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A Multilevel Analysis of Factors Associated with Childhood Diarrhea in Ethiopia

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ABSTRACT

BACKGROUND: Childhood diarrhea is the major contributor to the deaths of children under the age of 5 years in Ethiopia, but evidence at the national level to identify the contributing factors associated with diarrhea by considering the clustering effects is limited. Hence, this study aimed to identify factors associated with childhood diarrhea at the individual and community levels.

METHODS: A secondary data analysis was conducted using the 2011 and 2016 Ethiopian Demographic and Health Survey (EDHS) data. A total of 23 321 children with their mothers were included in this study, and multilevel logistic regression models were applied for the data analysis.

RESULTS: The odds of diarrhea among female children were 13% lower (AOR = 0.87; 95% CI: 0.79-0.94) compared with male children. The odds of diarrhea among children aged between 13 and 24 months were 31% higher than (AOR = 1.31; 95% CI: 1.17-1.47) their younger counter parts. Children aged ⩾25 months (AOR = 0.50; 95% CI: 0.45-0.56), those whose mothers were unemployed (AOR = 0.79; 95% CI: 0.73-0.87), and children live in households between 2 and 3 under-5 children (AOR = 0.87; 95% CI: 0.79-0.96) were associated with lower odds of experiencing diarrhea. The odds of diarrhea among children whose mother had no formal education were 49% higher than (AOR = 1.49; 95% CI: 1.08-2.07) their counterparts. Besides, children residing in city administrations (AOR = 0.69; 95% CI: 0.58-0.82) had lower odds of experiencing diarrhea than children living in agrarian regions.

CONCLUSIONS: At the individual level (sex and age of the child, mother's employment status, and educational level, and the number of under-5 children) and the community-level (contextual region) were found to be significant factors associated with childhood diarrhea in Ethiopia.

KEYWORDS: Diarrhea, Ethiopia, EDHS, multilevel, pooled data, under-5 children

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Introduction

Diarrhea is defined as the passage of 3 or more loose or liquid stools per day.[1] Globally, diarrhea was the eighth leading cause of mortality (1·6 million deaths) among all ages and the fifth leading cause of death among children younger than 5 years in 2016. About 90% of diarrheal deaths occurred in south Asia and sub-Saharan Africa.[2] In the sub-Saharan Africa, under-5 diarrhea morbidity remains a significant public health problem.[3] Childhood wasting, unsafe water, and unsafe sanitation were the leading risk factors for diarrhea, responsible for 80.4%, 72.1%, and 56.4% of diarrhea deaths in children younger than 5 years, respectively.[4]

In Ethiopia, diarrhea is the major contributor to the deaths of children under the age of 5 years. Key determinants of diarrhea among under 5 children in Ethiopia included lack of latrine,[5,6] maternal hand-washing practice after visiting a toilet,[5,7,8] child and maternal factors,[5,9-13] and socioeconomic factors.[13] According to the Ethiopian Demographic and Health Survey (EDHS) reports, the prevalence of diarrhea in 2000, 2005, 2011, and 2016 in under-5 Ethiopian children was 26%, 18%, 14%, and 12%, respectively.[14-17] These figures indicate that, though the prevalence of diarrhea has declined over the last 16 years, it was not significant enough and remains the country's top public health concern. A recent systematic review from 31 primary studies also revealed that the pooled prevalence of diarrhea among under-5 children in Ethiopia was 22%,[5] much higher than the recent 2016 EDHS report, 12%.[17]

Despite the available several epidemiological studies in different localities in Ethiopia, most studies did not account for the hierarchical nature and interrelationships among the multilevel determinants of childhood diarrhea[6-13] and in many cases, they are limited in scope and not representative at the national level.[6-13,18,19] Also, previous studies so far focus only on individual fixed effect factors that could ignore community-level

Table 1. Individual and community-level variables description and format for analysis.

VARIABLE DESCRIPTION	FORMAT FOR ANALYSIS
Individual-level variables	
Child's age	The categorical variable, the reference category, as a child's age between 0 and 12 mo
Child's sex	Binary, reference category was male sex
Number of under-5 children	Categorical variable, reference category was number of under 5 children 0 to 1
Age of the mother	Categorical variable, reference category was caregivers' age years ⩽24
Education of the mother	Categorical variable, reference category was higher education
Mother's employment status	Binary, reference category was employed
Mass media exposure of the mother	Binary, reference category was regularly exposed (yes)
Household wealth status	Categorical variable, reference category was rich
Type of toilet facility	Binary, reference category was improved sanitation
Type of drinking water source	Binary, reference category was improved water
Community-level variables	
Place of residence	Binary, reference category was urban
Region	Categorical variable, reference category was agrarian

variables, which may nullify or weaken the relation of the distal community-level factors.[6,7,11,12,19] Further, few studies have examined determinants of diarrhea among under-5 children at national level in Ethiopia. For example, 2 studies by Messelu et al[20] and Nigatu et al[21] were survey-specific, while the others focused on geographical disparities of childhood diarrhea.[22,23]

Evidence at the national level to identify the contributing factors associated with diarrhea by considering the clustering effects is still limited. Limitation of the previously conducted studies are that none of them used a nationally representative pooled dataset to assess the determinants of childhood diarrhea. Given the recent high diarrheal morbidity in Ethiopia and the time-varying nature of the determinants, there is a need to examine variables using country representative pooled dataset. The pooled datasets embrace blends characteristics of both cross-sectional and time-series data, which is vital to the analyst because it contains the information necessary to deal with both the inter-temporal dynamics and the individuality of the entities being investigated. Therefore, in this study, we aimed to investigate the various individual and community level factors influencing childhood diarrhea in Ethiopia using the latest nationally representative 2 Ethiopian Health and demographic surveys (DHS) datasets.

Methods

Study design, data source, and sampling procedures

A secondary data analysis of the recent 2011 and 2016 Ethiopia Demographic and Health Survey (EDHS) data was conducted. The Ethiopian DHS survey is a country-representative household surveys that provide estimates at the national and regional levels. A 2-stage stratified cluster sampling was used in the EDHS. A representative sample of 17 817 households from 624 clusters in EDHS-2011, and 16 650 households from 645 clusters in EDHS-2016 were selected in the first stage from the Ethiopian Population and Housing Census sampling frame conducted in 2007 through probability proportional to the unit size. Systematic random sampling was applied in the second stage to select households from each selected cluster. Details of the survey are described elsewhere.[16,17] We included all children under-5 years of age with their mother, whose measurements (outcome variable) were taken in the final analyses. An approval letter for the use of EDHS data was obtained from the Measure DHS and the dataset (EDHS-2011 and EDHS-2016) was downloaded from the Measure DHS website. The EDHS data is available and accessible on the DHS program website: http://dhsprogram.com/data/dataset/Ethiopia.

Study variables

Dependent variable. The outcome variable was acute diarrhea.

Independent variables. We grouped the independent variables into individual and community level variables (Table 1).

Individual-level variables. In this study, individual-level variables include: child's age (0-12 months, 13-24 months, ⩾25 months), sex of child (male, female), number of under-5 children (0-1, 2-3, and >3), age of the mother (⩽24, 25-34, ⩾35), educational attainment of the mother (no education, primary, secondary, higher), mother's employment status (not employed, employed), wealth index (poor, middle, rich), media exposure/watching

television (yes, no), drinking water source (improved, unimproved), and toilet facility (improved, unimproved).

Community-level variables. In this study, we considered the following community-level variables: the place of residence and region. Place of residence was categorized into 2 urban and rural. Contextual regions were classified into agrarian, pastoralist, and city. The regions of Tigray, Amhara, Oromiya, Southern Nation Nationality People Region (SNNP), Gambella, and Benshangul Gumuz were recorded as agrarian. The Somali and Afar regions were combined to form the pastoralist region, and the city administrations: Addis Ababa, Dire Dawa city administrations, and Harar were combined as the city.

Data analysis

Data were analyzed using the STATA statistical software system package version 14.0 (StataCorp., College Station, TX, USA). A sampling weight was used for computing all descriptive statistics to adjust for the non-proportional allocation of the sample to different regions and their urban and rural areas, as suggested by the DHS sample weight procedure. A detailed explanation of the weighting procedure can be found in the methodology of the EDHS final reports.[16,17] Descriptive statistics were reported with frequency and proportion. The 2 EDHS (2011 and 2016) datasets were merged using the STATA merge command, after ensuring the consistency of each variable across each dataset the pooled prevalence of diarrhea was computed. The EDHS asked respondents to answer the question "did your children have diarrhea within those 2 weeks?" So, the response is a dichotomous with possible values "Yes = 1" if the child had diarrhea and "No = 0" if the child had no diarrhea. Accordingly, the prevalence from pooled data was computed by dividing the number of children having diarrhea 2 weeks prior to the survey by the total number of children, and multiplied by 100.

Since EDHS data are hierarchical nature, that is, children are nested within households, and households are nested within clusters, use of standard models could underestimate standard errors of the effect sizes, which consequently affect decision on null hypothesis. With such data, children within a cluster may be more similar to each other than children in the rest of the cluster. This violates assumption of standard model; independence of observation and equal variance across the cluster. This implies a need to consider the between cluster variability. All these issues motivated to use the multilevel modeling, which was able to compute mixed effect that fixed effect for both individual and community factors and a random effect for between cluster variation simultaneously. Four models were fitted to estimate both fixed effects of the individual and community-level factors and random effect of between-cluster variation. Accordingly, the measures of community variation (random-effects) were estimated as the intraclass correlation coefficient (ICC) and the value was significant. Therefore, a multilevel logistic regression model is used instead of ordinary logistic regression. The data correlated, having intra-class correlation (ICC) = 10.71 (8.92, 12.81) and 10.91 (9.08, 13.06) for the null and final model, respectively, which shows the data were significantly clustered. According to Theall et al,[24] an ICC equal to or greater than 2% indicates significant group-level variance, which is a minimum precondition for a multilevel study design.

Variable having *P*-value up to .25 in the bivariate analysis was selected to fit the model in the multivariable analysis.[25] The fixed effects of individual determinant factors and community distinction on the prevalence of diarrhea were measured using an adjusted odds ratio (AOR) with 95% confidence intervals (CI). Within the multilevel multivariable logistical regression analysis, 4 models were fitted for the result variable. The primary model (null model) was fitted without explanatory variables. The second model (fitted for individual-level variables), third model (fitted for community-level variables) and fourth model (is the final model adjusted for individual- and community-level variables) were adjusted accordingly. The fourth model was used to check for the independent effect of the individual and community-level variables on childhood diarrheal morbidity. For the measures of association (fixed effect), an adjusted odds ratio with 95% confidence intervals was used. A $P < .05$ was considered to declare statistical significance.

Akaike's Information Criterion (AIC) and Schwarz's Bayesian information criteria (BIC) were used to assess goodness of fit. After the values for each AIC and BIC model were compared, the lowest one thought-about to be a better explanatory model.[26,27] For measures of variation (random effects), Intra-class correlation coefficient (ICC),[28,29] and median odds ratio (MOR) statistics were computed.[29] ICC explains the cluster variability, while MOR can quantify unexplained cluster variability (heterogeneity). Multicollinearity between the individual and community-level variables was checked using the Variance Inflation Factor (VIF) <10.[30]

Results

Socio-demographic and other health-related characteristics

Overall, 23 321 children with their mothers were included in the analysis. The mean (standard deviation) age of children who participated in the study was 28.63 months (±17.53). The majority of the study participants (87.6%) were from rural areas. Most of the children's mothers (67.1%) had no formal education. Only 11.4% of the households have improved toilet facilities, while 37.7 % used improved water as a source of drinking water. The overall prevalence of diarrhea in Ethiopia was 12.9% (95% CI: 12.5-13.4) (Table 2).

The proportion of children with diarrhea based on individual- and contextual-level background characteristics of the study participants are presented in Table 3. Among children who experienced diarrhea, 30.9%, 27.2%, and 41.9% were found in the age category of 0 to 12, 13 to 24, and ⩾25 months, respectively. Majority of children who experienced diarrhea,

Table 2. Background characteristics of the selected households (n = 23 321).

CHARACTERISTICS	WEIGHTED FREQUENCY	WEIGHTED PERCENT
Individual-level characteristics		
Socio-demographic variables		
Child's gender		
Male	12 047	51.7
Female	11 274	48.3
Child's age (mo)		
0-12	5584	24.0
13-24	4271	18.3
⩾25	13 466	57.7
Mother's age (y)		
⩽24	5441	23.3
25-34	12 266	52.6
⩾35	5615	24.1
Mother's occupation (n = 23 220)		
Not employed	11 873	51.1
Employed	11 347	48.9
Mother's education		
No education	15 651	67.1
Primary	6354	27.3
Secondary	849	3.6
Higher	467	2.0
Number of under-5 children		
0-1	8555	36.7
2-3	14 290	61.3
>3	476	2.0
Wealth index		
Poor	10 658	45.7
Middle	4754	20.4
Rich	7908	33.9
Watching TV (n = 23 306)		
Yes	6111	26.2
No	17 195	73.8
WASH variables		
Drinking water source (n = 22 828)		
Unimproved	14 220	62.3
Improved	8607	37.7
Toilet facility (n = 22 834)		
Unimproved	20 223	88.6
Improved	2611	11.4
Diarrhea		
Yes	3027	12.9
No	20 294	87.1
Survey–year (EDHS)		
2011	12 012	51.5
2016	11 309	48.5
Community level characteristics		
Region		
Agrarians	21 541	92.4
Pastoralist	1122	4.8
City dwellers	658	2.8
Residence		
Urban	2885	12.4
Rural	20 436	87.6

90.0% and 65.8% were from households without improved toilet and drinking water sources, respectively. Table 3 also present unadjusted or Crude odds ratio (Crude OR) results that were obtained when we are considering the effect of only one independent variable in the analysis.

Determinants of childhood diarrhea among under-5 children

Table 4 presents the results of the multilevel multivariable logistic regression analysis.

Individual-level variables. The odds of diarrhea among female children were lower (AOR = 0.87; 95% CI: 0.79-0.94) compared with male children. The odds of diarrhea among children aged between 13 and 24 months were 31% higher than (AOR = 1.31; 95% CI: 1.17-1.47) their younger counter parts. Children ⩾25 months were 50% less likely (AOR = 0.50; 95% CI: 0.45-0.56) to develop diarrhea than their younger counter parts. Likewise, the odds of diarrhea were 21% lower (AOR = 0.79; 95% CI: 0.73-0.87) among children whose mothers were unemployed compared with children who had employed mother. The odds of diarrhea were 49% (AOR = 1.49; 95% CI: 1.08-2.07) and 55% higher (AOR = 1.55; 95% CI: 1.12-2.14) among children whose mother had no formal education and primary education,

Table 3. Multilevel bivariate logistic regression analysis of the prevalence of diarrhea among children by different background characteristics and associated factors.

CHARACTERISTICS	PREVALENCE OF DIARRHEA		CRUDE OR (95% CI)	*P*-VALUE
	YES, N (%)	NO, N (%)		
Socio-demographic variables				
Child's gender				
Male	1659 (54.8)	10388 (51.2)	1	
Female	1367 (45.2)	9906 (48.8)	0.89 (0.82-0.96)*	0.003
Child's age (mo)				
0-12	936 (30.9)	4648 (22.9)	1	
13-24	824 (27.2)	3447 (16.9)	1.34 (1.20-1.49)*	<0.001
⩾25	1267 (41.9)	12199 (60.2)	0.52 (0.47-0.57)*	<0.001
Mother's age (y)				
⩽24	738 (24.4)	4703 (23.2)	1	
25-34	1614 (53.3)	10651 (52.5)	0.97 (0.88-1.07)	0.629
⩾35	675 (22.3)	4940 (24.3)	0.85 (0.75-0.95)**	0.006
Mother's occupation				
Not employed	1447 (48.2)	10425 (51.6)	0.82 (0.76-0.89)**	<0.001
Employed	1554 (51.8)	9791 (48.4)	1	
Mother's education				
No education	2044 (67.5)	13606 (67.0)	1.50 (1.11-2.03)*	0.008
Primary	816 (26.9)	5537 (27.3)	1.69 (1.24-2.29)*	0.001
Secondary	129 (4.3)	720 (3.5)	1.42 (1.01-2.01)*	0.046
Higher	37 (1.2)	429 (2.1)	1	
Number of under-5 children				
0-1	1214 (40.1)	7340 (36.2)	1	
2-3	1768 (58.4)	12521 (61.7)	0.90 (0.83-0.98)*	0.022
>3	44 (1.5)	432 (2.1)	0.84 (0.64-1.10)	0.214
Wealth Index				
Poor	1314 (43.4)	9344 (46.0)	0.97 (0.87-1.07)	0.541
Middle	653 (21.6)	4101 (20.2)	1.17 (1.03-1.32)*	0.016
Rich	1059 (35.0)	6848 (33.8)	1	
Watching TV				
Yes	725 (24.0)	5385 (26.6)	1	
No	2298 (76.0)	14897 (73.4)	1.10 (0.99-1.21)	0.052
WASH variables				
Drinking water source				
Unimproved	1952 (65.8)	12268 (61.8)	1.09 (0.99-1.20)	0.057
Improved	1013 (34.2)	7593 (38.2)	1	

(Continued)

Table 3. (Continued)

CHARACTERISTICS	PREVALENCE OF DIARRHEA		CRUDE OR (95% CI)	*P*-VALUE
	YES, N (%)	NO, N (%)		
Toilet facility				
Unimproved	2669 (90.0)	17 553 (88.4)	1.22 (1.08-1.37)*	0.001
Improved	297 (10.0)	2313 (11.6)	1	
Community-level characteristics				
Region				
Agrarians	2836 (93.7)	18 705 (92.2)	1	
Pastoralist	133 (4.4)	988 (4.9)	0.75 (0.66-0.85)*	<0.001
City dwellers	56 (1.9)	601 (2.9)	0.63 (0.55-0.73)*	<0.001
Residence				
Urban	337 (11.1)	2548 (12.6)	1	
Rural	2689 (88.9)	17 746 (87.4)	1.18 (1.04-1.34)*	0.011

**P*-value < .05
***P*-value < .001

Table 4. Factors associated with childhood diarrhea identified by multilevel multivariable logistic regression models.

CHARACTERISTICS	MODEL 1 (NULL MODEL)	MODEL 2 AOR (95% CI)	MODEL 3 AOR (95% CI)	MODEL 4 AOR (95% CI)
Individual-level characteristics				
Socio-demographic variables				
Child's gender				
Male		1		1
Female		0.87 (0.79-0.94)**		0.87 (0.79-0.94)**
Child's age (mo)				
0-12		1		1
13-24		1.31 (1.17-1.47)**		1.31 (1.17-1.47)**
⩾25		0.50 (0.45-0.55)**		0.50 (0.45-0.56)**
Mother's age (y)				
⩽24		1		1
25-34		1.08 (0.98-1.20)		1.08 (0.97-1.19)
⩾35		0.96 (0.85-1.09)		0.95 (0.84-1.08)
Mother's occupation				
Not employed		0.77 (0.71-0.84)**		0.79 (0.73-0.87)**
Employed		1		1
Mother's education				
No education		1.51 (1.09-2.08)**		1.49 (1.08-2.07)**
Primary		1.59 (1.15-2.19)**		1.55 (1.12-2.14)**
Secondary		1.32 (0.92-1.89)		1.29 (0.89-1.85)
Higher		1		1

(Continued)

Table 4. (Continued)

CHARACTERISTICS	MODEL 1 (NULL MODEL)	MODEL 2 AOR (95% CI)	MODEL 3 AOR (95% CI)	MODEL 4 AOR (95% CI)
Number of under-5 children				
0-1		1		1
2-3		0.87 (0.79-0.95)**		0.87 (0.79-0.96)**
>3		0.84 (0.64-1.12)		0.86 (0.65-1.13)
Wealth index				
Poor		0.89 (0.78-1.01)		0.88 (0.78-1.01)
Middle		1.05 (0.92-1.21)		1.03 (0.89-1.19)
Rich		1		1
Watching TV (n = 34 314)				
Yes		1		1
No		1.15 (1.02-1.29)**		1.12 (0.99-1.26)
WASH variables				
Drinking water source (n = 33 725)				
Unimproved		1.07 (0.96-1.19)		1.03 (0.93-1.15)
Improved		1		1
Toilet facility (n = 33 735)				
Unimproved		1.20 (1.05-1.38)**		1.13 (0.98-1.31)
Improved		1		1
Community-level characteristics				
Region				
Agrarian			1	1
Pastoralist			0.75 (0.66-0.86)**	0.88 (0.76-1.01)
City dwellers			0.64 (0.54-0.75)**	0.69 (0.58-0.82)**
Residence				
Urban			1	1
Rural			1.01 (0.87-1.15)**	0.95 (0.79-1.14)
Measures of variation				
Variance (SE)	0.394 (0.032)	0.408 (0.031)	0.378 (0.032)	0.402 (0.033)
P-value	<.001	<.001	<.001	<.001
ICC	10.71 (8.92-12.81)	11.07 (9.22-13.23)	10.31 (8.57-12.36)	10.91 (9.08-13.06)
MOR	1.82	1.46	1.26	1.16
Model fit statistics				
AIC	17 238.48	16 305.86	17 196.80	16 292.55
BIC	17 254.54	16 449.99	17 236.96	16 460.70
DIC (-2Log-likelihood)	17 234.46	16 269.86	17 186.80	16 250.54

Abbreviations: SE, standard error; ICC, intra-class correlation coefficient; MOR, median odds ratio; AIC, Akaike's information criterion; BIC, Bayesian information criteria; DIC, deviance information criterion.
Model 1 (Empty model) was fitted without determinant variables.
Model 2 is adjusted for individual-level variables.
Model 3 is adjusted for community-level variables.
Model 4 is the final model adjusted for an individual- and community-level variables.
***P*-value < .05 (Adjusted OR).

respectively compared with children whose mother had higher education. Children live in households between 2 and 3 under-5 children were 13% lower (AOR = 0.87; 95% CI: 0.79-0.96) odds of experiencing diarrhea than families with single or no under-5 children (Table 4).

Community-level variables. Children residing in city administrations (AOR = 0.69; 95% CI: 0.58-0.82) had 13% lower odds of experiencing diarrhea as compared with children residing in agrarian regions (Table 4).

Discussion

This study was conducted to assess the determinants of diarrhea among under-5 children in Ethiopia. We found that childhood diarrhea in Ethiopia was clustered and affected by different individual and community level variables. At the individual level, variables such as age of the child, sex of the child, maternal occupational status, maternal education, and number of under-5 children were significantly associated with childhood diarrhea. Similarly, at community-level region was found to be a significant factor. The intra-class correlation (ICC) results found in this study were to be above 10% of the total variance of childhood diarrhea in all models, indicating a multilevel study design.[24] The study also indicated that the median odds ratio (MOR) outcomes, a measure of unexplained cluster heterogeneity, were 1.82, 1.46, 1.26, and 1.16 in null model, model 2, model 3, and model 4, respectively. The unexplained community variation in childhood diarrhea decreased to an MOR of 1.16 when all variables were added to the empty model.

In the present study, childhood diarrhea was significantly associated with the child's age; the odds of diarrhea among children aged between 13 and 24 months were higher compared with younger counterparts. Similar studies were reported in Ethiopia,[31,32] Tanzania,[33] and Sudan.[34] This finding was also supported by systematic reviews.[35-37] These observations could easily explain as children in this age group start complementary foods and a large portion of children at this age start crawling, which may expose them to contaminated environments. Also, as suggested by the World Health Organization (WHO), exclusive and continuous breastfeeding has protective impacts for up to 1 year.[38] Our study found that children ⩾25 months were 50% less likely to develop diarrhea than their younger counter parts. Our study found that children ⩾25 months were 50% less likely to develop diarrhea than their younger counter parts. This might be due to oldest age group acquired natural immunity than youngest age group. In addition, diarrhea in the youngest age group may be escalated by several mechanisms such as introduction of complementary food which may be unsafe and poor in hygiene to children whose immunity was not well developed at the age of 6 months.

The odds of diarrhea among female children were lower compared with male children. This finding supported a cross-sectional study conducted in Ethiopia that showed boys have 2.52 times higher odds of having acute diarrhea as compared with girls.[39] A recent study from Palestine[40] and Bangladesh[41] also reported similar findings. "Despite several studies demonstrating an increased incidence of diarrheal illness in boys compared with girls in many developing countries, the reason for this difference remains unclear."[41] Researchers hypothesized that the variance may be due to gender-based factors, such as sex-based biological factors, environmental, and cultural factors. Environmental related hypothesis assumes that different exposures by gender, for example, older boys may be allowed more freedom to roam from home, or go to work with fathers, unequally exposing them to infectious pathogens.[39,40] The biological hypothesis assumes that there may exist pathophysiologic sex differences between girls and boys with regard to acute diarrhea that make boys more susceptible.[34,41]

Our study found that children from mothers who are not employed are protected from acquiring diarrhea than children from employed mothers. This finding was consistence a study conducted in Ethiopia.[20] This might explain by children from mothers who are not employed are more likely to breastfeed and receipt care from their mother than children who had a working mother, which possibly exposed children to diarrhea morbidity. Additionally, the association could also be attributed to the fact that mothers who are not employed may spent longer time with their children, which may reduce exposure of children to fecal-oral transmission route. In support of this assertion, a study by Taddele et al[38] on exclusive breastfeeding and maternal employment in Ethiopia demonstrated that employed mothers were less likely to exclusively breastfeed their infant(s) than unemployed mothers.

It is evident that the educational status of the mother is more likely to influence childhood diarrhea. In this study, the odds of diarrhea were higher among children whose mothers had no formal education and lower educational status than children whose mothers had higher education. The study findings are consistent with earlier studies, which found higher odds of childhood diarrhea among children whose mothers were of lower educational status in Ethiopia,[5,7,11,42,43] Ghana,[44] and Uganda.[45] These observations may be due to well-educated mothers who are more likely to have better experience, education, attitude, and the necessary health information required for the appropriate diarrheal prevention.

It was observed that children living in households having 2 and 3 under-5 children have lower odds of experiencing diarrhea than households with single or no under-5 children. This may satisfactorily be explained by in households having 2 or more under-5 children attention toward hygiene practice may probably increase as older children coach and instructor younger children. As a result, a child living in households with more under-5 children becomes less vulnerable to diarrhea. On the other hand, children in households having on 1 under-5 children lack experience and necessary support from their older sibling toward toilet training and other sanitary practice, which possibly correlate with childhood diarrhea. However, this

finding contradicts to studies conducted in Ethiopia.[9,11,43] For instance, a case-control study by Asfaha et al[11] reported that children living in households who had 3 and above under-5 children were 4-folds more likely to experience diarrheal disease compared to children living in households with 2 or less under-5 children.

At the community-level, the multilevel binary logistic regression analysis revealed that the place of residence was associated with childhood diarrhea. In this study, children residing in city administrations had lower odds of experiencing diarrhea as compared with children residing in agrarian regions (mostly rural residents). As indicated by related literature, children residing in rural administrative regions (such as Somali, Benshangul-Gumuz, SNNP, and Gambela were at higher odds of developing diarrhea.[20] These higher rates of diarrhea might be because the households in these regions were less favorable in terms of improved water, sanitation and hygiene (WASH) coverage and access to healthcare services.[17]

Limitations

Though the study explored deeper into many aspects contributing to diarrhea, it has some inherent limitations. Firstly, because the information on childhood diarrhea was self-reported, there is the possibility of recall bias. Although the recall period of illnesses, in this case, was limited to only 2 weeks preceding the survey. Secondly, the analyses were conducted using EDHS data collected in a cross-sectional survey, which prevents causal inferences. Third, the seasonal effect on diarrhea morbidity was not captured in this study because of the cross-sectional study design nature of EDHS data we used. Fourth, the data was pooled from different time frame, assuming that there was little change in the demographic characteristics in 5 years. Fifth, due to the secondary nature of the data, the present study was limited by unmeasured confounders. Despite these limitations, we fitted a multilevel model to account for the clustered nature of EDHS data and enhances the accuracy of estimates. Also, the use of nationally representative EDHS data that can enhance the generalizability of the findings.

Conclusion

Our findings highlight that childhood diarrhea was influenced by not only individual-level variables but also community-level variables. At the individual level (sex of the child, age of the child, maternal occupational status, maternal education, and the number of under-5 children) and the community-level (contextual region) were significant factors associated with childhood diarrhea in Ethiopia. The findings show that there is a need to consider some of the modifiable factors in the existing interventions in order to improve child health outcomes in the country.

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Author Contributions

BS: Conceptualizes, design the study and data curation, performed the analysis, wrote and approved the final manuscript. ZT, YT, DZ, KS, and DA: Contribute to the analysis, critically reviewed the manuscript and approved the final manuscript. VKC: Critically revised the manuscript and approved the final manuscript. All authors read and approved the final manuscript before submission.

Ethics Approval and Consent to Participate

Ethical clearance for this survey was obtained from the Ethiopia Health and Nutrition Research Institute Review Board, the National Research Ethics Review Committee at the Ministry of Science and Technology, and the Institutional Review Board of ICF International and the Centers for Disease Control and Prevention. Informed verbal consent was obtained from all mothers/caretakers of the selected children on behalf of their children. The data were obtained via online registration to measure the DHS program and downloaded after the purpose of the analysis was communicated and approved. The detail of the ethical issues has been published in the EDHS final report, which can be accessed at: http://www.dhsprogram.com/publications.

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Availability of Supporting Data

The dataset was retrieved from DHS website https://dhsprogram.com after formal online registration and submission of the project title and detail project description.

REFERENCES

1. World Health Organization. Diarrhoeal disease fact sheet. N° 330 May 2017. 2017. https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease
2. Moraga P; GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390:1151-1210.
3. Reiner RC Jr, Wiens KE, Deshpande A, et al. Mapping geographical inequalities in childhood diarrhoeal morbidity and mortality in low-income and middle-income countries, 2000–17: analysis for the Global Burden of Disease Study 2017. *Lancet*. 2020;395:1779-1801.
4. Troeger C, Blacker BF, Khalil IA, et al. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infect Dis*. 2018;18:1211-1228.
5. Alebel A, Tesema C, Temesgen B, Gebrie A, Petrucka P, Kibret GD. Prevalence and determinants of diarrhea among under-five children in Ethiopia: a systematic review and meta-analysis. *PLoS One*. 2018;13:e0199684.
6. Hashi A, Kumie A, Gasana J. Prevalence of diarrhoea and associated factors among under-five children in Jigjiga District, Somali Region, Eastern Ethiopia. *Open J Prev Med*. 2016;6:233–246.

7. Solomon ET, Gari SR, Kloos H, Mengistie B. Diarrheal morbidity and predisposing factors among children under 5 years of age in rural East Ethiopia. *Trop Med Health*. 2020;48:66.
8. Bitew BD, Woldu W, Gizaw Z. Childhood diarrheal morbidity and sanitation predictors in a nomadic community. *Ital J Pediatr*. 2017;43:91.
9. Mengistie B, Berhane Y, Worku Y. Prevalence of diarrhea and associated risk factors among children under-five years of age in Eastern Ethiopia: a cross-sectional study. *Open J Prev Med*. 2013;3:446-453.
10. Desalegn M, Kumie A, Tefera W. Predictors of under-five childhood diarrhea: Mecha District, West Gojjam, Ethiopia. *Ethiop J Health Dev*. 2011;25:192-200.
11. Asfaha KF, Tesfamichael FA, Fisseha GK, et al. Determinants of childhood diarrhea in Medebay Zana District, Northwest Tigray, Ethiopia: a community based unmatched case–control study. *BMC Pediatr*. 2018;18:120.
12. Getachew A, Tadie A, Hiwot MG, et al. Environmental factors of diarrhea prevalence among under five children in rural area of North Gondar zone, Ethiopia. *Ital J Pediatr*. 2018;44:95.
13. Woldu W, Bitew BD, Gizaw Z. Socioeconomic factors associated with diarrheal diseases among under-five children of the nomadic population in Northeast Ethiopia. *Trop Med Health*. 2016;44:40.
14. Central Statistical Authority [Ethiopia] and ORC Macro. *Ethiopia Demographic and Health Survey 2000*. Central Statistical Authority and ORC Macro; 2001.
15. Central Statistical Agency [Ethiopia] and ORC Macro. *Ethiopia Demographic and Health Survey 2005*. Central Statistical Agency/Ethiopia and ORC Macro; 2006.
16. Central Statistical Agency [Ethiopia] and ICF International. *Ethiopia Demographic and Health Survey 2011*. Central Statistical Agency and ICF International; 2012.
17. Central Statistical Agency (CSA) [Ethiopia] and ICF. *Ethiopia Demographic and Health Survey 2016*. CSA and ICF; 2016.
18. Yalew E. A qualitative study of community perceptions about childhood diarrhea and its management in Assosa District, West Ethiopia. *BMC Public Health*. 2014;14:975.
19. Gebrehiwot T, Geberemariyam BS, Gebretsadik T, Gebresilassie A. Prevalence of diarrheal diseases among schools with and without water, sanitation and hygiene programs in rural communities of north-eastern Ethiopia: a comparative cross-sectional study. *Rural Remote Health*. 2020;20:4907.
20. Messelu Y, Trueha K. Application of multilevel binary logistic regressions analysis in determining risk factors of diarrheal morbidity among under five children in Ethiopia. *Public Health Res*. 2016;6:110-118.
21. Nigatu D, Azage M, Motbainor A. Effect of exclusive breastfeeding cessation time on childhood morbidity and adverse nutritional outcomes in Ethiopia: analysis of the demographic and health surveys. *PLoS One*. 2019;14:e0223379.
22. Atnafu A, Sisay MM, Demissie GD, Tessema ZT. Geographical disparities and determinants of childhood diarrheal illness in Ethiopia: further analysis of 2016 Ethiopian demographic and health survey. *Trop Med Health*. 2020;48:64.
23. Bogale GG, Gelaye KA, Degefie DT, Gelaw YA. Spatial patterns of childhood diarrhea in Ethiopia: data from Ethiopian demographic and health surveys (2000, 2005, and 2011). *BMC Infect Dis*. 2017;17:426.
24. Theall K, Scribner R, Broyles S, et al. Impact of small group size on neighbourhood influences in multilevel models. *J Epidemiol Community Health*. 2011;65:688-695.
25. Vittinghoff E, David VG, Stephen CS, et al. Regression methods in biostatistics: linear, logistic, survival, and repeated measures models. Springer Science & Business Media; 2012: 139-202.
26. Goldstein H. *Multilevel Statistical Models*. 4th ed. John Wiley & Sons; 2011.
27. Vrieze SI. Model selection and psychological theory: a discussion of the differences between the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). *Psychol Methods*. 2012;17:228.
28. Raykov T, Marcoulides GA. Intraclass correlation coefficients in hierarchical design studies with discrete response variables: a note on a direct interval estimation procedure. *Educ Psychol Meas*. 2015;75:1063-1070.
29. Merlo J, Yang M, Chaix B, et al. A brief conceptual tutorial on multilevel analysis in social epidemiology: investigating contextual phenomena in different groups of people. *J Epidemiol Community Health*. 2005;59:729-736.
30. Midi H, Sarkar S, Rana S. Collinearity diagnostics of binary logistic regression model. *J Interdiscip Math*. 2010;13:253-267.
31. Mohammed AI, Zungu L. Environmental health factors associated with diarrhoeal diseases among under-five children in the Sebeta town of Ethiopia. *S Afr J Infect Dis*. 2016;31:122-129.
32. Gedamu G, Kumie A, Haftu D. Magnitude and associated factors of diarrhea among under five children in Farta wereda, North West Ethiopia. *Qual Prim Care*. 2017;25:199-207.
33. Edwin P, Azage M. Geographical variations and factors associated with childhood diarrhea in Tanzania: a national population based survey 2015-16. *Ethiop J Health*. 2019;29:513-524.
34. Siziya S, Muula AS, Rudatsikira E. Correlates of diarrhoea among children below the age of 5 years in Sudan. *Afr Health Sci*. 2013;13:376-383.
35. Bado AR, Susuman AS, Nebie EI. Trends and risk factors for childhood diarrhea in sub-Saharan countries (1990–2013): assessing the neighborhood inequalities. *Glob Health Action*. 2016;9:30166.
36. Fischer Walker CL, Perin J, Aryee MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC Public Health*. 2012;12:220.
37. Marriott BP, White A, Hadden L, Davies JC, Wallingford JC. World Health Organization (WHO) infant and young child feeding indicators: associations with growth measures in 14 low income countries. *Matern Child Nutr*. 2012;8:354-370.
38. Taddele M, Abebe L, Fentahun N. Exclusive breastfeeding and maternal employment in Ethiopia: A comparative cross-sectional study. *Int J Nutr Food Sci*. 2014;3:497-503.
39. Anteneh ZA, Andargie K, Tarekegn M. Prevalence and determinants of acute diarrhea among children younger than five years old in Jabithennan District, Northwest Ethiopia, 2014. *BMC Public Health*. 2017;17:99.
40. Abuzerr S, Nasseri S, Yunesian M, et al. Prevalence of diarrheal illness and healthcare-seeking behavior by age-group and sex among the population of Gaza strip: a community-based cross-sectional study. *BMC Public Health*. 2019;19:704.
41. Jarman AF, Long SE, Robertson SE, et al. Sex and gender differences in acute pediatric diarrhea: a secondary analysis of the Dhaka study. *J Epidemiol Global Health*. 2018;8:42.
42. Gebru T, Taha M, Kassahun W. Risk factors of diarrhoeal disease in underfive children among health extension model and non-model families in Sheko District rural community, southwest Ethiopia: comparative cross-sectional study. *BMC Public Health*. 2014;14:395.
43. Sinmegn Mihrete T, Asres Alemie G, Shimeka TA. Determinants of childhood diarrhea among underfive children in Benishangul Gumuz Regional State, North West Ethiopia. *BMC Pediatr*. 2014;14:102.
44. Boadi KO, Kuitunen M. Childhood diarrheal morbidity in the Accra metropolitan area, Ghana: socio economic, environmental and behavioral risk determinants. *World Health Popul*. 2005;7:1-13.
45. Bbaale E. Determinants of diarrhoea and acute respiratory infection among under-fives in Uganda. *Australas Med J*. 2011;4:400-409.