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Trends and Determinants of Anemia Among Under-Five Children in Gambia, Evidence from 2013 – 2019/2020 Gambian Demographic and Health Survey; Multilevel Binary Logistic Regression and Multivariate Decomposition Analysis

Asmare AA[1*] and Agmas YA[2]

[1]Department of Statistics, Mekdela Amba University, Tuluawlyia, Ethiopia

[2]Department of Rural Development and Agricultural Extension, Mekdela Amba University, P.O. Box: 32, Tuluawlyia, Ethiopia

***Corresponding author:** Abebew Aklog Asmare, Department of Statistics, Mekdela Amba University, P.O. Box: 32, Tuluawlyia, Ethiopia, Tel: +251912936789, Email: aklog28@gmail.com

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Abstract

Anemia is global health difficult. This situation touches most under-five-year-old children. This study aimed to examine the trends of anemia prevalence among children aged between 6 to 59 months and its determinants in the Gambia based on two consecutive Gambian Demographic and Health Surveys (GDHSs). A total of 2,258 in 2013, and 2,399 in 2019/20 children aged between 6 to 59 months were involved in this study. To identify significantly contributing factors for the decrement in anemia prevalence in the Gambia over the last 5 years. Logit-based multivariate decomposition analysis was used and a mixed-effect logistic regression model was fitted to identify determinant factors. 88.83% of the change in anemia prevalence over time was attributable to difference in coefficients. Being multiple (AOR = 1.879; 95%CI: 1.181 – 2.989), big stunted (AOR = 1.481; 95%CI: 1.094 – 2.004, being underweight (AOR = 1.661; 95%CI: 1.241 – 2.221), being wasted (AOR = 1.840; 95%CI: 1.203 – 2.814), mother was anemic (AOR = 1.577, 95%CI: 1.308 – 1.902), highest level of wealth index (AOR = 0.340; 95%CI: 0.287 – 0.702), being male household head (AOR = 0.739; 95%CI: 0.568 – 0.962) were more likely to experience the prevalence of anemia. This study found that the prevalence of anemia has decreased over time in the Gambia since 2013. Mother anemia level, birth order of children, age of children in a month, wasting, underweight, stunting, wealth status of a household, ever breastfeed, sex of household head, ethnicity were significant predictors of anemia prevalence. Designing interventions that address maternal anemia and strengthening the family's economic status are recommended to reduce childhood anemia. Furthermore, it is better to strengthen the strategies of early detection and management of stunted, wasted, and underweight children to decrease childhood anemia.

Keywords: Anemia, Mixed-effect Logistic Regression, Multivariate Decomposition Analysis, Prevalence

Abbreviations

AOR: Adjusted Odds Ratio, AIC: Akakie Information Criteria, Cofe: Coefficient, COR: Crude Odds Ratio, BIC: Bayesian Information Criteria, DHS: Demographic health survey; EAs: Enumeration areas, GDHS: Gambian demographic and health survey, ICC: Intra-cluster Correlation Coefficient, LLR: Log likelihood ratio, LR: Likelihood ratio, MOR: Median Odds Ratio, PCV: Proportional Change in Variance, Ref.: Reference Category.

Introduction

Anemia is global health difficult [1,2], however low and middle-income countries were more affected with young youngsters and pregnant women as the most affected population groups [2,3]. It is defined as the condition of having a small number of red blood cells or a little amount of hemoglobin from the regular level [4-7]. This condition touches most under-five children and pregnant and lactating women [8-10]. Anemia in children under five years is a universal public health difficulty related to increased disease and death [3,11]. It is also a sign of poor nourishment and wellbeing and is related to poor cognitive and motor-neurological development in children [4].

Globally anemia affects nearly two billion people [12,13], developing and middle-income countries account directly above 89% of anemia prevalence, kindergarten, and reproductive-age women are extremely affected by anemia [13]. In 2017, the WHO [4], data basis presented that the universal prevalence of anemia for children below five years aged was 41.7%. Thus the problem is inferior in Africa, more than 59% of children under five were anemic [11]. Besides, the estimated cases of anemia for children under-five years aged in Sub-Saharan Africa were approximately 84.5 million. This figure put Sub-Saharan Africa as the area with the maximum prevalence of anemia [14]. Anemia takes adverse effects on under-five children's physical development, attentiveness, memory, and academic performance [15].

Anemia remains one of the most significant health problems for under-five children in Gambia especially those under the age of five, who are highly susceptible to anemia [16]. In Gambia, the prevalence of anemia in under-five children is determinedly higher than expected for the last two decades. According to the two Gambian Demographic and Health Survey reports. Anemia prevalence among children 6 – 59 months of age decreased from 73% in 2013 to 45% in 2019/20 [17, 18]. Many types of studies had been conducted to show its prevalence and related factors. Anemia level of the mother, number of under-five children in the household, wealth index of the household, source of drinking water, sex of the household head, birth size of children, being a twin or single, birth order of the child, fever, cough, and diarrhea in the last two weeks prior to the survey period, age of children in months, stunting, underweight, wasting and region, ethnicity, breast feeding status, and religion, the variables were taken from the previous studies [6,7,19-26].

Anemia is a preventable illness and its control desires consistent data and continual checking and assessment process at the country level to determine a baseline, recognize the problems, develop comprehensive interventions, and evaluate the movement [27]. However, some of the studies were focused on forecasting the occurrence of anemia [16], the remainder were focused on the occurrence and related factors of anemia prevalence only [19,22,28,29] and didn't assume the trends and causes of anemia prevalence within the Gambia over time. Therefore, this study aimed to analyze the trend and determinants of anemia prevalence among under-five children within the Gambia for the last five years. Understanding the trends and determinants of anemia prevalence could help policymakers, and followers to take evidence-based involvement to reduce effectively the prevalence of anemia.

Materials and Methods

Data Source and Population

This study used 2013, and 2019/20 GDHSs data. These GDHSs data are a nationwide representative cross-sectional survey performed in eight Local Government Areas (LGAs). Individual GDHSs surveys, stratified two-stage clusters sampling was accomplished. Stratification was applied by dividing each specific Local Government Area into urban and rural areas. Therefore, a total of 14 sampling strata have been made. In the first step, a total of 281 Enumeration Areas (EAs) were randomly selected proportional to the enumeration areas size for each survey period. In the second phase, on average 25 households per enumeration area were designated [17,18]

Ethical Consideration

The data was retrieved from the Measure DHS website after authorization was approved through an online request by stating the objective of the study. The variables of the study were taken out from Kid Record (KR file) from each GDHSs data set. The whole technique for sampling was labeled in the detailed GDHS report [17,18].

Variables of the Study

Variables revealed in this study were originated from studies that have been conducted at the international level. The Possible determinant predictors related with the prevalence of anemia for under-five children were incorporated as variables in this study.

Outcome Variable

Occurrence of anemia, supported by hemoglobin levels is accustomed for altitude by hemoglobin in grams per decilitre (g/dl) [30]. Finally, the dependent variable of this study was anemia status of youngsters aged below five years which is a binary outcome indicating not anemic coded by zero or anemic coded

$$Y_{ij} = \begin{cases} \text{Not anemic} = 0 \\ \text{Anemic} = 1 \end{cases} \quad [1]$$

Explanatory variables: Local government areas of the study participants, number of under-five children in the household, source of drinking water, sex of household head, wealth index of the household, anemia level of the mother, birth order of children, being single or twin, age of children, birth size of children, fever, cough, and diarrhea in the last two weeks prior to the survey period, stunting, underweight and wasting status of children, body mass index of mother, breastfeeding status, family size, religion, and ethnicity were considered as independent variables for this study.

Data Analysis

The data were taken from the child Record (KR file for both GDHSs data set. Before starting any statistical investigation, the data were weighted using sampling weight for probability sampling to recover the representativeness of the survey and find consistent statistical estimates, the data analysis was executed by using STATA 16. The data analysis comprises three important parts. First, descriptive statistics and trends were analyzed by each variable level. Second, multivariate decomposition analysis was implemented to grasp the magnitude to which each selected covariate contributed to the observed trend in anemia prevalence, finally, multilevel binary logistic regression analysis was applied to determine factors correlated to prevalence of anemia among under-five children in Gambia.

Trend and decomposition analysis

The trend phase was single period which is (2019/20 – 2013), and accustomed to see the changes in magnitude of anemia over time for different characteristics. The trend was measured by applying descriptive analyses for each different characteristics and was evaluated separately for the phase; 2019/202 – 2013. To see the differences within the outcome between two surveys or between two points of time (comparable 2013 and 2019/2020 survey year), multivariate decomposition analysis is used. The decomposition process divides the whole decrement in prevalence of anemia into two portions; the portion that may be endorsed to the change in composition or the prevalence of a collection of indicators (referred to endowments portion) and the portion which attributed to the change within the effect of those indicators (referred to the coefficient portion). Therefore, the observed change in load of anemia between two points of time was additively decomposed in to endowment (characteristics) component and coefficient (characteristics) component. The analysis was applied via recently developed mvdcmp Stata package [31]. The equality is given by

$$\Delta Y^{i-j} = (X^i - X^j)\beta^i + X^j(\beta^i - \beta^j), i \neq j \quad [2]$$

Where $i, j = 2013 \ and \ 2016/2020$ ΔY is the c_i ference $_j$ average prediction of anemia prevalence between year and year , given that of different characteristics of X. β is the estimated regression coefficients. $(X^i - X^j)\beta^i$ represents the difference due to endowment between the i^{th} and j^{th} years. $X^j(\beta^i - \beta^j)$ represents the difference due to coefficients between the i^{th} and j^{th} years.

Determinants of anemia prevalence among under-five children

As the data used for this study had nested structure, under-five children within the same group share similar characteristics. In data which is nested, known statistical model like mixed-effect analysis is conducted to get consistent estimate. Thus, to draw a sound conclusion single-level mixed-effect logistic regression model (both fixed and random effect) was fitted using enumeration areas as a variation. The assumptions the model was tested using the Intra-class coefficient of correlation (ICC), which used to measure the degree of homogeneity for anemia prevalence between the cluster, and Likelihood Ratio (LR) test. Median Odds Ratio [25] and Proportional Change in Variance (PCV) were considered to calculate the deviation across clusters.

$$ICC = \frac{\sigma^2}{(\sigma^2 + \frac{\pi}{3})} \quad [3]$$

The MOR measures the variation between the clusters in terms of odds ratio. The odds ratio of the median value is the ratio between the cluster at higher risk of anemia and at lower risk of anemia prevalence when randomly picking out two clusters.

$$MOR = (0.95 * \sigma) \qquad [4]$$

σ is cluster standard deviation

PCV is used to measure total variation in anemia prevalence that was explained by the final model compared to the null model.

$$PCV = \frac{var(null\ model) - var(full\ model)}{var(null\ model)} \qquad [5]$$

The authors used Bayesian Information Criteria (BIC), Akaike Information Criteria (AIC), and deviance to evaluate the model. Models having lower deviance, Bayesian Information Criteria (BIC), and Akaike Information Criteria (AIC was chosen as a nested model. The Adjusted Odds Ratio [25] with a 95% Confidence Interval (CI) and p-value < 0.05 were used in the final model to announce significant factors correlated with anemia prevalence among under-five children.

Results

Characteristics of the study population

Table 1 presents the percentage distribution of anemia for under-five children based on selected material, children, and household characteristics reports from 2013 – 2019/20 GDHS. Thus, the analysis encompassed weighted data from 2,258 in 2013 and 2,399 in 2019/20.

Demographic characteristics of GDHSs data revealed that more than 43% of children's households lived in urban areas; 43.6% and 63.3% in 2019/20. More than 82%; 82.4% in 2013 and 84.9% in 2019/20 of the total households in the two consecutive GDHSs survey were led by males. Considering birth characteristics of GDHSs data, the highest percent (4.3%) of twin birth was in 2019/20. A higher and lower percent of small birth size (20.3%) and (14.6%) was reported in the 2013 and 2019/20 GDHSs survey period respective. Regarding the birth order of children, the highest percentage of children have birth order of 5 and more were recorded in the 2019/20 survey year which was 23.8%. Among the surveyed households, 11.2%, and 7.3% of households were not drink improved water in the 2013 and 2019/20 GDHSs survey period respectively. Concerning households' wealth status 21.4% of the households in 2013 and 23.7% in 2019/2020 were poorest. From the total surveyed population 59.5% of households in 2013 and 62.9% in 2019/2020 have 10 and more members per household.

Table 1: Frequency and Proportion distribution of characteristics of the respondents and their children in Gambia

Variable	Characteristics	Frequency and percentage in DHS Periods	
		GDHS 2013 Weighted frequency (%)	GDHS 2019 Weighted frequency (%)
Region	Banjul	31 (1.4)	26 (1.1)
	Kanifing	325 (14.4)	386 (16.1)
	Brikama	765 (33.9)	961 (40.1)
	Mansakanko	130 (5.8)	121 (5.0)
	Kerewan	269 (11.9)	277 (11.6)
	Kuntaur	174 (7.7)	145 (6.0)
	Janjanbureh	188 (8.3)	176 (7.3)
	Basse	375 (8.3)	308 (12.8)
Place of residence	Urban	984 (43.6)	1518 (63.3)
	Rural	1273 (56.4)	881 (36.7)

Educational level of mother	No education	1388 (61.5)	1139 (47.5)
	Primary education	323 (14.3)	424 (17.7)
	Secondary and above	546 (24.2)	836 (34.8)
Source of drinking water	Unimproved	253 (11.2)	175 (7.3)
	Improved	2005 (88.8)	2225 (92.7)
Religion	Islam	2214 (98.0)	2375 (99.0)
	Christianity	44 (2.0)	24 (1.0)
Number of household members	Small (1-4)	124 (5.5)	145 (6.0)
	Medium (5-9)	790 (35.0)	745 (31.1)
	Large (10 and more)	1344 (59.5)	1509 (62.9)
Sex of household head	Male	1859 (82.4)	2037 (84.9
	Female	398 (17.6)	362 (15.1)
Ethnicity	Mandinka /Jahanka	727 (32.2)	820 (34.2)
	Wollof	290 (12.9)	326 (13.6)
	Jola/karoninka	202 (9.0)	214 (8.9)
	Fula/Tukulur/Lorobo	604(26.8)	455 (19.0)
	Serere	48 (2.1)	61 (2.5)
	Serahuleh	163 (7.2)	201 (8.4)
	Creole/Aku Marabout	7 (0.3)	4 (0.1)
	Manjago	21 (0.9)	12 (0.5)
	Bambara	19 (0.9)	25 (1.0)
	Other	17 (0.7)	12 (0.5)
	Non-Gambian	159 (7.0)	269 (11.2)

Variable	**Characteristics**	**Frequency and percentage in GDHS Periods**	
		GDHS 2013 Weighted frequency (%)	**GDHS 2019 Weighted frequency (%)**
Husbands educational level	No education	1386 (61.4)	1311 (54.6)
	Primary education	414 (18.4)	517(21.6)
	Secondary and above	457 (20.2)	571 (23.8)
Currently breastfeeding	No	840 (37.2)	1069 (44.5)
	Yes	1418 (62.8)	1331 (55.5)
Wealth index	Poorest	483 (21.4)	569 (23.7)
	Poorer	555 (24.6)	505 (21.0)
	Middle	407 (18.0)	508 (21.2)
	Richer	434 (19.2)	406 (16.9)
	Richest	379 (16.8)	412 (17.2)
Body mass index	Thin	258 (11.4)	206 (8.6)
	Normal	1477 (65.4)	1241 (51.7)
	Over weight	523 (23.2)	952 (39.7)
Stunting	No	1766 (78.2)	2075 (86.5)
	Yes	491 (21.8)	324 (13.5)

Underweight	No Yes	1731 (76.7) 527 (23.3)	1950 (81.3) 449 (18.7)
Wasting	No Yes	2001 (88.6) 257 (11.4)	2257 (94.1) 142 (5.9)
Sex of child	Male Female	1181 (52.3) 1076 (47.7)	1269 (52.9) 1130 (47.1)
Children age in month	6-11 12-23 24-35 36-47 48-59	304 (13.5) 569 (25-2) 469 (20.8) 447 (19.8) 468 (20.7)	285 (11.9) 575 (24.0) 530 (22.1) 553 (23.1) 457 (19.0)
Diarrhea	No Yes	1848 (81.8) 410 (18.2)	1927 (80.3) 472 (19.7)
Fever	No Yes	1983 (87.8) 274 (12.2)	2025 (84.4) 374 (15.6)
Cough	No Yes	1946 (86.2) 312 (13.8)	1976 (82.4) 423(17.6)
Size of child at birth	Small Average Large	458 (20.3) 636 (28.2) 1164 (51.5)	349 (14.6) 1030 (42.9) 1020 (42.5)

Variable	**Characteristics**	**Frequency and percentage in GDHS Periods**	
		GDHS 2013 Weighted frequency (%)	**GDHS 2019 Weighted frequency (%)**
Child is twin	Single birth	2197 (97.3)	2297 (98.7)
	Multiple birth	61 (2.7)	102 (4.3)
Birth order number	First Two to three Four to five Six and more	447 (19.8) 738 (32.7) 570 (25.2) 503 (22.3)	367 (15.3) 858 (35.8) 603 (25.1) 571 (23.8)
Number of Under-five children	Only one 2 children 3 and more	301 (13.3) 676 (30.0) 1280 (56.7)	385 (16.1) 683 (28.5) 1331 (55.5)
Mother anemia level	Not anemic Anemic	823 (36.5) 1435 (63.5)	1264 (52.7) 1135 (47.3)
Children Anemia level	Not anemic Anemic	635 (28.1) 1623 (71.9)	1289 (53.7) 1111 (46.3)

Overall trends of anemia prevalence among children aged 6 – 59 in the Gambia

By observing the trend, there is a decrement in anemia prevalence among under-five children from the 2013 – 2019/20 survey period in Gambia. Accordingly, it was 71.9% in 2013 is decreased by 25.6% in 2019/2020. Generally, the overall change (2019/2020–2013) in anemia prevalence of under-five children was a 25.6% point change decrement (Figure 1).

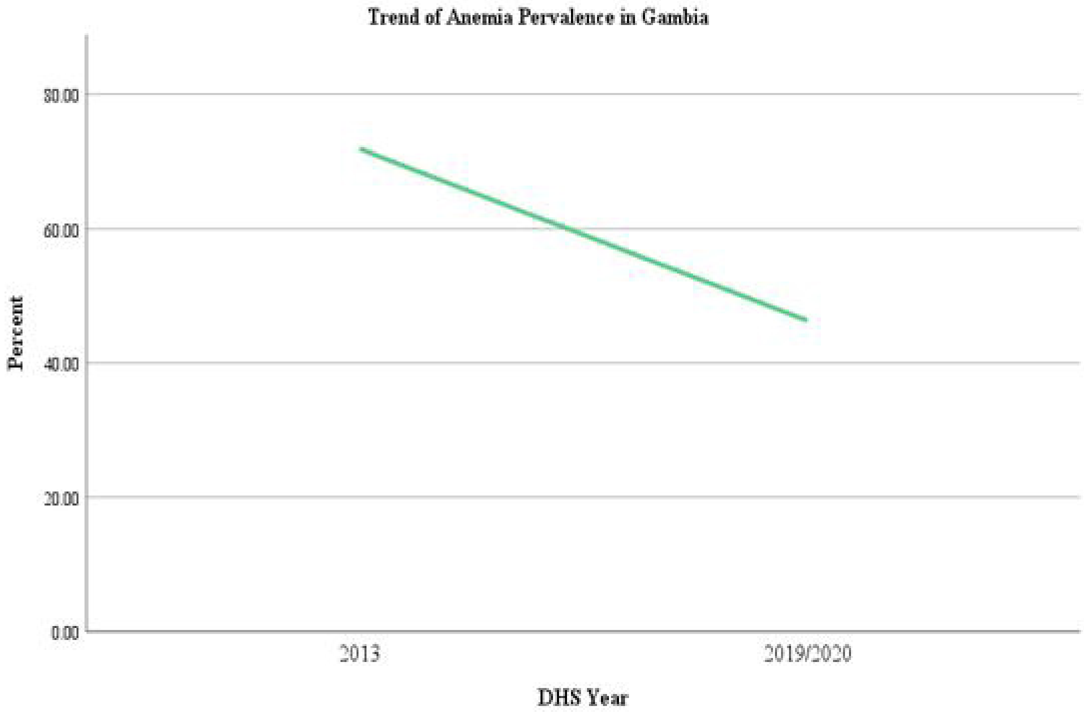

Figure 1: Trend of Anemia Prevalence in Gambia from 2013 to 2019/2020

Trends of anemia prevalence in Gambia by region, 2005 - 2016

Table 2 presents the Trends of anemia prevalence of under-five children in Gambia grounded on children's, maternal, and household characteristics from 2013 – 2019/20 GDHS.

The trends for prevalence of anemia among under-five children revealed that deviation based on predictor characteristics. Anemia prevalence decrement was observed in all of the characteristics in the phase (2013 – 2019/20). Considering ethnicity of Gambia, the largest decrement was recorded in Bambara. Based on local government areas, the largest decrement was observed in Banjul local government area with 23.4%-point decrement (Figure 2). Respondents who had have improved drinke ing water source showed decrement of anemia prevalence among under-five children in phase which is 26.4-point decrement.

Table 2: Anemia prevalence trend among under-five children by selected characteristics in the Gambia

Variable	Characteristics	GDHSs periods		Point difference in anemia prevalence (2019/2020-2013) Phase I
		2013 (2,278)	2019 (2,399)	
Region	Banjul	59.4	36	-23.4
	Kanifing	61.8	49.2	-12.6
	Brikama	66.3	30.6	-35.7
	Mansakanko	80.2	48.8	-31.4
	Kerewan	70.6	58.1	-12.5
	Kuntaur	84	75.9	-8.1
	Janjanbureh	79.8	60.8	-19
	Basse	81.3	58.8	-22.5
Place of residence	Urban	64.6	38.7	-25.9
	Rural	77.5	59.5	-18
Educational level of mother	No education	74.2	51.2	-23
	Primary education	72.5	45.8	-26.7
	Secondary and above	65.6	40	-25.6
Source of drinking water	Unimproved	78.3	42.5	-35.8
	Improved	71.1	46.6	-24.5
Religion	Islam	72.3	46.6	-25.7
	Christianity	52.3	20	-32.3
Number of household member	Small (1-4)	79	48.3	-30.7
	Medium (5-9)	65.7	42.6	-23.1
	Large (10 and more)	74.9	47.9	-27
Sex of household head	Male	73.4	48.1	-25.3
	Female	64.6	36.2	-28.4
Currently breastfeeding	No	67.7	42	-25.7
	Yes	74.3	49.7	-24.6
Ethnicity	Mandinka /Jahanka	72.9	41.1	-31.8
	Wollof	69	54.9	-14.1
	Jola/karoninka	60.4	39.7	-20.7
	Fula/Tukulur/Lorobo	76.5	53.9	-22.6
	Serere	64.6	29.5	-35.1
	Serahuleh	74.8	48.8	-26
	Creole/Aku Marabout	100	25.0	-75
	Manjago	47.6	8.3	-39.3
	Bambara	89.5	45.8	-43.7
	Other	82.4	38.5	-43.9
	Non-Gambian	67.9	48.3	-19.6

Variable	Characteristics	GDHSs periods		Point difference in anemia prevalence (2019-2013) Phase I
		2013 ()	2019 ()	
Husbands educational level	No education	76.1	51.2	-24.9
	Primary education	64.7	41.9	-22.8
	Secondary and above	65.4	39.1	-26.3
Wealth index	Poorest	76.6	63.6	-13
	Poorer	78.4	47.6	-30.8
	Middle	77.1	39.6	-37.5
	Richer	64.3	43.8	-20.5
	Richest	59.5	31.3	-28.2
Body mass index	Thin	72.5	55.6	-16.9
	Normal	74.7	48.1	-26.6
	Over weight	63.5	41.9	-21.6
Stunting	No	69.7	43.7	-26
	Yes	79.4	63	-16.4
Underweight	No	69	43.1	-25.9
	Yes	81	59.9	-21.1
Wasting	No	70.8	46.3	-24.5
	Yes	80.2	46.5	-33.7
Sex of child	Male	74.6	48.9	-25.7
	Female	68.9	43.5	-25.4
Child age in months	6-11	79.3	45.3	-34
	12-23	85.8	58.1	-27.7
	24-35	77.5	53	-24.5
	36-47	59.7	42.5	-17.2
	48-59	55.9	28.9	-27
Diarrhea	No	71.5	45.1	-26.4
	Yes	73.7	51.3	-22.4
Fever	No	71.2	45.6	-25.6
	Yes	77.1	49.9	-27.2
Cough	No	71.4	46.1	-25.3
	Yes	74.9	47.3	-27.9
Size of child at birth	Small	69.2	54.4	-14.8
	Average	73.9	46.4	-27.5
	Large	71.8	43.4	-28.4
Child is twin	Single birth	72	45.8	-11.1
	Multiple birth	68.9	56.9	-12

Variable	Characteristics	GDHSs periods		Point difference in anemia prevalence (2019-2013)
		2013	2019	
Number of under-five children	Only one	66.8	39	-27.8
	2 children	71.9	44.4	-27.5
	3 and more	73	49.4	-23.6
Birth order number	First	74.3	47	-27.3
	Two to three	69.4	45	-24.4
	Four to five	72.8	46.5	-26.3
	6 and more	72.4	47.6	-24.8
Mother anemia level	Not anemic	65.7	39.4	-26.3
	Anemic	75.4	53.9	-21.5

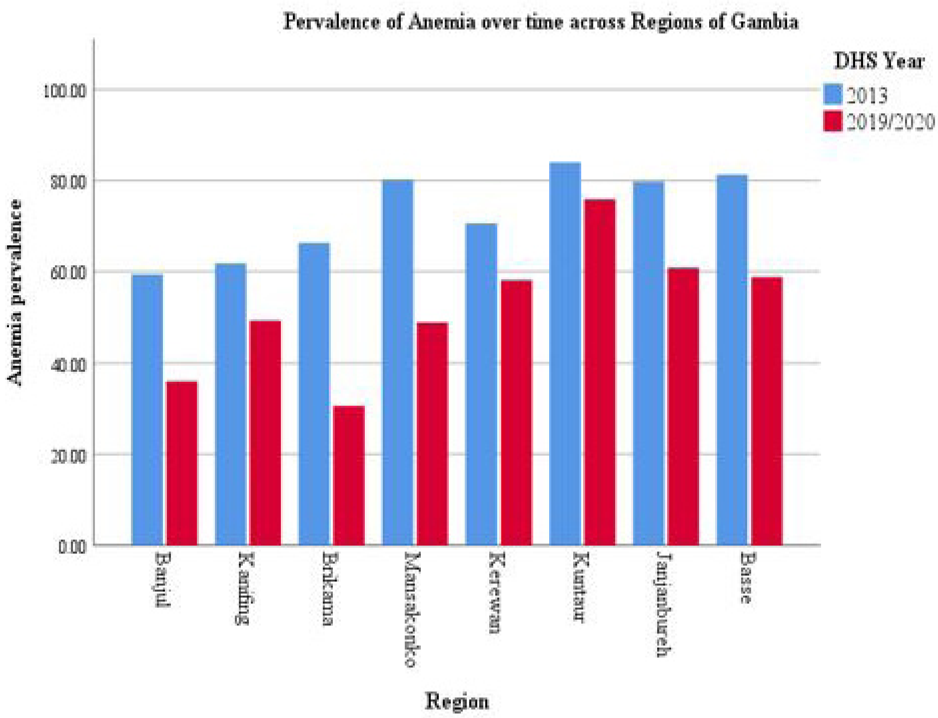

Figure 2: Trend of prevalence of anemia over time across regions of Gambia 2013, 2019/20

Decomposition analysis

Table 3: Total multivariate decomposition analysis of anemia prevalence in Gambia, 2013–2019/20

Prevalence of anemia	Cofe.	95 % CI.	Pct.
E	-0.0230	(-0.0374, -0.0087)*	11.17
C	-0.1831	(-0.2110, -0.1553)*	88.83
R	-0.2061	(-0.2301, -0.1822)*	

* Significance at 5% level of significance

Table 3 presents the general multivariate decomposie tion result of anemia prevalence of children aged below five years in the Gambia based on maternal and household characteristics from 2013 – 2019/20 GDHS.

Overall from 2013 to 2019/20, there is a significant decrement in the prevalence of anemia in the Gambia. The whole decomposition result showed that 11.17% of decrement in the prevalence of anemia over time was due to behavioral changes between the surveys, and 88.83% of decrement was due to differences in characteristics.

Factors residence of the household, educational level of the mother, educational level of husband, wealth index, sex of children, age of children, and birth size indicated a significant effect for the decline of anemia prevalence. Making compositional changes constant, behavioral change households who were urban settlers were contributed 6.66% for the decrement of anemia prevalence for the last five years as compared to rural settlers. Behavioral change of mother education who has secondary and above was contributed 2.61% decrement in anemia prevalence for the last five years as compared to no educated mother. Keeping compositional changes constant behavioral change of households who had richer wealth status was contributed 1.56% for the decrement of anemia prevalence for the last five years as compared to households who had the poorest wealth status. Similarly, the behavioral change of age of children who have 6 to 11, 24 to 35, and 48 to 59 months were contributed 0.05%, 0.87%, and 6.66% decrement of anemia prevalence in the last five years as compared to 0 to 5 months aged children respectively (*Table 4*).

Table 4: Comprehensive multivariate decomposition analysis of anemia prevalence in Gambia, 2013 – 2019/20

Anemia prevalence	**Difference due to characteristics (E)**		**Difference due to coefficients (C)**	
	Cofe. With 95 % CI	**Pct.**	**Cofe. With 95 % CI**	**Pct.**
Residence				
Rural	Ref.		Ref.	
Urban	-0.0137 (-0.0210, -0.0065)*	6.66	0.0493 (-0.0045, 0.1031)	-23.92
Education level of mother				
No education	Ref.		Ref.	
Primary	-0.0019 (-0.0041, 0.0002)	0.94	-0.0046 (-0.0145, 0.0053)	2.2
Secondary and +	-0.0054 (-0.0096, -0.0011)*	2.61	-0.0148 ()-0.0287, -0.0009)*	7.19
Sex of household head				
Male	Ref.		Ref.	
Female	0.0024 (0.0007, 0.0042)	-1.18	-0.0005 (-0.0117, 0.0011)	0.23
The educational level of the husband				
No education	Ref.		Ref.	
Primary	-0.0016 (-0.0031, -0.0001)*	0.79	0.0092 (-0.0014, 0.0198)	-4.45
Secondary and +	-0.0009 (-0.0024,0.0006)	0.46	0.0025 (-0.0092, 0.0141)	-1.20
Wealth status of the household				
Poorest	Ref.		Ref.	
Poorer	-0.0059 (-0.0090, -0.0028)*	2.87	-0.0246 (-0.0443, -0.0048)*	11.92
Middle	-0.0004 (-0.0007, -0.001)*	0.20	-0.0068 (-0.0022, 0.0085)	3.29
Richer	-0.0032 (-0.0058, -0.0006)*	1.56	0.0028 (-0.0121, 0.0178)	-1.37
Richest	-0.0014 (0.0022, -0.0005)	0.60	0.0029 (-0.0095, 0.0154)	-1.42
Stunting				
No	-0.0062 (-0.0107, -0.0017)	3.02	-0.0076 (-0.0657, 0.0607)	3.71
Yes	Ref.		Ref.	

Anemia prevalence	Difference due to characteristics (E)		Difference due to coefficients (C)	
	Cofe. With 95 % CI	Pct.	Cofe. With 95 % CI	Pct.
Underweight				
No	-0.0045 (-0.0080, -0.0010)*	2.19	0.0038 (-0.0530, 0.0607)	-1.83
Yes	Ref.		Ref.	
Wasting				
No	0.0049 (0.0002, 0.0096)	-2.37	0.0856 (-0.0091, 0.1802)	-41.50
Yes	Ref.		Ref.	
Sex of children				
Male	Ref.		Ref.	
Female	-0.0001 (-0.0002, -0.0001)*	0.07	-0.0075 (-0.0131, 0.0160)	3.66
Age of children in months				
0 to 5	Ref.		Ref.	
6 to 11	-0.0001 (-0.0002, -0.0001)*	0.05	0.0089 (-0.0135, 0.0312)	-4.29
12 to 23	0.0000 (0.0000, 0.0002)	-0.04	0.0199 (0.0004, 0.0393)*	-9.63
24 to 35	-0.0018 (-0.0034, -0.0002)*	0.87	0.0306 (0.0135, 0.0476)*	-14.83
36 to 47	-0.0004 (-0.0005, -0.0003)*	0.20	0.0120 (-0.0060, 0.0300)	-5.81
48 to 59	-0.0137 (-0.0210, -0.0065)*	6.66	-0.0148(-0.0287, -0.0009)*	7.19
Birth type				
Single birth	0.0003 (-0.0006, 0.0013)	-0.16	-0.0359 (-0.1839, 0.0112)	17.44
Multiple births	Ref.		Ref.	
Size of children at birth				
Small	Ref.		Ref.	
Average	-0.0075 (-0.0146, -0.0003)*	3.63	-0.0186 (-0.0390, 0.0018)	9.03
Large	0.0047 (0.0002, 0.0091)	-2.26	-0.0340 (-0.0694, 0.0014)	16.47
* Significance at 5% level of significance				

Determinants of children anemia

Model comparison

Table 5: Standard logistic regression and mixed-effects logistic regression models comparison

Model	AIC	BIC	Deviance
The standard binary logistic regression model	3398.525	3682.11	3302.525
The multilevel binary logistic regression model	2941.192	3224.557	2843.192

Table 6: Random effect parameters for the mixed-effects logistic regression model

Random effects parameters	Null model	Full model
σ^2	0.296 (0.100, 0.879)	0.212 (0.069, 0.624)
ICC	0.0826 (0.029, 0.211)	0.061 (0.021, 0.165)
MOR	1.52	1.44
PCV	Ref.	0.284
LR test: LR = 295.86, p-value = <0.001		

A multilevel binary logistic regression model was the best-fitted model because the model had a smaller deviance value (Table 5). The ICC value was 0.061 (95% CI: 0.021, 0.165), which is shows that 6.1% of the total variability in the prevalence of anemia among under-five children is significantly attributable to the local government areas level, and the rest 93.9% is attributable to individual levels within local government areas difference. The LR test was (X^2 = 295.86 with P-value <0.001) which indicates that the mixed-effect binary logistic regression model was the best-fitted model. Furthermore, the MOR value in the full model was 1.44, indicating that children in high anemia prevalence clusters were 1.44 times higher likelihood of anemic compared to children in low anemia prevalence clusters (*Table 6*). So analysis and reports were prepared based on a multilevel binary logistic regression model. From all explanatory variables included in the full model for multilevel analysis, mothers' anemia level, birth type of children, age of children in months, nourishment status of children (wasting. Underweight, and stunting), wealth status of the household, ever breastfeed, sex of household head and ethnicity were significantly associated with the prevalence of anemia for under-five children in Gambia. The odds of anemia among children who are from anemic mother is 57.7% (AOR = 1.577; 95% CI: 1.308 – 1.902) higher than those from non-anemic mother. Being twin, the odds of having anemia were 87.9% (AOR = 1.879; 95% CI: 1.181 – 2.989) higher than those children who were single. The odds of anemic among children aged 6 to 59 months whose family is headed by female is 73.9% (AOR = 0.739; 95% CI: 0.568 – 0.962) lower than children whose families were headed by males. The odds of developing anemia among children in the age group between 12 and 23 months were 3.953 times (AOR = 3.953; 95%CI: 2.909 – 5.372) higher than those children whose age was between 48 and 59 months. The odds of developing anemia among children in the age group between 24 and 35 months were 3.575 times (AOR = 3.575; 95%CI: 2.661 – 4.802) higher than those children whose age was between 48 and 59 months. The odds of developing anemia among children in the age group between 36 and 47 months were 2.064 times (AOR = 2.064; 95% CI: 1.546 – 2.757) higher than those children whose age was between 48 and 59 months. The odds of anemia among children aged between 6 and 59 months who are from families having wealth status of poorer, middle, and richest family were 0.660 (AOR = 0.660; 95% CI: 0.505 – 0.921), 0.526 (AOR = 0.526; 95% CI: 0.393 – 0.796), 0.340 (AOR = 0.340; 95% CI: 0.287 – 0.702) times lower than among children aged between 6 and 59 months who are from families having poorest wealth status respectively. The odds of developing anemia for wasted, underweight and stunted children were 1.840 (AOR = 1.840; 95% CI: 1.203 – 2.814), 1.661 (AOR = 1.661; 95% CI: 1.241 – 2.221), and 1.481 (AOR = 95% CI: 1.094 – 2.004) times higher than that of not wasted, not underweight and not stunted children respectively (Table 7).

Table 7: Simple and multiple multilevel binary logistic regression analysis of determinants of anemia prevalence among under-five in Gambia, 2019/20

Variable	Characteristics	COR (95% CI)	P-value	AOR (95% CI)	P-value
Mother anemia level	Not anemic (0)	Ref.		Ref.	
	Anemic (1)	1.630 (1.377, 1.934)*	<0.001	1.577 (1.308, 1.902)*	<0.001
Number of under-five children	Only one (0)	Ref.		Ref.	
	2 to 3 (1)	1.281 (0.983, 1.670)	0.066	1.114 (0.827, 1.500)	0.477
	3 and more (2)	1.467 (1.147, 1.878)*	0.002	1.225 (0.883, 1.698)	0.225
Birth order of children	Firs (0)	0.920 (0.699, 1.212)	0.555	1.090 (0.783, 1.517)	0.609
	2 to 3 (1)	0.986 (0.788, 1.232)	0.900	1.206 (0.925, 1.574)	0.169
	4 to 5 (2)	1.027 (0.808, 1.306)	0.827	1.149 (0.878, 1.504)	0.311
	6 and more (3)	Ref.		Ref.	
Birth type of children	Single (0)	Ref.		Ref.	
	Multiple (1)	2.257 (1.484, 3.432)*	<0.001	1.879 (1.181, 2.989)*	0.008
Birth size of children	Small (0)	Ref.		Ref.	
	Average (1)	0.754 (0.585, 0.972)*	0.030	0.900 (0.679, 1.192)	0.462
	Large (2)	0.687 (0.533, 0.887)*	0.004	0.882 (0.661, 1.177)	0.392
Cough	No (0)	Ref.		Ref.	
	Yes (1)	1.033 (0.829, 1.287)	0.773	1.075 (0.836, 1.384)	0.571

Fever	No (0)	Ref.		Ref.	
	Yes (1)	1.114 (0.884, 1.404)	0.361	1.007 (0.765, 1.302)	0.987
Diarrhea	No (0)	Ref.		Ref.	
	Yes (1)	1.289 (1.044, 1.592)*	0.018	1.003 (0.756, 1.214)	0.722
Age of children in month	0 to 11 (0)	2.357 (1.703, 3.261)*	<0.001	2.148 (1.488, 3.100)*	<0..001
	12 to 23 (1)	4.236 (3.210, 5.591)*	<0.001	3.953 (2.909, 5.372)*	<0.001
	24 to 35 (2)	3.418 (2.583, 4.522)*	<0.001	3.575 (2.661, 4.802)*	<0.001
	36 to 47 (3)	2.136 (1.619, 2.818)*	<0.001	2.064 (1.546, 2.757)*	<0.001
	48 to 59 (4)	Ref.		Ref.	

Variable	**Characteristics**	**COR (95% CI.)**	**P-value**	**AOR (95% CI)**	**P-value**
Wasting	No (0)	Ref.		Ref.	
	Yes (1)	1.011 (0.702,1.500)	0.926	1.840 (1.203, 2.814)*	0.005
Underweight	No (0)	Ref		Ref.	
	Yes (1)	1.925 (1.548, 2.393)*	<0.001	1.661 (1.241, 2.221)*	<0.001
Stunting	No (0)	Ref.		Ref.	
	Yes (1)	2.132 (1.656, 2.746)		1.481 (1.094, 2.004)*	0.011
Body mass index of mother	Thin (0)	Ref.		Ref.	
	Normal (1)	0.774 (0.568, 1.055)	0.105	0.888 (0.632, 1.248)	0.495
	Overweight (2)	0.715 (0.520, 0.988)*	0.040	1.017 (0.708, 1.459)	0.929
Wealth status of the household	Poorest (0)	Ref.		Ref.	
	Poorer (1)	0.660 (0.507, 0.859)*	0.002	0.682 (0.505, 0.921)*	0.013
	Middle (2)	0.526 (0.397, 0.697)*	<0.001	0.559 (0.393, 0.796)*	<0.001
	Richer (3)	0.665 (0.488, 0.909)*	<0.010	0.753 (0.507, 1.132)	0.172
	Richest (4)	0.340 (0.287, 0.556)*	<0.001	0.449 (0.287, 0.702)*	<0.001
Ever breast feed	No (0)	Ref.		Ref.	
	Yes (1)	0.700 (0.591, 0.830)*	<0.001	0.789 (0.634, 0.981)*	0.033
Husband education level	No education (0)	Ref.		Ref.	
	Primary (1)	0.873 (0.701, 1.089)	0.227	0.990 (0.772, 1.270)	0.937
	secondary + (2)	0.825 (0.665, 1.024)	0.081	1.036 (0.807, 1.331)	0.871
Sex of household head	Male (0)	Ref.		Ref.	
	Female (1)	0.682 (0.536, 0.867)*	0.002	0.739 (0.568, 0.962)*	0.024
Family size	Small (0)	Ref.		Ref.	
	Medium (1)	0.737 (0.509, 1.068)	0.107	0.739 (0.492, 1.111)	0.146
	Large (2)	0.883 (0.616, 1.265)	0.496	0.829 (0.535, 1.286)	0.403
Religion	Islam (0)	Ref.		Ref.	
	Christianity (1)	0.305 (0.110, 0.846)*	0.022	0.779 (0.221, 2.743	0.698

Variable	Characteristics	COR (95% CI.)	p-value	AOR (95% CI)	P-value
Source of dirking water	Unimproved (0)	1.005 (0.720, 1.403)	0.976	1.023 (0.700, 1.500)	0.905
	Improved (1)	Ref.		Ref.	
Education level of mother	No education (0)	Ref.		Ref.	
	Primary (1)	0.962 (0.760, 1.216)	0.743	0.872 (0.763, 1.130)	0.301
	Secondary + (2)	0.812 (0.700, 1.034)	0.113	0.925 (0.724, 1.184)	0.537
Ethnicity	Mandinka/Jahanka (0)	Ref.		Ref.	
	Wollof (1)	1.305 (0.986, 1.728)	0.063	1.274 (0.936, 1.736)	0.124
	Jola/Karoninka (2)	1.232 (0.854, 1.696)	0.202	1.039 (0.722, 1.497)	0.836
	Fula (3)	1.241 (0.969, 1.589)	0.087	1.047 (0.795, 1.379)	0.745
	Serere (4)	0.508 (0.283, 0.912)*	0.023	0.420 (0.217, 0.814)*	0.010
	Serahuleh (5)	0.828 (0.580, 1.182)	0.299	0.883 (0.600, 1.300)	0.526
	Creole/Aku Marabout (6)	0.210 (0.014, 3.052)	0.253	0.275 (0.015, 4.923)	0.380
	Manjago (7)	0.092 (0.008, 1.061)	0.056	0.099 (0.007, 1.441)	0.091
	Bambara (8)	0.889 (0.386, 2.049)	0.783	0.743 (0.308, 1.791)	0.508
	Other (9)	1.020 (0.305, 3.414)	0.974	1.405 (0.376, 5.249)	0.613
	Non-Gambian (10)	1.128 (0.841, 1.500)	0.432	1.000 (0.724, 1.384)	0.995

* Significance at 5% level of significance

Discussion

Harshness stages of anemia prevalence of children among under-five children in the Gambia was a major public health difficulty.

In this study, the trend of anemia prevalence has been significantly decreased from 71.6% in 2013 to 46.3% in 2019/20. This result agrees with the study done in Sub – Saharan Africa and the Lao People's Democratic Republic [6, 25] respectively. Decomposing this change, behavioral change of the respondents between the survey periods contributed 11.17% for the decrement of anemia prevalence over the last five years and the remaining 88.83% of decrement was due to difference in characteristics (population proportion). Behavioral change of households who had the highest (richer) wealth status was contributed 1.56% for the decrement of anemia prevalence for the previous five years as compared to households who had lowest (poorer) wealth status this study is consistent with [32] in Brazil and [33] in Ecuador. Similarly, the behavioral change of households who were urban settlers' contributed a 6.66% decrement of anemia prevalence for the previous five years as compared to rural settlers.

Furthermore, in the multilevel binary logistic regression model, mother anemia level, birth order of children, children' age, nutritional status of children (wasting, stunting and underweight), wealth status of children, ever breastfeed, sex of household head, and ethnicity have significantly associated the prevalence of anemia among children aged between 6 and 59 months in Gambia.

Under-five children of the lower, middle, and higher class households had lower prevalence of anemia compared to the poorest households. This study is compatible with the study [28] in Ethiopia, [6] in Sub- Saharan Africa, [24] in Bangladesh and [34] in Ghana. The possible reason could be because scarcity is intensely connected with food shortage and hereafter children from having lower income household might get foods rich in iron, vitamin, and vitamin B complex, this increases their risk of evolving anemia. The matching probable clarification is that households with low income are not gaining nutrient-rich foods, secure food accessibility, and get health facilities during infection for their children.

Maternal anemia was significantly related to higher odds of anemia prevalence among children aged between 6 and 59 months. This study is coinciding with the study findings [28] in Ethiopia and [35] in Togo. This is due to the mother is the primary source of food for youngsters, and hence the children stake the same nutrition, so their eating behaviors and worth of life may well be the same. Also, through transplacental diffusion and breastfeeding, infective causes of anemia like malaria and HIV/AIDS that will affect with their growth of red blood cells and iron stores is also transmitted to childhood.

The results also revealed that the possibility of children anemia within the age range of 12 to 23, 24 to 35, and 36 to 47 months were higher those in 48 to 59 months aged. The results of the study were coinciding to the results of various studies [19] in Ethiopia, [10] in Uganda and [34] in Ghana. The possible reason for the higher probability of anemia could be associated with little balanced nutritional consumptions which will not be adequate for his or her zoom related demands. The other probable motives may also the real fact that poor infant and young children feeding practices particularly timely initiation of complementary food is low in the Gambia as evidenced by published data of 2013 and 2019/2020 GDHS survey [17, 18].

In this study, the odds of prevalence of anemia for stunted, underweight, and wasted under-five were higher than normal children. This was consistent with studies [6] in Sun-Saharan Africa and [28] in Ethiopia. The reason behind it is, poor nutritional status is related to poor resistance and, therefore, contaminations and infestations also have synergistic effects of micronutrient shortages for occurrence of anemia and also, undernourished children are venerable to micronutrient scarcities, such as iron, vitamin A, vitamin B12 and folic acid, which are supportive for haemoglobin and DNA synthesis during red blood cell construction, and in turn, results in anemia [36]. Anemia and undernourishment often share joint causes; it is likely that numerous types of undernourishment would co-exist in identical people, and rise the growth of anemia in synergetic manner. Further, the gastrointestinal epithelium trouble in undernourished people may decline absorption, and donate towards expansion and worsening of anemia [37]. Accordingly, low hemoglobin level may also compromise the linear growth of the children.

The result also indicated that children who were breast feed have lower likelihood of anemic as compared to children who were not breastfed. This study is consistent with the study [22]

This study indicated that being twins were at a further risk to have anemia as compared to single children. This finding is consistent with the study conducted [24] in Bangladesh and [28] in Ethiopia. This might be due to children who are twin might not get exclusive breast milk at early ages and this reduces their resistance and disposition to diarrhea. Similarly, the quality of attention from parents is reduced. So they are easily disposed to diverse diseases.

Strength and limitations

This research had numerous strengths. First, the study was founded on nationwide representative DHS datasets, and therefore it had acceptable statistical power. Second, the estimates of the study were done after the data were weighted for the probability sampling, to type it representative at nationwide and local area government level: so, it can be comprehensive to all births from women of reproductive age in the Gambia. Third, to understand the factors that significantly contributed to the decreases in childhood anemia prevalence, multivariate decomposition analysis was adopted. Limitation, since this study was based on secondary data, we were not able to examine all dynamics that may be applicable to anemia in children, including eating habits, parasite infestations (malaria, Visceral Leishmaniasis, and hookworm, previous hospitalization, and use of nutritional supplements (such as vitamin B12 and folate).

Conclusion and Policy Recommendation

In deduction, anemia among under-five children in the Gambia was the most important public health difficulty. Mother anemia level, birth type of children, age of children in a month, nutritional status of children (wasting, stunting and underweight), wealth status of the household, breastfeeding, sex of household head, and ethnicity in the Gambia were found significant determinants of the prevalence of childhood anemia. Interventions to address maternal anemia, and improve the monetary status of the household are optional to decrease childhood anemia. Moreover, it is important to brace the policies of primary recognition and organization of stunted, wasted, and underweight children to dimension childhood anemia occurrences.

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Authors' contributions

AA wrote the proposal, analyzed the data and manuscript writing. YA accredited the proposal with revisions, analysis the data and manuscript writing. Both YA and AA read and approved the very last manuscript.

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Availability of data and materials

The data used in this study are from the Measure DHS program https://www.dhsprogram.com/data/dataset_admin/login_main.cfm, and can be accessed following the protocol outlined in the Methods section.

Ethics Approval and Consent to Participate

Ethical approval and participant consent were not necessary for this particular study since the study was a secondary data analysis based on the publically available DHS data. We requested the data from the MEASURE DHS Program and permission was granted to download and use the data for this study. There are no names of individuals or household addresses in the data files.

Consent for Publication

Not applicable

Competing Interests

The authors declare that they have no competing interests.

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