Trends and determinants of diarrhea among under-five children in Gambia, evidence from 2013 – 2019/20 Gambian demographic and health survey; multilevel binary logistic regression and multivariate decomposition analysis

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Abstract

Background

Diarrhea is the opening of three and more movable or liquid stools per day, or more frequently than is common for the individual. It is usually an indicator of gastrointestinal infection which can be caused by a variety of bacterial, viral, and parasitic organisms.

Objective

This study aimed to analyze the trend and determinants of diarrhea prevalence among under-five children within the Gambia for the last five years (2013–2019/20).

Methods

A total of 6,705 in 2013, and 5,780 in 2019/20 under-five aged children were involved in this study. Multivariate decomposition and multilevel analysis based on a binary logistic regression analysis approach were performed.

Results

74.57% of the change in diarrhea prevalence over time was attributable to differences in behavior. Unimproved water source (AOR = 1.4061; 95% CI: 1.0415–1.8982), Wollof ethnicity (AOR = 1.5442; 95% CI: 1.2196–1.9551), not vaccinated for rotavirus (AOR = 3.1476; 95% CI: 2.1486–4.6110) and for measles (AOR = 1.5128; 95% CI: 1.2384–1.8479), average birth size (AOR = 0.8038; 95% CI: 0.6555–0.9855), child age less than one year (AOR = 0.6160; 95% CI: 0.4710–0.8057).

Conclusion

The prevalence of diarrhea was significantly increased over the last five years and the decline was due to differences in behavior between the surveys. Source of drinking water, ethnicity, birth size, age of children, rotavirus, and measles vaccine were significantly associated with diarrhea among under-five children in the Gambia. Therefore, the Gambian régime should attention to the creation and topping up of behavioral change packages of the public regarding the protection of hygiene and sanitation of the community and their environment, vaccinating of their children to prevent diarrheal disease.

Introduction

Diarrhea is the initial of three and more movable or liquid stools per day, or additional repeatedly than is common for the individual people. It is commonly a sign of gastrointestinal poison which can be happen by a multiplicity of bacteriological, disease-causing, and sponging organisms [1]. Universally diarrhea is the second major cause of mortality among under-five children and responsible nearly one in five children deaths, and accounts for around 1.5 million children losses each year. Cumulatively, diarrhea only murders more childhood than acquired immune deficiency syndrome (AIDS), malaria, and measles [2, 3].

Globally diarrhea is the key causes of childhood illness and death, mainly in emerging countries like Gambia. It is accountable for 525,000 losses [4], and 1.7 billion cases [5] among under five children each year. The microorganisms which are a source of diarrhea disease spread through unimproved water and contaminated food. They can also transferee from one individual to another individual. Microorganisms are usually common in situations with unimproved intake water and hygiene [6].

In emerging countries, a child involves three or more happenings of diarrheal illness per year [7]. Diarrhea becomes a severe reason of undernourishment and undernourished youngsters have a chance to fall ill from diarrhea [8]. Maximum losses from diarrhea happen among children less than two years of age living in Asia and sub-Saharan Africa [9]. Minor rotavirus poisons can be preserved successfully in the similar method as other forms of diarrhea, by giving liquids and salts (verbal rehydration treatment). But, children with severe rotavirus diarrhea can come to be dehydrated and regularly want intravenous solutions or they risk to dying. [10]

The possibility reasons for diarrhea incidences different from place to place among children included the size of child at birth, type of toilet facility[11], quality of drinking water and lack of hygiene services reason the loss of millions of the world's poorest individuals through diarrheal illnesses each year [12, 13]. Additionally, studies shows that age of child [14, 15], maternal education [14, 16, 17], lack of awareness of mothers/caregivers [18, 19], lower socio-economic status [16], distance and source of drinking water[14, 20, 21], latrine and hand washing facilities [22, 23], breast feeding [22, 24], place of residence [11, 23, 25], disposal of children's stool [25, 26], family size [17, 18, 27], number of under-five children in the household [17], maternal age [18], and maternal employment status 16 as the determinant factors of diarrhea among under-five children. Rotavirus vaccines have to be announced as measure of a widespread method to control diarrheal illness, alongside with additional involvements including oral rehydration therapy, breastfeeding, zinc treatment, and improvements in water and hygiene.[28]

Even though still illness and death of youngsters due to diarrhea is high in Gambia; the occurrence of diarrhea among under five children increase from 17% in 2013 to19% in 2019-20 [29, 30]. The increases in the incidence of diarrhea is due the change of population growth in the country [29]. The problem of crucial attention in this study is just in what way of the variation is basically due to the enhancement of behavior suggesting the concrete raise in diarrhea occurrence and just how much is due to a compositional variation in the population distribution. Therefore, to end and control diarrhea, it is vital to differentiate the trends of diarrhea over time, source of deviation, the fundamental features for the variation in occurrence of diarrhea precisely and factors of diarrhea using appropriate statistical technique of analysis. Since unsuitable result clues to confusing deduction and involvement. But there is no suggestion that displays studies done at national level to determine main factors of diarrhea prevalence by considering the regional effect using mixed effect model method and that study the causal factors for the variation in the occurrence of diarrhea among youngsters through decomposition analysis. Therefore, the current study aimed to analyze the trend and determinants of diarrhea prevalence among under-five children within the Gambia for the last five years. Knowing the trends and determinants of diarrhea incidence could aid policymakers, and followers to take evidence-based involvement to reduce effectively the incidence of diarrhea.

Materials And Methods

Data Source and Population

The current study used 2019/20, and 2013 GDHSs data. These GDHSs data are a countrywide representative cross-sectional survey executed in eight Local Government Areas (LGAs). In both 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. At the second phase, 25 households per enumeration area are designated [31, 32].

Variables of the Study

Variables exposed in this study were originated from studies that have been conducted at the international level [3, 12, 33–35]. The possible factor related with the occurrence of diarrhea for under-five children were included as variables in the current 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.

Outcome Variable

The outcome variable of this study was diarrhea status of children aged below five years. The outcome is specifying have not diarrhea coded by zero or have diarrhea coded by one.

$$Y_{ij} = \begin{cases} Havenotdiarrhea = 0 \\ Havediarrhea = 1 \end{cases} \quad [1]$$

Explanatory variables

Local government areas of the study participants, types of place of residence, Religion, Ethnicity, Number of household member, Number of children 5 and under, Types of toilet facility, Sex of household head, Wealth index, Mothers education level, mothers husband education level, current working of mother, Birth order number, Child is twin, Sex of child, Duration of breastfeeding, Size of child, Covered by health insurance, Age of child, Media exposer, Received Measles, and Rotavirus were considered as independent variables for this study.

Data Analysis

The data were retrieved from the child Record (KR file for both GDHSs data set. Before the initial statistical analysis, the data were weighted via 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 inspection includes three important portions. First, descriptive statistics and trends were analyzed by each variable characteristics. Second, multivariate decomposition analysis was applied to hold the magnitude to which each nominated covariate contributed to the observed trend in diarrhea prevalence, finally, multilevel binary logistic regression analysis was applied to determine factors correlated to prevalence of diarrhea among under-five children in Gambia.

Analysis of trend and decomposition

The trend stage was particular period which is (2019/20–2013), and familiarized to see the changes in magnitude of diarrhea over the last five years for various features. The trend was evaluated through descriptive analyses method for each different levels of the covariates and was assessed 2019/202–2013 period. Multivariate decomposition analysis is used to understand the differences within the outcome between two survey (comparable 2013 and 2019/20 survey year). The decomposition procedure splits the entire increment in prevalence of diarrhea into two parts; the part that may be recognized to the variation in composition or the occurrence of a collection of indicators (stated as endowments part) and the part which recognized to the variation within the effect of those indicators (stated as coefficient part). Therefore, the observed variation in load of diarrhea between two points of survey time was additively decomposed in to endowment (characteristics) part and coefficient (characteristics) part. The analysis was applied through newly established Stata package [36].

The equality is given by

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

Where $i, j = 2013 and 2016/2020$ ΔY is the dissimilarity average prediction of diarrhea prevalence between year $i$and year$j$, given that of different features of X. β is the estimated regression coefficients. $\left(X^i - X^j\right)\beta^i$, Represents the alteration due to endowment between the i^{th} and j^{th} years. $X^j\left(\beta^i - \beta^j\right)$, Represents the difference due to coefficients between the i^{th} and j^{th} years [36].

Determinants of diarrhea 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 [33]. The assumptions the model was tested using the Intra-class coefficient of correlation (ICC), which used to measure the degree of similarity for diarrhea prevalence between the cluster, and Likelihood Ratio (LR) test. Median Odds Ratio [35] and Proportional Change in Variance (PCV) were considered to calculate the deviation across groups [35].

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

The MOR measures the variation between the groups in terms of odds ratio. The odds ratio of the median value is the ratio between the cluster at higher risk of diarrhea and at lower risk of diarrhea prevalence when randomly picking out two clusters [33].

$$MOR = (0.95 * \sigma) \text{ [4]}$$

σ Is cluster standard deviation

PCV is used to measure total variation in diarrhea prevalence that was explained by the final model compared to the null model [35].

$$PCV = \frac{var(\,nullmodel) - var(\,fullmodel)}{var(\,nullmodel)}$$ [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 [35] with a 95% Confidence Interval (CI) and p-value < 0.05 were used in the final model to announce significant factors correlated with diarrhea prevalence among under-five children.

Results

Characteristics of the study population

Table 1 presents the percentage distribution of diarrhea for under-five children based on selected measurable, children, and household characteristics reports from 2013–2019/20 GDHS. Thus, the analysis encompassed weighted data from 6,705 in 2013 and 5,780 in 2019/20. Demographic characteristics of GDHSs

Table 1

Frequency and Percentage distribution of characteristics of respondents and their children in Gambia

Variable	Characteristics	Frequency and percentage in DHS Periods	
		GDHS 2013	GDHS 2019
		Weighted frequency (%)	Weighted frequency (%)
Region	Banjul	98(1.5)	58 (1)
	Kanifing	1112(16.4)	911 (15.8)
	Brikama	2269(33.6)	2274 (39.4)
	Mansakanko	349 (5.2)	257 (4.4)
	Kerewan	805 (11.9)	728 (12.6)
	Kuntaur	470 (7.0)	382 (6.6)
	Janjanbureh	578 (8.5)	414 (7.2)
	Basse	1080 (16.0)	755 (13.1)
Type of place of residence	Urban	3156 (46.7)	3626 (62.7)
	Rural	3607 (53.3)	2153 (37.3)
Source of drinking water	Unimproved	721(10.7)	414 (7.2)
	Improved	6038 (89.3)	5365 (92.8)
Religion	Islam	6632 (98.1)	5691(98.5
	Christianity	129 (1.9)	89 (1.5)
Number of household member	five and less	876(13)	698(12.1)
	Six and more	5885(87.0)	5081 (87.1)
sex of household head	Male	5730 (84.7)	4961 (85.8)
	Female	1031 (15.3)	818 (14.2)
Type of toilet facility	Unimproved	2889(42.7)	2059 (35.6)
	Improved	3872 (57.3)	3720 (64.4)

Variable	Characteristics	Frequency and percentage in GDHS Periods	
		GDHS 2013	GDHS 2019
		Weighted frequency (%)	Weighted frequency (%)
Ethnicity	Mandinka /Jahanka	2297 (34.0)	1919 (33.2)
	Wollof	895(13.2)	752 (13)
	Jola/karoninka	565 (8.4)	430 (7.4)
	Fula/Tukulur/Lorobo	1643(24.3)	1179 (20.4)
	Serere	183(2.7)	138 (2.4)
	Serahuleh	540 (8)	476 (8.2)
	Creole/Aku Marabout	17 (0.3)	6 (0.1)
	Manjago	67 (1)	36 (0.6)
	Bambara	63(0.9)	72(1.3)
	Other	65 (1)	38 (0.7)
	Non-Gambian	427 (6.3)	732 (12.7)
Number of children 5 and under in household	Two and less	2831 (42.2)	2468 (42.7)
	Three and more	3873 (57.4)	3312 (57.3)
Wealth index	Poor	2838 (42)	2603 (45)
	Medium	1367 (20.2)	1198(20.7)
	Reach	2556 (37.8)	1979 (34.2)
Mothers education level	No education	4103 (60.7)	2822(48.8)
	Primary education	923(13.7)	988 (17.1)
	Secondary and above	1518 (22.5)	1731 (30)
	Higher	216 (3.2)	238 (4.1)
Husbands educational level	No education	4240 (62.7)	3175(54.9)
	Primary education	435 (6.4)	395(6.8)
	Secondary and above	1656 (24.5)	1726 (29.9)
	Higher	430 (6.4)	484 (8.4)
Current working	No	3509 (51.9)	2582 (44.7)
	Yes	3252 (48.1)	31.97 (55.3)

Variable	Characteristics	Frequency and percentage in GDHS Periods	
		GDHS 2013	GDHS 2019
		Weighted frequency (%)	Weighted frequency (%)
Birth order number	First	1315 (19.5)	977 (16.9)
	Two to three	2323 (34.4)	2078 (36)
	Four to five	1639 (24.2)	1430 (24.8)
	Six and more	1483 (21.9)	1293 (22.4)
Child is twin	Single	6563 (97.1)	5595 (96.8)
	Multiple	198 (2.9)	184 (3.2)
Duration of breastfeeding	Never breastfeed	52 (0.8)	52 (0.9)
	Ever breastfeed not currently	3916 (57.9)	3542 (61.3)
	Still breastfeeding	2793 (48.5)	2186 (37.8)
Sex of child	Male	3462 (51.2)	2991 (51.7)
	Female	3299 (48.8)	2789 (48.3)
Current age of child	Less than one	3086 (45.6)	2513 (43.5)
	One and less two	1266 (18.7)	1129 (19.5)
	Two and less than three	1203 (17.8)	1153 (19.9)
	Three and less than five	1206 (17.8)	984 (17)
Size of child at birth	Small	1398 (20.7)	869 (15)
	Average	1843 (27.3)	2442 (42.3)
	Large	3520 (52.1)	2468 (42.7)
Had diarrhea recently	No	5615 (83.1)	4706 (81.4)
	Yes	1146 (16.9)	1074 (18.6)
Received MEASLES	No	1804 (26.7)	1288 (22.3)
	Yes	1957 (73.3)	4491 (77.7)
Covered by health insurance	No	6651 (98.4)	5636 (97.5)
	Yes	110 (1.6)	144 (2.5)
Media exposure	No	4029 (59.6)	3830 (66.3)
	Yes	2732 (40.4)	1950 (33.7)

Demographic characteristics of GDHSs data revealed that 46.7% and 62.7% of children's households lived in urban and rural areas in 2013 and 2019/20 respectively. 84.7% in 2013 and 85.8% in 2019/20 of the total households in the two consecutive GDHSs survey were led by males. Considering birth features of GDHSs data, the highest percent (3.2%) of twin birth was in 2019/20. 20.7% and 15% of small birth size was reported in the 2013 and 2019/20 GDHSs study period respectively. Regarding the birth order of children, the highest percentage of children has birth order of two to three were recorded in the 2019/20 survey year which was 36%. Among the surveyed households, 10.7%, and 7.2% of households were not drink improved water in the 2013 and 2019/20 GDHSs survey years respectively.

Regarding households' wealth status 42% of the households in 2013 and 45% in 2019/20 was poorest. From the total surveyed population 87% of households in 2013 and 87.1% in 2019/2020 have 6 and more members per household.

Overall Trends Of Anemia Prevalence Among Children Aged 6–59 In The Gambia

By observing the trend, there is an increment in diarrhea prevalence among under-five children from the 2013–2019/20 survey period in Gambia. Accordingly, it was 17.0% in 2013 and was increased 1.6% in 2019/20. Generally, the overall change (2019/20–2013) in diarrhea prevalence of under-five children was 1.6% point change increment (Fig. 1).

Table 2 presents the Trends of diarrhea 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 diarrhea among under-five children discovered that originality based on predictor levels. Diarrhea prevalence increment was observed in most of the characteristics in the phase (2013–2019/20). Considering ethnicity of Gambia, the largest increment was recorded in Manjago which is was 16.7%. Based on local government areas, the largest increment was observed in Kuntaur local government area with 7.2% point increment. Respondents who had have unimproved Toilet facility showed that under-five children diarrhea prevalence increment which is 2.9%.

Table 2. Trends of diarrhea prevalence among under-five children by selected characteristics in Gambia.

Variable	Characteristics	GDHSs periods		Point difference in anemia prevalence (2019/20-2013)
		2013 (1142(17.0%))	2019 (1074(18.6%))	
Region	Banjul	25(25.5)	13 (22.4)	-2.8
	Kanifing	237 (21.5)	152 (16.7)	-4.8
	Brikama	427 (18.9)	451 (19.8)	0.9
	Mansakanko	49 (14.4)	55 (21.4)	7.0
	Kerewan	100 (12.5)	103 (14.1)	1.6
	Kuntaur	100 (21.6)	110 (28.8)	7.2
	Janjanbureh	83 (14.5)	77 (18.6)	4.1
	Basse	122 (11.4)	114 (15.1)	3.7
Type of place of residence	Urban	558 (17.8)	676(18.6)	0.8
	Rural	584 (16.4)	398 (18.5)	2.1
Source of drinking water	Unimproved	123 (17.1)	64 (15.5)	-1.6
	Improved	1019 (17)	1010 (18.8)	1.8
Religion	Islam	1119 (17)	1060 (18.6)	1.6
	Christianity	23(17.8	14 (15.7)	-2.1
Number of household member (listed)	five and less	126 (14.4)	128 (18.3)	3.9
	Six and more	1016 (17.4)	946 (18.6)	1.2
sex of household head	Male	951 (17.2)	935 (18.8)	1.6
	Female	167 (16.3)	138 (16.9)	0.3
Type of toilet facility	Unimproved	444 (15.5)	378 (18.4)	2.9
	Improved	698 (18.1)	696 (18.7)	0.6

Variable	Characteristics	GDHSs periods		Point difference in anemia prevalence (2019-2013)
		2013 (1142(17.0%))	2019 (1074(18.6%))	
Ethnicity	Mandinka /Jahanka	339(14.9)	312 (16.3)	1.4
	Wollof	190 (21.4)	166 (22.1)	0.7
	Jola/karoninka	116 (20.6)	68 (15.8)	-4.8
	Fula/Tukulur/Lorobo	247 (15.2)	244 (20.7)	5.5
	Serere	41(23.2)	20 (14.5)	-8.7
	Serahuleh	94 (17.6)	81 (17)	-0.6
	Creole/Aku Marabout	3 (17.6)	1 (14.3)	-3.3
	Manjago	13 (19.4)	13 (36.1)	16.7
	Bambara	16 (25.8)	13 (17.8)	-8.0
	Other	15(23.4)	5 (13.2)	-10.2
	Non-Gambian	66 (15.5)	151 (20.6)	5.1
Current age of child	Less than one	694 (22.5)	638 (25.4)	2.9
	One and less two	267 (21.2)	230 (20.4)	-0.8
	Two and less than three	103(8.7)	120 (10.4)	1.7
	3 and less than four	78 (6.6)	85 (8.6)	2.0
Husbands/partners educational attainment	No education	703(16.7)	586 (18.5)	1.8
	Primary	67 (15.5)	83 (21.0)	5.5
	Secondary	292 (17.8)	302 (17.5)	-0.3
	Higher	80 (18.8)	102 (21.1)	2.3
Duration of breastfeeding	Never breastfeed	3(5.8)	11 (21.6)	15.8
	Ever breastfeed not currently	543 (13.9)	514 (14.5)	0.6
	Still breastfeeding	596 (21.7)	548 (25.1)	3.4
Wealth index	Poor	470 (16.6)	496 (19.1)	2.5
	Medium	217 (16.4)	196 (16.4)	0.0
	Reach	454 (17.8)	382 (19.3)	2.3
Current working	No	541 (15.6)	487 (18.9)	3.3
	Yes	600 (18.6)	587 (18.4)	-0.2

Variable	Characteristics	GDHSs periods		Point difference in anemia prevalence
		2013 (1142(17.0%))	2019 (1074(18.6%))	(2019-2013)
Birth order number	First	234 (18)	197 (20.2)	-37
	Two to three	407 (17.7)	403 (19.4)	-4
	Four to five	257(15.8)	260 (18.2)	3
	Six and more	243(16.5)	214 (16.6)	-29
Child is twin	Single	1105 (17)	1052 (18.8)	-53
	Multiple	37(19.1)	22 (12)	-15
Sex of child	Male	624 (22.5)	586 (19.6)	-38
	Female	267 (21.2)	488 (17.5)	221
Size of child at birth	Small	253 (18.3)	185 (21.3)	-68
	Average	286 (15.7)	433 (17.7)	147
	Large	603(17.2)	456 (18.5)	-147
Received MEASLES	No	317 (17.6)	247 (19.2)	-70
	Yes	825 (16.8)	827 (18.4)	2
Covered by health insurance	No	1115(16.9)	1048 (18.6)	-67
	Yes	27 (24.5)	26 (18.1)	-1
Media exposure	No	684 (17.1)	706 (18.4)	22
	Yes	458 (16.9)	368 (18.9)	-90
Number of children 5 and under	Two and less	435 (15.4)	456 (18.5)	21
	Three and more	707 (18.3)	617 (18.6)	-90
Highest education level	No education	-	511 (18.1)	-
	Primary	-	204 (20.6)	-
	Secondary	-	324 (18.7)	-
	Higher	-	36 (15.1)	-
Rotavirus	No	-	35 (9)	-
	Yes	-	1039 (19.3)	-

Table 3
Over all multivariate decomposition analysis of diarrhea prevalence in Gambia 2013–2019/20

Prevalence of diarrhea	Cofe.	95%CI	Pct.
E	0.0055	(0.0019 – 0.0010)*	25.43
C	0.0159	(0.0029–0.0289)*	74.57
R	0.0214	(0.0086–0.0334)	

Table 3 presents the general multivariate decomposition result of diarrhea prevalence of children aged below five years in the Gambia some selected characteristics from 2013–2019/20 GDHSs survey.

Overall from 2013 to 2019/20, there is a significant increment in the prevalence of diarrhea in the Gambia. The whole decomposition result showed that 25.43% of increment in the prevalence of diarrhea over time was due to behavioral changes between the surveys, and 74.57% of increment was due to differences in characteristics.

Factors region, ethnicity, type of toilet facility, wealth index, current working status of mother, birth order number, sex of children, age of children, and received MEASLES indicated a significant effect for the increment of under-five children diarrhea prevalence in Gambia. Making compositional changes constant, behavioral change households who are use improved toilet facility were contributed 21.84% for the decrement of control the prevalence of diarrhea for the last five years as compared to used unimproved toilet facilities. Keeping compositional changes constant behavioral change of households who had medium wealth status was contributed 18.59% for the decrement in resist of diarrhea prevalence for the last five years as compared to households who had the poor wealth status. Similarly, the behavioral change of mother who have current working was 45.61% decrement of control diarrhea prevalence in the last five years as compared to mother who had no current working (Table 4).

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

Diarrhea prevalence	duo to Difference characteristics (E)			duo to Difference coefficients (C)		
	Cofe.	95%CI	Pct.	Cofe.	95%CI	Pct.
Region						
Banjul	Ref			Ref		
Kanifing	0.0007	-0.00008, 0.0015	3.178	-0.0016	-0.0068, 0.0037	-7.2719
Brikama	0.0003	-0.0005, 0.0011	1.2444	0.0036	-0.0049, 0.0119	16.503
Mansakanko	0.0001	-0.0006, 0.0007	0.2227	0.0089	0.0023, 0.0154	41.434
Kerewan	0.0013	0.0005, 0.0010	5.6855	0.0111	0.0026, 0.0195	51.707
Kuntaur	0.0009	-4.9219, 0.0018	4.0126	0.0119	0.0039, 0.0110	55.772
Janjanbureh	-0.0006	-0.0014, 0.0003	-2.5449	0.0083	0.0013, 0.0151	38.585
Basse	-0.0023	-0.0044, -0.0002	-10.574	0.0133	0.0040, 0.0225	62.214
Ethnicity						
Mandinka /Jahanka	Ref			Ref		
Wollof	-0.0003	-0.0005, -0005	-1.4749	-0.0030	-0.0079, 0.0019	-14.135
Jola/karoninka	0.0004	-0.0008, 0.0015	1.6413	-0.0014	-0.0047, 0.0019	-6.7504
Fula/Tukulur/Lorobo	0.0009	-0.0017, -0.0002	-4.6273	0.0019	-0.0058, 0.0098	9.2622
Serere	0.0000	-0.0006, 0.0004	-0.2656	-0.0014	-0.0034, 0.0005	-6.8244
Serahuleh	0.0007	-0.0002, 0.0017	3.3839	-0.0013	-0.0049, 0.0021	-6.418
Creole/Aku Marabout	0.0000	-0.0003, 0.0004	0.3027	-0.0003	-0.0009, 0.0004	-1.2085
Manjago	-0.0002	-0.0007,0.0002	-1.123	0.0004	-0.0005, 0.0014	2.0435
Bambara	0.000 1	-0.0001, 0.0004	0.6089	-0.0003	-0.0012, 0.0007	-1.3014
Other	0.0000	-0.0006, 0.0007	0.2199	-0.0007	-0.0019, 0.0004	-3.4716
Non-Gambian	0.0037	0.0014,0.0059	17.401	0.0033	0.0007,0.0059	15.43
Type of toilet facility						
Unimproved	Ref			Ref		
Improved	0.0005	0.0000, 0..0010	2.6098	-0.0047	-0.0171, 0.0078	-21,844
Wealth index						
Poor	Ref					
Medium	0.0005	0.00003, 0.0009	2.3584	-0.0039	-0.0102, 0.0023	-18.588
Reach	0.0010	-0.0006, 0.0027	4.8952	0.0075	-0.0024, 0.0174	35.106
Current working status of mother						
No	Ref			Ref		
Yes	0.0015	0.0005, 0.0025	7.1134	-0.0097	-0.0201, 0.0007	-45.608

Anemia prevalence	Duo to Difference characteristics E			duo to Difference coefficients (C)		
	Cofe.	95%CI	Pct.	Cofe.	95%CI	Pct.
Birth order number						
First	Ref			Ref		
Two to three	-0.0000	-0.0003, 0.0000	-0.4682	0.0000	-0.0094, 0.0095	0.3066
Four to five	0.0000	6.1242, 0.0000	0.1306	-0.0011	-0.0089, 0.0067	-5.3514
Six and more	-0.0008	-0.0013, -0.0003	-3.8685	-0.0032	-0.0107, 0.0043	-15.306
Sex of child						
Male	Ref			Ref		
Female	0.0000	-0.0000, 0.0002	0.3123	0.0072	-0.0028, 0.0173	33.839
Age of child in year						
Less than one	Ref			Ref		
One and less two	-0.0000	-0.0000, -0.0000	-0.2871	-0.0048	-0.0105, 0.0009	-22.546
2 and < 3	-0.0029	-0.0035, -0.0024	-14.03	0.0013	-0.0074, 0.0048	-6.1107
3 and < 4	-0.0018	-0.0021, -0.0015	-8.589	-0.0000	-0.0069, 0.0067	-0.4657
Received MEASLES						
No	Ref			Ref.		
Yes	0.0038	0.0028, 0.0048	17.964	0.0214	-0.0001, 0.0428	100.17

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 diarrhea prevalence clusters were 1.44 times higher likelihood of diarrhea compared to children in low diarrhea prevalence clusters (Table 6).

So investigation and reports were prepared based on a multilevel binary logistic regression model. From all independent variables included in the full model for multilevel analysis, source of drinking water, ethnicity, birth order number, size of child at birth, age of child, received rotavirus and measles vaccine were significantly associated with the prevalence of diarrhea for under-five children in Gambia. The odds of getting diarrhea among children who have un improved source of drinking water were 40.61% (AOR = 1.4061; 95% CI: 1.0415–1.8982) higher than the odds of children who have not improved drinking water. In this finding the chance of developing diarrhea among under-five children who were from Wollof ethnicity were 54.42% (AOR = 1.5442; 95% CI: 1.2196–1.9551) higher than the odds of under-five children who were from Mandinka/Jahanka. Similarly, the odds of developing diarrhea for under-five children who were from Fula/Tukulur/Lorobo and Manjago ethnicity were 1.4394 (AOR = 1.4394; 95% CI: 1.1738–1.7651) and 2.9667 (AOR = 2.9667; 95% CI: 1.3127–6.7046) times the odds of under-five children who were from Mandinka/Jahanka respectively. The chance of developing diarrhea for children who have six and more birth number were 0.7296 (AOR = 0.7296; 95% CI: 0.5711–0.9321) times as compared to children who have first birth number. The odds of having diarrhea among children whose birth size was average (normal) were 19.62% (AOR = 0.8038; 95% CI: 0.6555–0.9855) lower as compared to children whose birth size was small. The chance of developing diarrhea for children having age less than one year, one to less than two years, two to less than three years was decreased by 38.4% (AOR = 0.6160; 95% CI: 0.4710–0.8057), 72.98% (AOR = 0.2726; 95% CI: 0.2019–0.3680), and 77.98% (AOR = 0.2202; 95% CI: 0.1595–0.3040) as compared to children having age three to five years respectively. The chance of developing diarrhea for children who were not take rotavirus vaccine was 3.1476 (AOR = 3.1476; 95% CI: 2.1486–4.6110) times as compared to children who was take the vaccine. Moreover, the chance of developing diarrhea for children who were not received measles was 51.28% (AOR = 1.5128; 95% CI: 1.2384–1.8479) higher as compared to children who were received measles (Table 7).

Table 7
Bivariable and multivariable mixed effect logistic regression analysis of determinants on diarrhea prevalence

Variable	Characteristics	AOR(95%CI)	P value	COR(95%CI)	P value
Type of place of residence	Urban	0.9154(0.7176, 1.1679)	0.477	0.9152(0.7911,1.1930)	0.783
	Rural	Ref.		Ref.	
Source of drinking water	Un improved	1.4061 (1.0415, 1.8982)	0.026	1.4299(1.0798,1.8935)	0.013
	Improved	Ref.		Ref.	
Religion	Islam	Ref		Ref	
	Christianity	0.7353 (0.3674, 1.4175)	0.385	0.8080(0.4536,1.4393)	0.469
Ethnicity	Mandinka /Jahanka	Ref		Ref	
	Wollof	1.5442(1.2196, 1.9551)	0.000	1.4874(1.1929, 1.8546)	0.000
	Jola/karoninka	0.9419 (0.6945, 1.2773)	0.700	0.9425(0.7060, 1.2582)	0.688
	Fula/Tukulur/Lorobo	1.4394 (1.1738, 1.7651)	0.000	1.3478(1.1136, 1.6314)	0.002
	Serere	1.2190 (0.7342, 2.0239)	0.444	0.9916(0.6068, 1.6203)	0.973
	Serahuleh	1.2805 (0.9349, 1.7538)	0.123	1.2502(0.9269, 1.6861)	0.143
	Creole/Aku Marabout	0.7793 (0.0425, 14.2875)	0.867	0.5361(0.0312, 9.1958)	0.667
	Manjago	2.9667 (1.3127, 6.7046)	0.009	2.8675(1.4398, 5.7107)	0.003
	Bambara	1.2138 (0.6294, 2.3404)	0.563	1.2660(0.6737, 2.3789)	0.464
	Other	0.6743(0.2520, 1.8044)	0.433	0.7044(0.2705, 1.8341)	0.473
	Non-Gambian	1.5224 (1.1971, 1.9360)	3.43	1.3779(1.1069, 1.7152)	0.004
Number of household member	five and less	Ref		Ref	
	Six and more	1.2424(0.9761, 1.5813)	0.078	1.0192(0.8269, 1.2561)	0.858
Number of children 5and under	Two and less	Ref		Ref	
	Three and more	0.9929(0.8490, 1.1612)	0.930	1.0148(0.8841, 1.1649)	0.476
Types of toilet facility	Unimproved	1.0805(0.9113, 1.2813)	0.373	1.0563(0.9085,1.2282)	0.476
	Improved	Ref		Ref	
Sex of household head	Male	Ref		Ref	
	Female	0.9264 (0.7504, 1.1436)	0.477	0.8899(0.7297, 1.0854)	0.250

Variable	Characteristics	AOR(95%CI)	P value	COR(95%CI)	P value
Wealth index	Poor	Ref		Ref	
	Medium	0.8305(0.6667, 1.0346)	0.098	0.8654(0.7134, 1.0497)	0.142
	Reach	0.9639(0.7603, 1.2221)	0.762	1.0470(0.8766, 1.2505)	0.612
Mothers education attainment	No education	Ref.		Ref	
	Primary	1.0345 (0.9921, 1.2321)	0.079	1.1861(0.9872, 1.4252)	0.068
	Secondary	1.0092 (0.8941, 1.0221)	0.642	1.0384(0.8836, 1.2203)	0.647
	Higher	0.7602 (0.7609, 1.0168)	0.331	0.7972(0.5473, 1.1610)	0.237
Husbands/partners education attainment	No education	Ref		Ref	
	Primary	1.1708(0.8870, 1.5453)	0.266	1.2017(0.9260, 1.5595)	0.167
	Secondary	0.9395(0.7812, 1.1298)	0.507	0.9444(0.8030, 1.1107)	0.490
	Higher	1.2931(0.9782, 1.7094)	0.071	1.1915(0.9352, 1.5180)	0.156
Current working	No	Ref		Ref	
	Yes	1.1359(0.9808,1.3156)	0.089	0.9752(0.8523,1.1158	0.715

Variable	Characteristics	AOR(95%CI)	P value	COR(95%CI)	P value
Birth order number	First	Ref		Ref	
	Two to three	0.9310(0.7608,1.1394)	0.488	0.9473(0.7823, 1.1472)	0.580
	Four to five	0.8079(0.6458,0.0107)	0.062	0.8738(0.7103, 1.0750)	0.202
	Six and more	0.7296(0.5711,0.9321)	0.012	0.7730(0.6226, 0.9597)	0.020
Child is twin	Single	0.6406(0.3983, 1.0303)	0.066	0.5731(0.3647, 0.9005	0.016
	Multiple	Ref		Ref	
Sex of child	Male	Ref		Ref	
	Female	0.9000(0.7828, 1.0348	0.139	0.8724(0.7634, 0.9970)	0.045
Duration of breastfeed	Never breastfeed	Ref		Ref	
	Ever breastfeed not currently	0.5996(0.2958, 1.2154)	0.156	0.5940(0.3036, 1.1621)	0.128
	Still breastfeeding	0.6808(0.3292, 1.4080)	0.300	1.1774(0.6015, 2.3044)	0.634
Size of child	Small	Ref			
	Average	0.8038(0.6555, 0.9855)	0.036	0.7907(0.6513, 0.9600)	0.018
	Large	0.8444(0.6876, 1.0370)	0.107	0.8282(0.6830, 1.0048)	0.056
Covered by health insurance	No	Ref		Ref	
	Yes	0.8796(0.5550, 1.3939)	0.585	0.9743(0.6317, 1.5028)	0.907
Age of child in year	Less than one	0.6160(0.4710, 0.8057)	0.000	0.7467(0.6292, 0.8861)	0.001
	1 and < 2	0.2726(0.2019, 0.3680)	0.000	0.4309(0.2764, 0.4205)	0.000
	2 and < 3	0.2202(0.1595, 0.3040)	0.000	0.2769(0.2177, 0.3521)	0.000
	3 to 5	Ref.		Ref.	
Media exposer	No	1.0679(0.9199,1.239)	0.387	1.0322(0.8963, 1.1887)	0.659
	Yes	Ref		Ref.	
Received MEASLES	No	1.5128(1.2384,1.8479)	0.000	1.146 (0.8074, 1.1086)	0.494
	Yes	Ref			
Rotavirus	No	3.1476(2.1486,4.6110)	0.000	2.4381(1.7093, 3.4778)	0.000
	Yes	Ref		Ref.	

Discussion

Diarrhea disease are a main cause of under-five children death and one of the key reasons of medical session for under-five children in low income countries Gambia [33, 37]. The aim of the current study was to analyze the trend and determinants of diarrhea prevalence among under-five children in Gambia for the last five years. In this paper, the trend of diarrhea incidence has been meaningfully rise from 17% in 2013 to 18.6% in 2019/20 (overall phase). This finding is not compatible with the pervious study done in Ethiopia, and Democratic Congo [33, 38]. The reason for the increment of diarrhea prevalence is that the change of population proportion in Gambia [29]. After we decompose this change, behavioral change of the respondents between the studies contributed 74.57% for the increment of diarrhea prevalence over the last five years, and the endowment portion contributes 25.43%.

The multilevel binary logistic regression reveled that source of drinking water, ethnicity, birth order number, size of child at birth, age of children, received measles, and rotavirus vaccine were significantly associated with the prevalence of diarrhea for under-five children in Gambia. This finding shown that there is the significant relationship between diarrhea prevalence of under-five children and unsafe drinking water source. The finding is in agreement with the study conducted in Cameroon [39].The possible reason is unclean drinking water is a potential risk of diarrhea-causing organisms transmission. In this study birth order number of children are statistically significant with the prevalence of diarrhea for under-five children in Gambia. lower birth order number of children have less chance of developing diarrhea as compared to higher birth order number children. This paper is in line with the study conducted in Ethiopia and Gahanna [33, 40]. Children who were small size at birth were more likely to develop diarrhea as compared to children who were normal (average) size at birth. This study is coincides with the pervious study conducted in Ethiopia [33]. The possible explanation is infectious metabolites, mostly short chain fatty acids, can lead to representing changes in the host enterocytes and motility disorders and lastly sources diarrhea [41]. The odds of developing diarrhea among children in the age group between 1 and 2 years were higher than those children whose age was three and above three years. Similarly, the odds of developing diarrhea among children in the age group between two to three and less than one year were more likely to be occur than those children whose age was between 4 and 5. This finding was supported by previous studies conducted from Ethiopia, Ghana, and Cameroon [34, 39, 40].

Moreover, taking rotavirus and measles vaccine were interrelated with diarrhea among under five children in Gambia. The study shown that children who were not vaccinated for rotavirus and measles were additional danger to develop diarrhea as compared to under five children who were take rotavirus and measles vaccine. This finding was in agreement with the previous study done in Ethiopia [33, 42]. Measles is a extremely infectious disease which disturbs the epithelial cells and defeats the immune system leading to poison in numerous organ systems and protein dropping enteropathy [43]. Similarly, Rotavirus is common cause of severe gastroenteritis and diarrhea among young children universally specially emerging countries like Gambia [44]. In the direction of this reason, rotavirus vaccine was hosted by WHO in 2006 [44].

Conclusion

The prevalence of diarrhea was significantly increased over the last five years. A major driver for increment in diarrhea prevalence over time was behavioral change of respondents who were from Kuntaur region and contributed 55,772% for the increment. Based on multilevel analysis source of drinking water, ethnicity, birth order number, size of child at birth, age of child, received rotavirus and measles vaccine were significantly associated with the prevalence of diarrhea for under-five children in Gambia. Therefore, Gambian government and other concerned body should focus on the establishment and scaling up of behavioral change package strategies of the community regarding to keeping hygiene and sanitation of the community and their environment, vaccinating their children, accessing health care services to prevent diarrheal disease. Similarly, the government should resolve structural related problems that precipitate diarrheal disease of under-five children. And also under-five should vaccinate their children based on the national guideline.

Abbreviations

AOR
Adjusted odds ratio
CI
confidence interval:Cofe.:coefficient
COR
crude odds ratio
DHS
Demographic health survey
EAs
Enumeration areas, GDHS:Gambian demographic and health survey, Ref.:Reference Category, OR:Odds ratio
WHO
world health organization.

Declarations

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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 http://dhsprogram.com, and can be accessed following the protocol outlined in the Methods section, and data can be found at https://www.dhsprogram.com/data/dataset_admin/login_main.cfm

Ethics approval and consent to participate

The current study was built on the analysis of openly accessible secondary data with all identifier information were removed. The Institutional Review Board (IRB) of ICF Macro at Fairfax, Virginia in the USA reviewed and approved the MEASURE DHS Project Phase three. The 2010–2018 DHS's are considered under that approval. The IRB of ICF Macro complied with the United States Department of Health and Human Services requirements for the "Protection of Human Subjects" (45 CFR 46). The IRB approved procedures for DHS public use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified. In addition, written informed consent was obtained from a parent or guardian for participants under 16 years old. DHS Program has remained consistent with confidentiality and informed consent over the years. We obtained express approval to use the data from ICF Macro. The data is secondary data and hence no further approval was required for this study. The data owners can be contacted at https://dhsprogram.com/Data/terms-of-use.cfm, and data can be found at https://www.dhsprogram.com/data/dataset_admin/login_main.cfm, Further documentations on ethical issues relating to the surveys are available at http://dhsprogram.com. All methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Figures

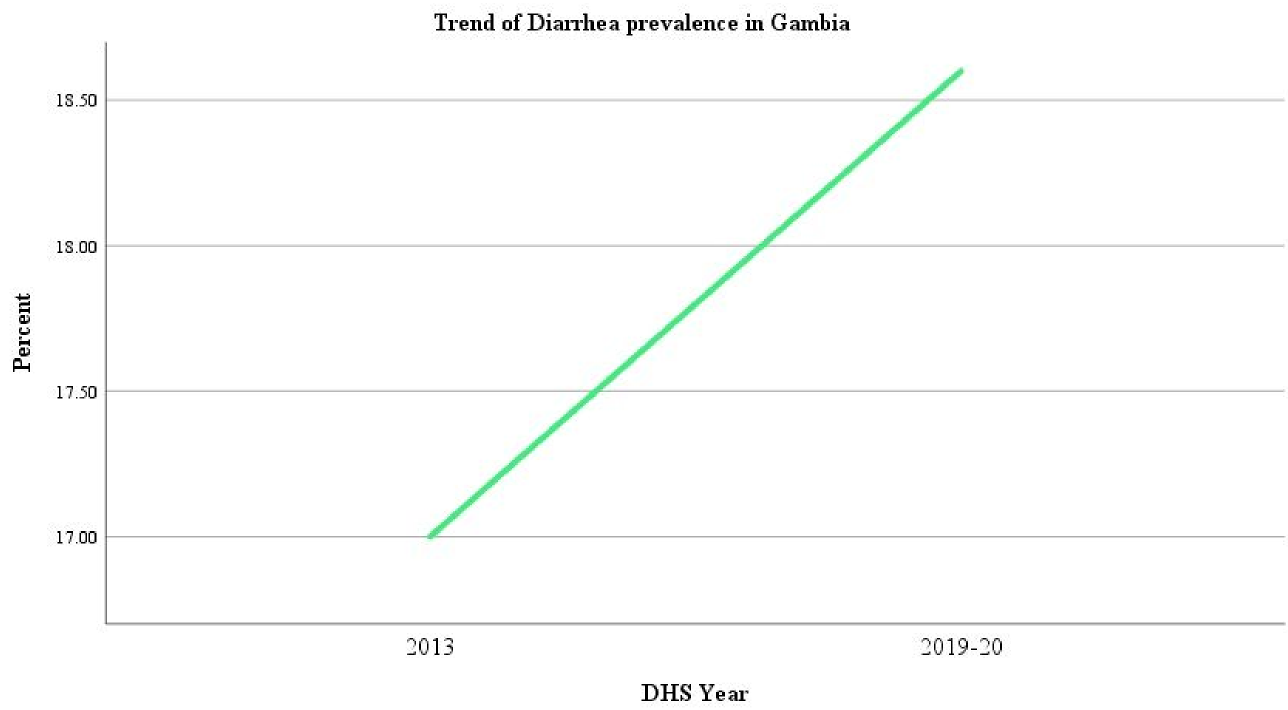

Figure 1

Trend of diarrhea prevalence in Gambia (2013 – 2019/20)