faso	2021	10.91	18.47	58.94	11.68
Benin	2017–2018	3.39	27.76	40.57	28.28
Burundi	2016–2017	3.29	24.59	30.99	41.13
Congo Dr	2013–2014	3.74	24.72	34.53	37.01
Congo	2011–2012	1.24	31.49	33.48	33.79
Cote d'ivoire	2021	3.53	24.95	46.92	24.60
Cameroon	2018	2.01	25.50	29.92	42.57
Ethiopia	2016	4.00	23.79	32.58	39.63
Gabon	2019–2021	1.77	29.40	32.47	36.36
Ghana	2014	2.98	27.30	39.49	30.23
Gambia	2019–2020	1.83	24.70	26.70	46.77
Guinea	2018	2.10	29.50	42.00	26.40
Liberia	2019–2020	2.40	28.10	40.10	29.40
Lesotho	2014	1.74	25.08	26.20	46.98
Madagascar	2021	0.55	26.26	20.77	52.42
Mali	2018	5.14	24.52	50.41	19.93
Mauritania	2019–2021	8.40	20.01	46.08	25.51
Malawi	2015–2016	1.75	26.88	34.00	37.07
Mozambique	2011	3.37	26.24	36.67	33.72
Nigeria	2018	3.16	27.26	38.57	31.36
Niger	2012	2.82	26.58	45.06	25.44
Namibia	2013	0.98	24.60	25.00	49.42
Rwanda	2019–2020	0.29	21.30	14.90	63.51
Sierra Leone	2019	3.16	30.51	36.27	30.06
Sao tome and Principe	2008–2009	1.04	31.10	27.06	40.80
Swaziland	2009	1.10	22.94	20.99	54.97
Togo	2013–2014	2.63	25.90	42.34	29.13
Tanzania	2022	1.53	27.25	29.70	41.52
Uganda	2016	2.28	24.44	27.84	45.54
South Africa	2016	2.75	25.99	32.89	38.37
Zambia	2018	1.43	28.54	28.00	42.03
Zimbabwe	2015	0.51	22.21	15.50	61.78

independent variables were taken into consideration. The attributes related to households, maternal factors and child-related traits were categorised as individual-level factors. Household-related factors included household wealth index, family size, the gender of the household head and media exposure. Maternal age, maternal education, marital status, maternal anaemia, the number of antenatal care (ANC) visits during pregnancy and the place of delivery were all maternal-related factors. The following child-related factors are included: a child's age, size at birth, sex, type of birth, birth order, diarrhoea or fever within the previous 2 weeks, and use of an intestinal parasite medication within the previous 6 months. Stunting status (Z-scores for height for age (HAZ)), wasting status (Z-scores for weight-for-height (WHZ)) and underweight status (WAZ)). Children who are stunted are those whose height-for-age Z-score (HAZ) is less than two SD, wasted are those whose weight-for-height Z-score (WHZ) is less than two SDs and underweight are those whose weight-for-age Z-score (WAZ) is less than two SDs. The SSA region and residence were community-level variables.

Data management and analysis

Data extraction, coding and analysis were done using Stata V.17 statistical software. To make the data more representative again, analysis was done using the weighted data. The intra-class correlation coefficient (ICC) was estimated to evaluate the clustering effect because the DHS data are hierarchical in nature. There was a sizeable clustering effect, according to the ICC (ICC>10%). This study was a cross-sectional study and the prevalence of not anaemic (positive deviant) was greater than 10%, and if we report the OR, it could overestimate the association between anaemia status and the independent variables. The best measure of association in these situations is the prevalence ratio, so multilevel Poisson regression analysis with robust variance was fitted to find predictors of not being anaemic (normal Hb concentration). In the bivariable multilevel Poisson regression analysis, variables with a p-value of <0.2 were taken into account for the multivariable analysis.

Four models were constructed for the multilevel Poisson regression analysis. The first model was a null model without explanatory variables to determine the extent of cluster variation in childhood normal Hb concentration. The second model was fitted with individual-level variables, the third with community-level variables and the fourth with both individual and community-level variables at the same time. The deviance (−2Log-likelihood ratio) was used to compare the nested models, and the model that had the lowest deviance was the one that best fit the data. The adjusted prevalence ratio (APR) and its 95% CI were then reported, and variables with a p<0.05 in the multivariable analysis were regarded as significant predictors of normal Hb concentration in children under the age of five.

Ethical consideration

This study did not require ethical approval or participant consent because it was a secondary data analysis of publicly available survey data from the MEASURE DHS programme. We have obtained permission to download and use the data from http://www.dhsprogram.com for this study. There are no names or addresses of individuals or households recorded in the data sets.

Patient and public involvement statement

Patients and public involvement were not involved in this study since we have conducted a secondary data analysis based on already available DHS data, which were collected to provide estimates of common health, and health related indicators.

RESULTS

Descriptive characteristics of the study participants

A total of 129408 children aged 6–59 months were included in the study. Of these, 87612 (67.70%) were from rural area. Regarding the SSA region, 23766 (18.36%), 54734 (42.30%), 23645 (18.27%) and 27262 (21.07%) were from East Africa, West Africa, Southern Africa and Central Africa, respectively. About 59772 (64.49%) aged 24–59 months and 65189 (50.38%) were males. Regarding nutritional status, 46733 (36.11%), 8116 (6.27%) and 23052 (17.81%) of the children were stunted, underweight and wasted, respectively (table 2).

The pooled prevalence of normal haemoglobin concentration

The pooled prevalence of normal haemoglobin concentration among children aged 6–59 months in SSA were 34.89% (95% CI: 34.63% to 35.14%), Rwanda 63.53% (95% CI: 61.90% to 65.16%) and Burkina Faso 11.68% (95% CI: 10.83% to 12.53%) had the highest and lowest prevalence, respectively (figure 1).

Individual and community-level determinants of normal haemoglobin concentration

High maternal education, older maternal age, middle and rich household wealth index, being a female child, ANC visit >4, not anaemic mothers, taking drugs for an intestinal parasite, and having normal nutritional status (not stunted and wasted) were significantly associated with increased odds of having a normal Hb concentration. Whereas higher order birth, having fever in the last 2 weeks, having diarrhoea in the last 2 weeks, rural residence, residing in southern and western SSA regions were significantly associated with lower odds of having a normal Hb concentration.

The prevalence of having a normal Hb concentration among female children were 6% (APR=1.06, 95% CI: 1.04 to 1.08) higher than male children. The prevalence of having normal Hb concentration among children whose mother aged 25–34 years, and ≥35 years were increased by 8% (APR=1.08, 95% CI: 1.05 to 1.11) and 19 % (APR=1.19, 95% CI: 1.15 to 1.24) compared with children whose mother aged less than 25 years, respectively. Children from middle and rich household wealth had 9 % (APR=1.09, 95% CI: 1.05 to 1.12) and 7 % (APR=1.07, 95% CI: 1.04 to 1.11) higher prevalence of having normal Hb concentration compared with children from the poor household wealth, respectively. Children who had diarrhoea in the last 2 weeks had decreased prevalence of having normal Hb concentration (APR=0.93, 95% CI: 0.90 to 0.96) compared with their counterparts. Theprevalence of having normal Hb concentration among children in Southern and Western Africa were decreased by 19% (APR=0.81, 95% CI: 0.77 to 0.85) and 27% (APR=0.73, 95% CI: 0.70 to 0.77), compared with children in Central Africa, respectively (table 3).

DISCUSSION

Using nationally representative data, this study investigated the determinants of normal Hb concentration among children aged 6–59 months in SSA. Rather than focusing on at-risk or children with poor health outcomes, the analysis focused on children who are doing well (positive deviants).

The pooled prevalence of normal haemoglobin concentration among children aged 6–59 months in SSA were 34.89% (95% CI: 34.63% to 35.14%), Rwanda

Table 2 Descriptive characteristics of children aged 6–59 months in sub-Saharan Africa

Variable	Frequency (N=129 408)	Percentage (%)
Household characteristics		
Household wealth status		
Poor	57 241	44.23
Middle	26 284	20.31
Rich	45 883	35.46
Family size		
2–4	32 386	25.03
4–8	67 999	52.55
>8	29 022	22.43
Sex of household head		
Male	102 528	79.23
Female	26 879	20.77
Media exposure		
No	45 788	35.38
Yes	83 619	64.62
Maternal-related characteristics		
Maternal age		
15–24	34 405	26.59
25–34	63 163	48.81
≥35	31 840	24.60
Maternal education		
No formal education	47 028	36.34
Primary	45 421	35.10
Secondary	32 968	25.48
Higher	3991	3.08
Maternal marital status		
Single	7966	6.16
Married/living together	112 426	86.88
Widowed/divorced/separated	9015	6.97
Maternal anaemia status		
Anaemic	59 883	46.27
Not anaemic	69 524	53.73
Maternal ANC visit		
No	7792	6.02
1–3 visits	28 591	22.09
>4 visits	93 024	71.88
Place of delivery		
Home	40 985	31.67
Health facility	884 223	68.33
Child's characteristics		
Sex of child		
Male	65 189	50.38
Female	64 218	49.62
Age of child (in months)		
6–23	32 916	35.51
24–59	59 772	64.49
Size of child at birth		
Average	66 306	51.27
Small	19 653	15.20
Large	43 373	33.54
Type of birth		
Single	125 390	96.90
Multiple	4017	3.10
Taking drug for intestinal parasite in the last 6 months		
No	66 476	55.27
Yes	53 809	44.73
Diarrhoea in the last 2 weeks		
No	108 805	84.12
Yes	20 542	15.88
Fever in the last 2 weeks		
No	100 920	78.02
Yes	28 427	21.98
Birth order		
1–3	73 981	57.17
4–6	39 118	30.23
>6	16 309	12.60
Underweight status		
Underweight	8116	6.27
Normal	121 291	93.73
Wasting status		
Wasted	23 052	17.81
Normal	106 354	82.19
Stunting status		
Stunted	46 733	36.11
Normal	82 675	63.89
Community-level variables		
Residence		
Urban	41 796	32.30
Rural	87 612	67.70
Sub-Saharan African region		
Central Africa	27 262	21.07
East Africa	23 766	18.36
South Africa	23 645	18.27
West Africa	54 734	42.30

ANC, antenatal care.

63.53% (95% CI: 61.90% to 65.16%) and Burkina Faso 11.68% (95% CI: 10.83% to 12.53%) had the highest and lowest prevalence, respectively. Rwanda has achieved tremendous success in health and development in recent years. The World Bank confirms that Rwanda's economy has been consistently rising for over a decade, with an impressive annual growth rate of 7.2% from 2007 to 2019.[22] Furthermore, Rwanda has made remarkable progress in improving living standards, becoming one of the only two SSA countries to achieve all of the Millennium Development Goals related to health.[23] Rwanda has successfully tackled childhood anaemia by taking a proactive approach to combat infectious diseases, malnutrition

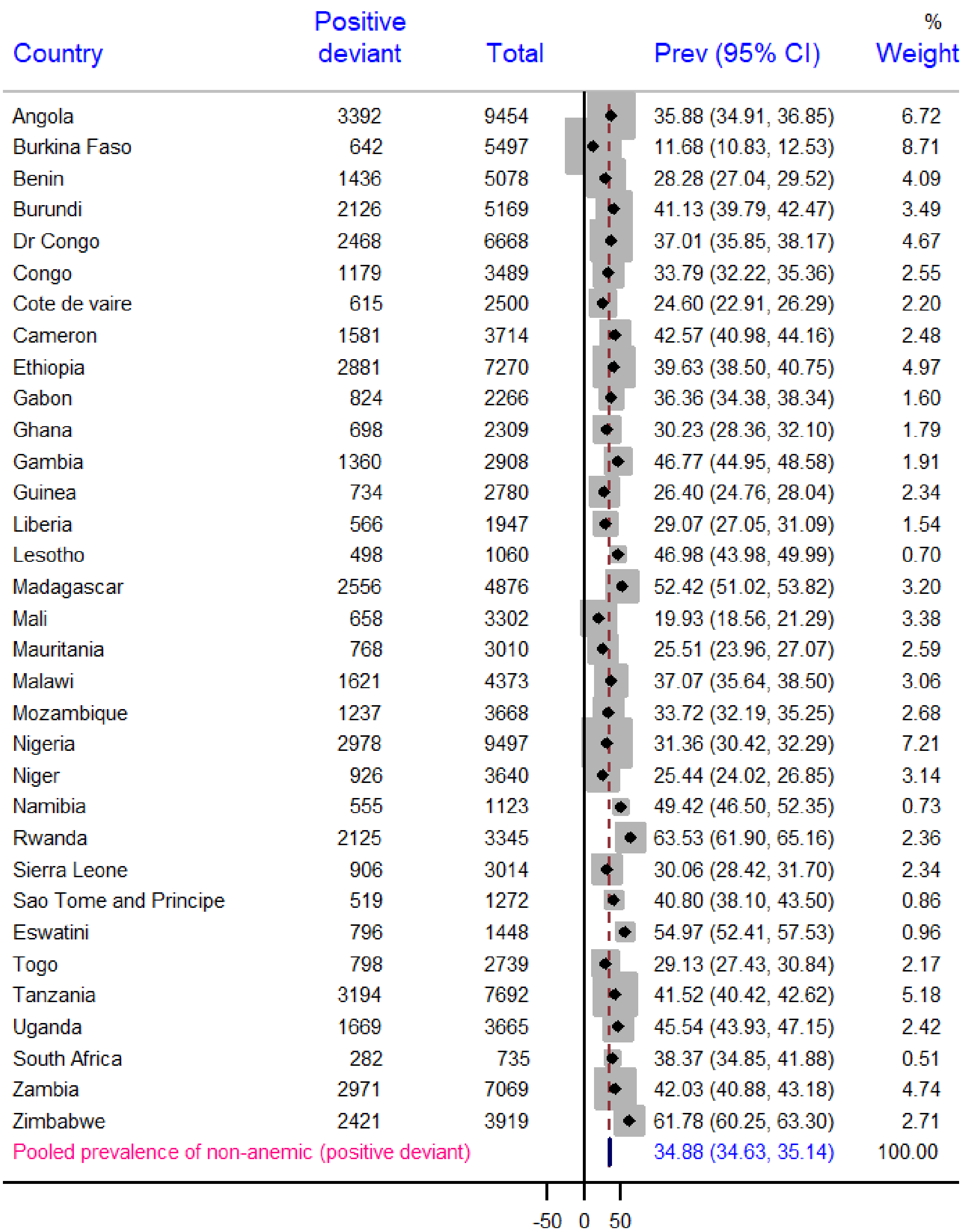

Figure 1 Pooled prevalence of normal haemoglobin concentration among under five children in sub-Saharan Africa.

and poor hygiene and sanitation.[24] The aforementioned factors may explain the high prevalence of normal haemoglobin levels among Rwandan children under the age of five.

The following factors were significantly associated with normal Hb concentration in children: child sex, child age, maternal educational status, household wealth status, number of ANC visits, maternal age, having fever in the last 2 weeks, having diarrhoea in the last 2 weeks, residence SSA region, child twin status, birth order and child's nutritional status (stunting and wasting). In line with this study,[25–27] previous studies revealed that female children were at lower odds of having higher levels of anaemia compared with male children. The possible justification could be due to too early initiation of complementary feeding for male children than females, which in turn expose them to different infectious diseases and malabsorption problems.[28 29] Furthermore, male children in their first 2 years of life experience rapid growth, which increases their micronutrient demands, including vitamin B_9, B_{12} and iron, increasing their risk of anaemia when compared with female children.[30]

Mothers who have more years of education were more likely to have children with a normal Hb concentration; this might be because of maternal education is a reliable predictor of children's nutritional outcomes.[31 32] Maternal education helps to improve maternal understanding of child health and nutrition (such as exclusive breastfeeding and

Table 3 Multilevel robust Poisson regression analysis of individual and community-level variables associated with normal Hb concentration among children aged 6–23 months in Sub-Saharan Africa

Variables	Model 1	Model 2	Model 3
	APR with 95% CI	APR with 95% CI	APR with 95% CI
Individual-level variables			
Maternal age			
15–24	1		1
25–34	1.09 (1.06 to 1.12)		1.08 (1.05 to 1.11)*
≥35	1.21 (1.16 to 1.25)		1.19 (1.15 to 1.24)*
Maternal education			
No formal education	1		1
Primary	1.16 (1.13 to 1.19)		1.12 (1.09 to 1.15)*
Secondary	1.15 (1.11 to 1.19)		1.14 (1.10 to 1.18)*
Higher	1.26 (1.19 to 1.33)		1.24 (1.17 to 1.32)*
Household wealth status			
Poor	1		1
Middle	1.10 (1.07 to 1.14)		1.09 (1.06 to 1.13)*
Rich	1.15 (1.12 to 1.18)		1.07 (1.05 to 1.11)*
Family size			
2–4	1		1
4–8	0.97 (0.94 to 0.99)		0.98 (0.95 to 1.00)
>8	0.93 (0.89 to 0.96)		0.97 (0.94 to 1.01)
Maternal anaemia status			
Anaemic	1		1
Not anaemic	1.49 (1.46 to 1.52)		1.45 (1.42 to 1.49)*
Maternal ANC visit			
No	1		1
1–3	1.08 (1.02 to 1.15)		1.06 (0.99 to 1.12)
>4	1.12 (1.06 to 1.18)		1.11 (1.05 to 1.18)*
Media exposure			
No	1		1
Yes	1.00 (0.98 to 1.03)		11.01 (0.99 to 1.04)
Sex of child			
Male	1		1
Female	1.06 (1.04 to 1.08)		1.06 (1.04 to 1.08)*
Age of child (in months)			
6–23	1		1
24–59	1.72 (1.67 to 1.76)		1.72 (1.67 to 1.77)*
Size of child at birth			
Average	1		1
Small	1.02 (0.98 to 1.05)		1.00 (0.97 to 1.03)
Large	0.99 (0.97 to 1.02)		1.00 (0.98 to 1.03)
Type of birth			
Single	1		1
Multiple	0.96 (0.90 to 1.01)		0.96 (0.91 to 1.03)
Taking drug for intestinal parasite in the last 6 months			
No	1		1

Continued

Table 3 Continued

Variables	Model 1	Model 2	Model 3
	APR with 95% CI	APR with 95% CI	APR with 95% CI
Yes	1.08 (1.05 to 1.10)		1.06 (1.04 to 1.08)*
Diarrhoea in the last 2 weeks			
No	1		1
Yes	0.94 (0.91 to 0.97)		0.94 (0.91 to 0.97)*
Fever in the last 2 weeks			
No	1		1
Yes	0.82 (0.79 to 0.84)		0.81 (0.79to 0.84)*
Birth order			
1–3	1		1
4–6	0.93 (0.91 to 0.96)		0.94 (0.91 to 0.96)*
>6	0.96 (0.92 to 0.99)		0.94 (0.91 to 0.99)*
Underweight status			
Underweight	1		1
Normal	1.02 (0.97 to 1.07)		1.02 (0.97 to 1.07)
Wasting status			
Wasted	1		1
Normal	1.09 (1.05 to 1.13)		1.11 (1.07 to 1.14)*
Stunting status			
Stunted	1		1
Normal	1.15 (1.12 to 1.18)		1.16 (1.13 to 1.19)*
Community-level variables			
Residence			
Urban		1	1
Rural		0.82 (0.81 to 0.84)	0.93 (0.90 to 0.96)*
Sub-Saharan African region			
Central Africa		1	1
East Africa		1.13 (1.09 to 1.16)	0.97 (0.92 to 1.01)
South Africa		1.12 (1.08 to 1.15)	0.81 (0.77 to 0.85)*
West Africa		0.72 (0.44 to 0.46)	0.74 (0.71 to 0.77)*
Random-effect analysis result			
Community-level variance	0.25	0.22	0.20
LR test Prob≥chibar^2<0.00			
LLR	−45, 897.26	−94, 852.69	−45, 696.74
Deviance	91 794.52	189, 705.38	91, 393.48
AIC	91, 862.52	189, 719.4	91, 471.48
BIC	92, 170.71	189, 787.8	91, 824.98

*P<0.05.
AIC, Akaike Information Criteria; ANC, antenatal care; APR, adjusted prevalence ratio; BIC, Bayesian Information Criteria; Hb, haemoglobin; LLR, log-likelihood ratio; LR, likelihood ratio.

appropriate complementary feeding), which helps to improve the quality of children's diets.[31] Furthermore, mothers' educational levels can positively influence their children's healthcare and feeding practices.[33] This finding is consistent with previous studies showing that children with more educated mothers are less likely to develop anaemia than those with less educated mothers.[20 34 35]

Children of mothers aged 25–34, and >34 years had lower odds of being anaemic compared with children of a mother aged 15–25 years. This was in agreement with study findings in SSA,[35] Haiti,[36] Brazil[37] and India.[38] Extensive research indicates that older mothers are far better equipped to meet their children's healthcare needs. It is evident that children born to younger mothers are at a higher risk of developing anaemia, which underscores the fact that younger mothers are often not prepared to fulfil their children's nutritional requirements and maternal obligations. The reasons for this could include limited financial resources, inadequate knowledge about anaemia and childcare and insufficient guidance.[37 39 40]

The possibility of having normal Hb concentration was more prevalent among children in households with middle and rich wealth indices had increased odds of having normal levels of Hb concentration compared with those from the poorest households. This is consistent with study findings in SSA,[35] Sri Lanka[41] and Bangladesh,[42] this could be due to parents from the wealthiest households can provide their children with a balanced diet rich in macro and micronutrients, as well as minerals and vitamins.[43 44] Furthermore, children from wealthy families have a better chance of accessing healthcare for common illnesses that cause childhood anaemia.[45]

According to the findings of this study, mothers who were able to attend at least four ANC visits were more likely to have children with normal haemoglobin levels. This could be because pregnant mothers benefit from iron-folate supplementation as well as prompt diagnosis and treatment of diseases such as malaria, visceral leishmaniosis and hookworm, which have been identified as leading causes of anaemia, which in turn reduces the risk of child anaemia.[46] A strong relationship between maternal anaemia and child haemoglobin concentration was observed in this study. Non-anaemic mothers have children with normal haemoglobin concentrations. Thus, whether or not a child has a normal Hb concentration is dependent on the mother's anaemia status. This could be because children's primary source of nutrition is their mother, also because the children eat a similar diet, it is possible that their eating practices and quality of life are the same.[47] Furthermore, non-anaemic mothers' breast milk may contain sufficient iron, zinc, folate and vitamin B_{12}, resulting in a normal Hb concentration in the child.[48]

In this study, children who have two or more older siblings in the household were found to have lower odds of having a normal Hb concentration. It is congruent with the findings of studies in SSA[34] and Central India.[49] The possible explanation could be that increasing birth order is associated with a depletion of nutrients such as iron, folate, and vitamin B_{12} in the mother, which could result anaemia in children.[50]

Consistent with studies done in SSA[34] and Indonesia,[51] in this study, children who had a fever and diarrhoea in the last 2 weeks had higher odds of higher levels of anaemia compared with their counterparts. This could be because children with febrile and diarrhoeal illnesses may experience a loss of appetite as well as decreased absorption of essential nutrients (iron, folate and vitamin B_{12}), which may increase the likelihood of anaemia (low Hb concentration).[52]

In this study, children who were not stunted or wasted had a higher chance of having normal Hb concentrations than stunted and wasted children. Low immunity is related to poor nutritional status, in addition to deprivation of nutrients required for hematopoiesis. Therefore, diseases and infestations cause anaemia by a synergistic effect of nutritional deficits.[53] Furthermore, well-fed children are less likely to suffer from micronutrient deficiencies, such as iron, vitamin A, vitamin B_{12} and folic acid, which aid in haemoglobin and DNA synthesis during red blood cell production.[53]

Consistent with studies done in SSA[34] and Thailand,[54] children who had taken intestinal parasite drugs in the previous 6 months had a higher chance of having a normal Hb concentration than children who had not taken intestinal parasite drugs. This could be because intestinal parasites can cause anaemia, and thus drugs for intestinal parasites can reduce the risk of anaemia in children.[55]

The implications of these findings are that there are several factors that can influence the haemoglobin concentration of children in SSA. Addressing these factors could have a positive impact on the health outcomes of children in the region. For instance, interventions aimed at enhancing maternal education, household income and access to health services could improve the nutritional status of children and reduce the incidence of anaemia. Additionally, interventions targeting infectious diseases, such as intestinal parasites, could help to mitigate the prevalence of anaemia. By prioritising these interventions, stakeholders and policymakers can make a significant contribution to improving the health and well-being of children in SSA.

When interpreting our study's findings, keep the following limitations in mind. Owing to the cross-sectional design of the DHS data, it is imperative to note that establishing cause-and-effect relationships is unfeasible. It is important to highlight that the DHS data set did not include crucial factors such as malaria infection, visceral leishmaniosis, hookworm and congenital illnesses, and thus it was not possible to assess their impact.

CONCLUSION

This study tries to provide a thorough understanding of the factors that promote normal Hb concentration rather than the risk factors for low Hb concentration (anaemia) among children aged 6–23 months in sub-Saharan Africa. Both individual and community-level variables were found significant predictors of normal Hb concentration among children aged 6–23 months. Child age, child sex, size at birth, maternal education, maternal age, fever in the last 2 weeks, birth order and household wealth status were among individual-level predictors of normal Hb concentration among children aged 6–23 months. Among community-level variables, SSA regions and residence were found significant predictors of normal Hb concentration.

According to the study's findings, mothers with more years of education were more likely to have children with normal Hb concentrations. This suggests that maternal education may be able to protect children from anaemia.There were a strong relationship between ANC visits and child Hb concentrations. Therefore, promoting ANC attendance among women of reproductive age will have the potential to protect their children from developing anaemia in the first 5 years of their life. Furthermore, providing treatment for febrile illness and strengthening the economic status of the family could contribute for the better reduction in the risk of anaemia and improvements in haemoglobin levels among children. Furthermore, in order to reduce child anaemia, it is preferable to strengthen early detection and management strategies for stunted, wasted and underweight children.

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