Trends and determinants of diarrhea among under-five children in Ethiopia: Cross-sectional study design: Multivariate decomposition and multilevel analysis based on Bayesian approach evidenced by EDHS 2000-2016 data.

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Trends and determinants of diarrhea among under-five children in Ethiopia: cross-sectional study design: Multivariate decomposition and multilevel analysis based on Bayesian approach evidenced by EDHS 2000-2016 data.

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Abstract

Background: Despite significant progress in the reduction of under-five child deaths over the last decades in Ethiopia, still diarrhea remains the second cause of morbidity and mortality among under five children next to pneumonia.

Objective: To show trends and determinants of diarrhea among under five children in Ethiopia based on the four Ethiopian Demographic and health surveys data (2000-2016).

Methods: Community-based cross-sectional study design was used. A total of 10753 in 2000, 10039 in 2005, 10946 in 2011 and 10337 in 2016 under five age children were involved. Multivariate decomposition and multilevel analysis based on Bayesian approach was performed.

Results: Ninety seven percent of the change in diarrhea prevalence over time was attributable to difference in behavior. Being twin (AOR=1.3; 95% CrI 1.1-1.5), big weight (AOR=1.63; 95% CrI 1.62–2.02), not vaccinated for rotavirus (AOR= 1.44; 95% CrI 1.12–1.9) and for measles (AOR= 1.2; 95% CrI 1.1–1.33), poor wealth status (AOR 2.6; 95% CrI 1.7–4.06), having more than three under-five children(AOR 1.3; 95% CrI 1.1–1.61), member of health insurance(AOR 2.2; 95% CrI 1.3–3.8) and long distance from the health facility (AOR 2.7; 95% CrI 2.2–3.5) were more likely to experience diarrhea.

Conclusion: The prevalence of diarrhea was significantly declined over the last sixteen years and the decline was due to difference in coefficients between the surveys. Being twin, weight of child at birth, vaccinated for measles and rotavirus, number of under-five children, wealth status, distance to health facility, health insurance and child waste disposal method were significantly associated with diarrhea among under five children in Ethiopia. Therefore Ethiopian government should primarily focus on the strengthening and scaling up of behavioral change packages to prevent diarrheal disease.

Key words: Trends of diarrhea, decomposition analysis, Bayesian, EDHS.
Introduction

Background

According to World Health Organization (WHO) diarrhea is defined as passing loose or watery stool for three or more times during a 24-hour’s period\(^1\). It is classified in to different categories based on different ways, but commonly classified as acute and persistent diarrhea\(^2-4\). Acute diarrhea is caused by an infection and usually begins within 12 hours to 4 days after exposure and resolves within three to seven days; whereas Persistent diarrhea is a diarrhea with or without blood that begins acutely and lasts for $\geq$ 14 days\(^4-5\). Despite significant worldwide progress in reduction of child death by diarrhea over time, still diarrhea remains the major cause of morbidity and mortality of child. Globally, it accounts for one-fourth of all childhood deaths annually and in Africa, is the third leading cause of mortality and were responsible for an estimated 30,000,000 cases of diarrhea and 333,000 death\(^4-6-9\). Different studies showed that, inadequate and unsafe water, lack of sanitation and poor hygiene practices are a complex issue for different diseases and accountable for the occurrence of diarrheal diseases\(^10-13\). Approximately 1.5 to 2.2 million people dies each year by diarrhea linked to poor sanitation, unsafe disposal of wastes, lack of awareness of good hygienic practices, lack of vaccination and drinking contaminated water\(^14-15\). It has also a detrimental impact on childhood growth and cognitive development beyond the cause of death\(^13\). But the development of targeted approaches to address this burden has been hampered by a paucity of comprehensive, fine-scale estimates of factors related to diarrheal disease and death among and within countries\(^8\). Even though still morbidity and mortality of children due to diarrhea is high in Ethiopia; the prevalence of diarrhea among under five children decreased from 26% in 2000 to 12% in 2016\(^16-17\). The decrease in the prevalence of diarrhea could be explained by: (1) behavioral change among households (2) increase in the proportion of children living in households with access to improved drinking water source, living in urban areas, educated parents, exposure to media, small number of family members and under-five children and other related variables. The question of substantive interest in this context is: how much of the change is actually due to the improvement of behavior suggesting the actual decrease in diarrhea prevalence and how much is due to a compositional change in the population distribution. So to prevent and control diarrhea, it is necessary
to know the trends of diarrhea over time, source of variation, the contributing factors for the change in prevalence of diarrhea precisely and determinants of diarrhea using appropriate statistical method of analysis. But there is no evidence that shows studies conducted at national level to identify determinants of diarrhea by considering the clustering effect using Bayesian analysis approach and that examine the contributing factors for the change in the prevalence of diarrhea among under-five children via decomposition analysis. Therefore, this study was done at national level and examines the factors that contribute for the change in the prevalence of diarrhea starting from 2000 to 2016. Moreover, it also identified determinants of diarrhea by considering clustering effect using Bayesian estimation technique evidenced by the recent EDHS data of 2016.

**Methods**

**Study design, period and area**

To conduct this study cross sectional study design was employed. This study was done in Ethiopia from 19 February 2019 to 19 April 2020 using EDHS 2000, 2005, 2011 and 2016 survey data. Ethiopia is East African country located 3°-14°N and 33° – 48°E. Administratively, it contains nine regions and two city administrations. Based on household composition, nearly 12% of Ethiopians are under-five aged children and 4% are age 65 and older 18. Ethiopia is an agrarian country and agriculture accounts for 43% of the gross domestic product (GDP) and 84% of the population lives in rural areas 18. Ninety seven percent of urban households had access to an improved source of drinking water as compared with 57% of rural households 18.

**Data source**

The four consecutive EDHS (2000 to 2016) data were used for this study. Approval letter for the use of those data was gained from the Measure DHS and the data set was downloaded from the Measure DHS website.

**Source and study population**

All under-five children live in Ethiopia during the surveys were the source population. From this, all under-five children in the selected households during the surveys were included in this study. But children whose status was not known (whether they experience or not diarrhea two weeks before the data collection time) were excluded from this study.
Sample size determination and sampling technique

The EDHS data were collected using stratified two stage cluster sampling technique. The 2000 and 2005 data were collected based on the 1994 population and housing census frame and 2011 and 2016 data were collected based on 2007 population and housing census frame. In the first stage, regions were stratified into urban and rural areas from the list of population. In the second stage, each enumeration areas or clusters were selected systematically and then households were selected from each EA. In 2000 EDHS, a representative sample was collected from 138 in urban areas and 401 in rural areas. In 2005 EDHS, a representative sample was collected from 145 urban and 395 rural enumeration areas. In 2011 EDHS, a national representative sample from 187 urban and 437 rural enumeration areas. In 2016 EDHS, a representative sample was collected from 645 clusters, of which 202 in urban areas and 443 in rural enumeration areas.

Figure 1: Schematic presentation of the sampling procedure.

Variables

The outcome variable of this study was diarrheal disease (Yes/No). The independent variables were classified as community and individual level variables. Place of residence and region of the study participants were considered as community level variables. Whereas family size, number of under-five children, educational status of both husband and mother, working status of mother, wealth index of parents, media exposure, distance to health facility, health insurance, age of the child, sex of the child, being twin, weight of the child at birth, breast feeding, vaccinated for rotavirus and measles, vitamin A supplementation, type of drinking water source, type of latrine and way of child waste disposal were considered as individual level factors.

Data processing and analysis

The variables of the study were extracted from kid record (KR) data set using STATA version 14.2. The data were weighted using sampling weight before any statistical analysis to account the sampling design. STATA version 14.2 was used for Editing, recoding, exploratory and multivariate decomposition analysis. For multilevel analysis based on Bayesian approach R version 4.0 software was used. After the data were
cleaned, categorized, coded and weighted, we explored the descriptive statistics by using the frequencies and percentages of data and presented by using tables. Similarly after diarrhea was coded as “1” having diarrhea and those don’t have diarrhea was coded as “0” in the last two weeks prior to the survey and transforming some of the variables and maintaining other variable as it was using Stata version 14.2 software, the trends of diarrhea prevalence among under five children was explained by descriptive analysis, stratified by regions, urban-rural residence and by using selectively important socio-demographic variables. The trend period was divided into four phases; first phase (2000-2005), second phase (2005-2011), third phase (2011-2016) and the overall or fourth phase (2000-2016) to see the differences in diarrhea prevalence over time. The data from EDHS 2000, 2005, 2011 and 2016 were appended together to perform decomposition analysis. And also, the data was imported in to R version 4.0 after the data is exported in .csv excel format from Stata version 14.2 and multilevel analysis was done using Bayesian approach based on EDHS 2016 data.

Multivariate decomposition analysis
Multivariate decomposition was used to split components of group differences in proportion into a component attributable to compositional change between groups and a components attributable to the effect of population behavior or effect of characteristics. The multivariate decomposition analysis is a statistical analysis for examining the change in event that results in differences in outcome between any two surveys. The aim of using decomposition analysis was to compare the difference in two time periods and identify the sources of variations of diarrhea prevalence among under five children. The difference between any two surveys was explained by the compositional changes or characteristics of surveys (endowments), which is explained and by the effects of those characteristics (coefficients) that is not explained. Therefore, the observed change in burden of diarrhea between two surveys was additively decomposed in the endowment (characteristics) component and coefficient (effect of characteristics) component using recently developed mvdcmp Stata package. In the nonlinear model, the response variable is a function of a linear combination of predictors and regression coefficients.

\[ Y = F(X\beta) = \logit(Y) = X\beta \]

Where \( Y \) represent the dependent variable.
$X$ represents a set of predictor variables
$\beta$ denote set of regression coefficients

The proportion difference in $Y$ between the two surveys of A and B can be decomposed as

$$Y_A - Y_B = F(X_A\beta_A) - (X_B\beta_B) \tag{22}.$$  

Let the recent 2016 EDHS and reference 2000 EDHS datasets can be denoted by A and B respectively.

For logistic regression, the log-odds or logit of the burden of diarrhea is given by\textsuperscript{22}

$$\text{logit}(A) - \text{logit}(B) = F(X_A\beta_A) - F(X_B\beta_B)$$

Where; $E$ represents endowments, which is explained by characteristics. An endowment is a change in diarrhea due to differences in characteristics. $C$ denotes coefficients or effect of characteristics which is unexplained \textsuperscript{22}. The coefficient is the change in diarrhea due to the effect of predictor variables.

The equation can be presented as:

$$\text{logit}(A) - \text{logit}(B) = [\beta_{0A} - \beta_{0B}] + \sum X_{ijB} \cdot [\beta_{ijA} - \beta_{ijB}] + \sum \beta_{ijB} \cdot [X_{ijA} - X_{ijB}]$$

Where; $\beta_{0B}$ is the intercept in the regression equation for EDHS 2000
$\beta_{0A}$ is the intercept in the regression equation for EDHS 2016.

$\beta_{ijB}$ is the coefficient of the $j^{th}$ category of the $i^{th}$ determinant in EDHS 2000
$\beta_{ijA}$ is the coefficient of the $j^{th}$ category of the $i^{th}$ determinant in EDHS 2016
$X_{ijB}$ is the proportion of the $j^{th}$ category of the $i^{th}$ determinant in the EDHS 2000
$X_{ijA}$ is the proportion of the $j^{th}$ category of the $i^{th}$ determinant in EDHS 2016

To determine the specific contribution of each independent variable to each component of differences in the burden of diarrhea we partitioned the endowment and coefficients denoted by $C$ and $E$ into a portion of $C_k$ and $E_k$, which represent the specific contribution of $K^{th}$ independent variables for each component of $C$ and $E$ respectively.

**Multilevel analysis based on Bayesian approach**

Multilevel models allow to estimate the relationship between the explanatory variables at different level and dependent variables, and the extent of variation in the outcome of
interest at each level in the model both before and after the inclusion of the explanatory variables in the model. In this study, two levels of data hierarchy was stated. Level one unit were individual children of households and level two units were enumeration areas. Level one (children in the household) are nested within units at the next higher level (enumeration areas). The outcome variable was represented by \( Y_{ij} = \{ \text{having diarrhea, \ no \ diarrhea} \} \), the category is binary type of data. Therefore multilevel binary logistic regression analysis based on Bayesian approach was performed using \textit{Brms} R-package to estimate the parameters of the variable and the extent of random variations between clusters. This package allows R users to easily specify a wide range of Bayesian single-level and multilevel models, which are fitted with the probabilistic programming language of Stan.

**Two level model formulation**

In this study, the response variable was a dichotomous variable that is whether a child had diarrhea or not within two weeks prior to the start of the 2016 survey. So, the effect of explanatory variables on the dependent variable was investigated using the multilevel binary logistic regression model based on Bayesian statistical analysis approach.

The basic data structure of the two-level logistic regression is a collection of \( j \) groups (enumeration area) and within-group \( j \) (\( j = 1, 2, \ldots, J \)), a random sample \( n \) of level-one units (individual children).

\[
Y_{ij} = \begin{cases} 
1 & \text{if } i^{th} \text{ children have diarrhea in the } j^{th} \text{ region} \\
0 & \text{if } i^{th} \text{ children have no diarrhea in the } j^{th} \text{ enumeration area}
\end{cases}
\]

So, this variable has a Bernoulli distribution with successes when the child had diarrhea and failure when the child hadn’t diarrhea.

The probability of having diarrhea for \( i^{th} \) children in the \( j^{th} \) region is \( \pi_{ij} \)

\[
P(X_{ij} = x) = \binom{n}{x} p^x (1-p)^{n-x}, \quad \text{if} \quad X = \sum_{i=1}^{n} Y_{ij}
\]

Let \( \pi_{ij} \) be modeled using a logit link function. The two-level model is given by:

\[
\text{Logit} (\pi_{ij}) = \beta_0 + \sum_{h=1}^{H} \beta_{hj} X_{hj} + \mu_{0j} + \sum_{h=1}^{H} \mu_{hj} \ldots \ldots
\]

Where, \( \beta_{0j} = \beta_0 + \mu_{0j} \)

\( \beta_{1j} = \beta_1 + \mu_{1j} \)

\( \beta_{hj} = \beta_h + \mu_{hj} \)
\[ \beta_0 + \sum_{h=1}^k \beta_{hj} X_{hj}, \] is called fixed part of the model
\[ \mu_{0j} + \sum_{h=1}^k \mu_{hj}, \] is called random effect of the model
\[ X_{ij}, \] are the covariates in the model
\[ \beta, \] is the regression coefficient of the parameter.
\[ \mu_{hj}, \] is the estimate of random intercept

**Models**

The following four models were fitted using R version 4.0 software:

**I.** Null or variance multilevel binary logistic model
**II.** A model fitted with individual level factors
**III.** A model fitted with community level factors
**IV.** A model fitted with both individual and community level factors

**Parameter estimation**

Bayesian analysis approach is one of the data analysis approach independent to the classical analysis approach and the parameters are estimated from the posterior distribution which is the combination of the prior information and the likelihood of the data. A prior distribution of a parameter is the probability distribution that represents our uncertainty about the parameter before the current data are examined and the likelihood function (often simply called the likelihood) expresses how probable a given set of observations is for different values of the statistical parameters. For this study we used vague prior with beta distribution (1, 1), iteration = 10,000, warmup =1000 (number of iterations that was discarded), chains =2, initials (the starting values of the iterations) =0, cores (specifies the number of cores used for the algorithm) =2 and adapt delta (controls divergent transition) = 0.95.

The posterior distribution was determined as follow using beta distribution (1, 1):

\[ f(\theta) = \frac{1}{\beta(1,1)} (\beta_l, \sigma_\mu^2)^{1-1} (1 - \beta_l, \sigma_\mu^2)^{1-1}, \] is the prior distribution

\[ \pi_{ij} = \frac{e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} + \mu_{0j}}}{1 + e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} + \mu_{0j}}} \] is the probability of having diarrhea

Where, \( e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} } \) is the fixed effect and \( e^{\mu_{0j}} \) is the random effect of the model with \( \mu_{0j} \sim N (0, \sigma_\mu^2) \). The likelihood of the data is given by:

\[ L(y|\beta_{ij}, \sigma_\mu^2) = \prod_{i=1}^{n} \prod_{j=1}^{q} \left[ \frac{e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} + \mu_{0j}}}{1 + e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} + \mu_{0j}}} \right]^{y_{ij}} \left( 1 - \frac{e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} + \mu_{0j}}}{1 + e^{\beta_0 + \beta_1 x_{1ij} + \ldots + \beta_h x_{hij} + \mu_{0j}}} \right)^{1-y_{ij}} \]
The posterior distribution is the product of the prior and the likelihood as follow:

\[
 f(\beta_{ij}, \sigma_{\mu}^2 | y) = \prod_{i=1}^{n} \prod_{j=1}^{n} \left[ \left( \frac{e^{\beta_0 + \beta_0 x_{1ij} + \cdots + \beta_h x_{hij} + \mu_0}}{1 + e^{\beta_0 + \beta_0 x_{1ij} + \cdots + \beta_h x_{hij} + \mu_0}} \right)^{y_{ij}} \left( 1 - \frac{e^{\beta_0 + \beta_0 x_{1ij} + \cdots + \beta_h x_{hij} + \mu_0}}{1 + e^{\beta_0 + \beta_0 x_{1ij} + \cdots + \beta_h x_{hij} + \mu_0}} \right)^{1-y_{ij}} \right] \]

\[
 \times \frac{1}{\beta_{(1,1)}} (\beta_{ij}, \sigma_{\mu}^2)^{1-1} (1 - \beta_{ij}, \sigma_{\mu}^2)^{1-1} \text{ } 26
\]

After posterior distribution was determined, we used Hamiltonians Monte Carlo (HMC) methods to simulate direct draws from the complex posterior distribution. Hamiltonian Monte Carlo (HMC) avoids the random walk behavior and sensitivity to correlated parameters that plague many MCMC methods by taking a series of steps informed by first-order gradient information 28. These features allow the model to converge to high-dimensional target distributions much more quickly than simpler methods such as random walk Metropolis or Gibbs sampler 28. No-U-Turn Sampler (NUTS), an extension to HMC uses a recursive algorithm to build a set of likely candidate points that spans a wide swath of the target distribution, stopping automatically when it starts to double back and retrace its steps28. Therefore since the iteration convergences is fast, we used No-U-Turn Sampler (NUTS). Summary statistics was carried out from the posterior distribution after the model was converged and the 95% credible interval was used for test of significance.

**Intra cluster correlation coefficient (ICC)**

The main reason to apply multilevel analysis was the existence of significant intra-class correlation. ICC was calculated as follow:

\[
 \text{ICC} = \frac{\sigma_{\mu_0}^2}{\sigma_{\mu_0}^2 + \sigma_{e}^2} \text{ } 25 \text{ where, } \sigma_{e}^2 \text{ and } \sigma_{\mu_0}^2 \text{ are the variance within and between the region respectively. In multilevel logit model, level one residual variance } (\sigma_{e}^2) \text{ is } \pi^2/3 \approx 3.29 \text{ and the formula is written as } \frac{\sigma_{\mu_0}^2}{\sigma_{\mu_0}^2 + 3.29} \text{ } 26. \text{ The 95% posterior credible interval was used for test of significances, in which the interval containing zero for the variance between the regions is considered as non-significant and that doesn’t contain zero is considered as significant. We used the ICC value greater than 10% to consider variation of diarrhea prevalence in the cluster.}

**Convergence of the Algorithm**

The results obtained from a given HMC analysis are not deemed reliable until the chain has reached its stationary distribution27. The term convergence of an HMC algorithm refers to whether the algorithm has reached its equilibrium (target) distribution27. If the
algorithm has reached its equilibrium, then the generated sample comes from the correct target distribution. So, monitoring the convergence of the algorithm is essential for producing valid results from the posterior distribution. Therefore, to monitor the convergence of the algorithm we used the most popular and straightforward convergence assessment methods in which Rhat = 1, Bulk_ESS and Tail_ESS were greater than 1000, chains of the time serious plots were mixed well and density plot were smooth.

**Model comparison and Selection**

Models fitted using Bayesian approach was compared based on their Widely Applicable Information Criteria (WAIC) and Leave-One-Out Cross-Validation (LOO) value. A model with small WAIC and LOO is best model. So, a model with small WAIC and LOO value was selected and inference was made based on this model.

**Results**

**Characteristics of the study population**

Based on socio-demographic reports of EDHS data, more than 85% of the households were rural settlers. More than four fifth; 86.7% in 2000, 89.2% in 2005, 85.2% in 2011 and 86.2% of the total households in 2016 were leaded by males. With regard to education, the proportion of maternal higher educational status was 0.2% in 2000, 0.4% in 2005, 1.5% in 2011 and 2.5% in 2016 (Table 1).

According to birth related reports of EDHS data, the highest percentage (2.2%) of twin birth was reported in 2016. Both the highest and lowest proportion of small birth weight (34%) and (26.1%) was reported in 2000 and 2016 respectively. The highest proportion of narrow birth interval (<= 23 months) was reported in 2005 (34%) whereas the smallest proportion (23%) was also reported in 2000 (Table 1).

The proportion of children vaccinated for measles was 26.9% both in 2000 and 2005, 47% in 2011 and 60.7% in 2016. Though there was no reports about rotavirus vaccine in the first three EDHS’s, the last EDHS report showed that only 27.7% of children were vaccinated. Amongst the surveyed households, 77% in 2000, 80% in 2005, 63.8% in 2011 and 61.2% of households practiced unsafe way of infant waste disposal (Table 2).

Regarding households’ wealth status and health insurance, 35% of the households in 2005, 44.7% in 2011 and 46.9% in 2016 were poor. Though Community Based Health Insurance (CBHI) was not practiced in 2000 and 2005, exactly 99.4% of the households
in 2011 and 96.3% in 2016 didn’t use it. More than two third; 74.6% in 2005, 75.2% in 2011 and 60.8 % of the households in 2016 reported that distance to health facility was their big problem (Table 1).
| Variables                      | Characteristics | Frequency and percentage distribution of characteristics |
|-------------------------------|----------------|--------------------------------------------------------|
|                               |                | EDHS 2000  | EDHS 2005  | EDHS 2011  | EDHS 2016  |
|                               | No (%)         | No (%)     | No (%)     | No (%)     | No (%)     |
| Sex of child                  | Male           | 5460 (51)  | 5089 (51)  | 5636 (51.5)| 5307 (51)  |
|                               | Female         | 5293 (49)  | 4950 (49)  | 5310 (48.5)| 5030 (49)  |
| Twin                          | Yes            | 136 (1)    | 143 (1.4)  | 203 (1.9)  | 292 (2.2)  |
|                               | No             | 10617 (99) | 19896 (98.6)| 10743 (98.1)| 10105 (97.8)|
| Weight of child at birth      | Small          | 3651 (34)  | 2805 (28)  | 3251 (29.7)| 2676 (26.1)|
|                               | Average        | 388 (36)   | 4069 (40.1)| 4275 (39.1)| 4328 (42.2)|
|                               | Big            | 3200 (30)  | 3149 (31.4)| 3406 (31.2)| 3255 (31.7)|
| Birth order                   | First          | 1982 (19)  | 1666 (16.6)| 2068 (18.9)| 1923 (18.6)|
|                               | 2 – 3          | 3264 (30)  | 3069 (30.6)| 3422 (31.3)| 3155 (30.5)|
|                               | 4 – 5          | 2362 (22)  | 2382 (23.7)| 2522 (23)  | 2473 (23.9)|
|                               | =>6            | 3144 (29)  | 2920 (29.2)| 2935 (26.8)| 2786 (27)  |
| Birth interval                | <=23 month     | 2215 (23)  | 3420 (34)| 2407 (25)  | 2446 (27.3)|
|                               | =>24 month     | 7951 (77)  | 6618 (66)  | 7221 (75)  | 6499 (72.7)|
| Age of child                  | <1 year        | 2186 (20.3)| 222 (22)   | 2383 (21.8)| 2264 (21.9)|
|                               | =>1<2 year     | 2145 (20)  | 1872 (18.7)| 1915 (17.5)| 2001 (19.4)|
|                               | =>2<3 year     | 2084 (19.4)| 1883 (18.8)| 2045 (18.7)| 1926 (18.6)|
|                               | =>3<4 year     | 2260 (21)  | 2078 (20.7)| 2351 (21.5)| 1980 (19.1)|
|                               | =>4<5 year     | 2080 (19.3)| 1984 (19.8)| 2251 (20.6)| 2165 (21)  |
| Breast feeding                | Still feeding  | 5318 (49.5)| 5111 (51.2)| 5253 (45)  | 4325 (42)  |
|                               | Ever feed but not now | 5366 (50) | 4699 (47)  | 5532 (50.5)| 5624 (54.4) |
|                               | Never feed     | 69 (0.64)  | 178 (4.1)  | 161 (1.5)  | 388 (3.8)  |
| Rotavirus vaccine             | vaccinated     | -          | -          | -          | 2858 (27.7)|
|                               | Not vaccinated | -          | -          | -          | 7479 (72.4)|
| Measles’ vaccine              | Vaccinated     | 2894 (26.9)| 2535 (26.9)| 5053 (47.1)| 3692 (60.2)|
|                               | Not vaccinated | 7859 (73.1)| 6877 (73.1)| 5682 (52.9)| 2446 (39.8)|
| Vitamin A supplemented        | Yes            | 6000 (56.5)| 4399 (44.5)| 5274 (48.8)| 4574 (48.7)|
|                               | No             | 4624 (43.5)| 5492 (55.5)| 5540 (51.2)| 4825 (51.3)|
| Wealth index                  | Poor           | -          | 4312 (35)  | 4889 (44.7)| 4848 (46.9)|
|                               | Medium         | -          | 2197 (22)  | 2259 (20.6)| 2139 (20.7)|
|                               | Rich           | -          | 3529 (35)  | 3798 (34.7)| 3350 (32.4)|
| Mothers work status           | Working        | 6003 (55.9)| 8572 (76.8)| 3733 (34.1)| 2803 (27.1)|
|                               | Not working    | 4745 (44.1)| 2590 (23.2)| 4061 (68.9)| 7534 (72.9)|
| Health insurance              | Yes            | -          | -          | 59 (0.5)   | 378 (3.7)  |
|                               | No             | -          | -          | 10882 (99.4)| 9959 (96.3)|
| Distance to health facility   | Not long       | -          | 2553 (25.4)| 2710 (24.8)| 4056 (39.2)|
|                               | Long           | -          | 7485 (74.6)| 8227 (75.2)| 6281 (60.8)|

*Table 1: Frequency and Percentage distribution of characteristics of respondents and their children in Ethiopia.*
## Continuation of above table

| Variables                  | Characteristics | Frequency and percentage distribution of characteristics | EDHS 2000  | EDHS 2005  | EDHS 2011  | EDHS 2016  |
|----------------------------|-----------------|--------------------------------------------------------|------------|------------|------------|------------|
|                            |                 |                                                        | No (%)     | No (%)     | No (%)     | No (%)     |
| Residence                  | Urban           | 1141 (10.6)                                            | 741 (7.4)  | 1413 (12.9)| 1151 (11.1)|            |
|                            | Rural           | 9612 (89.4)                                            | 2298 (92.6)| 9534 (87.1)| 9186 (88.9)|            |
| Region                     | Tigray          | 709 (6.6)                                              | 652 (6.5)  | 701 (6.3)  | 682 (6.6)  |            |
|                            | Afar            | 107 (1)                                                | 96 (1)     | 110 (1)    | 104 (1)    |            |
|                            | Amhara          | 2797 (26)                                              | 2299 (22.9)| 2472 (22.6)| 1954 (18.9)|            |
|                            | Oromia          | 4356 (40.5)                                            | 3982 (39.7)| 4615 (42.2)| 4537 (43.9)|            |
|                            | Somali          | 127 (1.2)                                              | 428 (4.3)  | 330 (3)    | 472 (4.6)  |            |
|                            | B/Gumuz         | 108 (1)                                                | 95 (0.9)   | 125 (1)    | 113 (1.1)  |            |
|                            | SNPP            | 2297 (21.4)                                            | 2265 (22.6)| 2287 (20.9)| 2149 (20.8)|            |
|                            | Gambella        | 25 (0.2)                                               | 28 (0.3)   | 35 (0.3)   | 24 (0.2)   |            |
|                            | Harari          | 23 (0.2)                                               | 21 (0.2)   | 26 (0.2)   | 24 (0.2)   |            |
|                            | Addis Ababa     | 167 (1.6)                                              | 140 (1.4)  | 208 (1.9)  | 233 (2.3)  |            |
|                            | Dire-Dawa       | 35 (0.3)                                               | 34 (0.3)   | 36 (0.3)   | 43 (0.4)   |            |
| Mother's educational level | No formal education | 8771 (82)                                             | 7896 (78.7)| 7562 (69.1)| 6809 (65.9)|            |
|                            | Primary         | 1426 (13)                                              | 1699 (16.9)| 2980 (27.2)| 2777 (26.9)|            |
|                            | Secondary       | 532 (4.9)                                              | 401 (4)    | 245 (2.2)  | 491 (4.8)  |            |
|                            | Higher          | 24 (0.2)                                               | 42 (0.4)   | 159 (1.5)  | 260 (2.5)  |            |
| Father's educational level | No formal education | 6732 (63.5)                                           | 5771 (58.1)| 5360 (49.7)| 4700 (48.2)|            |
|                            | Primary         | 2682 (25.3)                                            | 3054 (30.8)| 4527 (42)  | 3849 (39.5)|            |
|                            | Secondary       | 1054 (10)                                             | 1000 (10.1)| 550 (5.1)  | 766 (7.9)  |            |
|                            | Higher          | 140 (1.3)                                              | 111 (1.1)  | 348 (3.2)  | 442 (4.5)  |            |
| Head of household          | Male            | 9327 (86.7)                                            | 8957 (89.2)| 9323 (85.2)| 8908 (86.2)|            |
|                            | Female          | 1426 (13.3)                                            | 1082 (10.8)| 1623 (14.8)| 1429 (13.8)|            |
| Media exposure             | Yes             | 893 (8.3)                                              | 1222 (12.2)| 2007 (18.4)| 1846 (17.9)|            |
|                            | No              | 9849 (91.7)                                            | 8799 (87.8)| 8927 (81.6)| 8491 (82.1)|            |
| Family members             | <=5             | 4655 (43.3)                                            | 4116 (41)  | 4812 (44)  | 5865 (56.7)|            |
|                            | >=6             | 6098 (56.7)                                            | 5922 (59)  | 6134 (56)  | 4472 (43.3)|            |
| Number of U-5 children     | <=2             | 9169 (85.3)                                            | 5922 (83.2)| 9041 (82.6)| 8541 (82.6)|            |
|                            | >=3             | 1584 (14.7)                                            | 1685 (16.8)| 1906 (17.4)| 1796 (17.4)|            |
| drinking water             | Improved        | 2224 (21.4)                                            | 5289 (55.4)| 4951 (46.5)| 5719 (56.2)|            |
|                            | Not improved    | 8169 (78.6)                                            | 4254 (44.6)| 5686 (53.5)| 4464 (43.8)|            |
| Child waste disposal       | Safe            | 2457 (23)                                              | 1987 (20)  | 3647 (36.2)| 2553 (38.8)|            |
|                            | Not safe        | 8256 (77)                                              | 7945 (80)  | 6419 (63.8)| 4035 (61.2)|            |
| Type of toilet             | Improved        | 1494 (14.4)                                            | 891 (9)    | 1342 (12.6)| 1036 (21.4)|            |
|                            | Not improved    | 8903 (85.6)                                            | 9073 (91)  | 9287 (87.4)| 3804 (78.6)|            |
**Overall trends of diarrhea among under five-children in Ethiopia**

By looking the trend, Ethiopia has been shown a decrement in diarrhea prevalence among under-five children over the study period, from 26% in 2000 to 18% in 2005, to 14% in 2011 and to 12% in 2016. The highest decrement was noticed in the first phase (2000-2005 with a 10.4% point change compared with 8%, 4% and 2% point change in second phase (2005-2011) and in the third phase (2011-2016) respectively. The overall change (2000-2016) in diarrhea prevalence was 14% (Figure 2).

*Figure 2: Trend of diarrhea prevalence in Ethiopia from 2000 to 2016.*

**Trends of diarrhea prevalence in Ethiopia by selected characteristics**

The trends of diarrhea prevalence among under-five children showed variation based on different characteristics. Diarrhea prevalence decrement was observed in most of the characteristics and increment in some of the characteristics in each phases. Among rural residents, the largest decrement was observed during the first phase of the study period (2000-2005) with 7.6% point change followed by second (2005-2011) and third (2011-2016) phases with 4.7% and 1.9% point changes respectively and the overall change (2000-2016) was 14.2% point change. Based on region, the largest point change in first phase was observed in Gambella regional state with 17.7% point change followed by Dire-Dawa with 13.9% point change. But in the second phase, diarrhea prevalence was increased in Gambella by 8.6% point change, in Benishangul-Gumuz by 1.9% point change and in Tigray by 0.5% point change. Similarly in third phase it was increased by 3.3% point change in Dire-Dawa and by 1% point change in Harari. The overall change of decrement of diarrhea prevalence based on region was higher in southern nation nationalities and people of Ethiopia (SNNP) regional state with 18.5% point change. Households that have more than three under-five age children showed highest point of change (10.9%) in the second phase and the overall point change of diarrhea prevalence was 16%. Respondents who had have improved drinking water source showed decrement of diarrhea prevalence among under-five children with 8.5%, 4%, 0.6% and 13.1% point change in first, second, third and fourth phases respectively (Table 2).
### Table 2: Trends of diarrhea prevalence among under-five children by selected characteristics in Ethiopia.

| Variables          | Characteristics          | 2000 | 2005 | 2011 | 2016 | Phase 1 (2000-2005) | Phase 2 (2011-2015) | Phase 3 (2016-2020) | Over all (2016-2020) |
|--------------------|--------------------------|------|------|------|------|---------------------|---------------------|---------------------|----------------------|
| Sex of child       | Male                     | 26.3 | 18.1 | 14.4 | 12.2 | -8.2                | -4.1                | -2.2                | -14.1                |
|                    | Female                   | 24.9 | 18.1 | 12.6 | 11.5 | -6.8                | -5.5                | -1.1                | -13.4                |
| Twin               | Yes                      | 19.3 | 14.8 | 23.6 | 13.8 | -4.5                | 4.3                 | 5.5                 | -7.5                 |
|                    | No                       | 25.7 | 18.2 | 13.4 | 11.8 | -7.5                | -4.8                | -1.6                | -13.9                |
| Weight of child at birth | Small                 | 26.3 | 20   | 14.9 | 15.7 | -6.3                | -5.9                | 0.8                 | -10.6                |
|                    | Average                  | 23.3 | 15.5 | 12.6 | 9.8  | -7.8                | -2.9                | -2.8                | -13.5                |
|                    | Big                      | 27.5 | 19.8 | 13.5 | 11.6 | -7.7                | -6.3                | -1.9                | -15.9                |
| Birth order        | First                    | 27.2 | 17.5 | 11.2 | 13.1 | -9.7                | -6.3                | 1.9                 | -14.1                |
|                    | 2 – 3                    | 26.6 | 16.7 | 13.4 | 12.4 | -9.9                | -3.3                | -1                  | 14.2                 |
|                    | 4 – 5                    | 25.4 | 20.9 | 14.7 | 12   | -4.5                | -6.2                | -2.7                | -13.4                |
|                    | =>6                      | 23.8 | 17.8 | 14.4 | 10.4 | -6                  | -3.4                | -4                  | -13.4                |
| Birth interval     | <=<23 month              | 25.2 | 17.6 | 10.4 | 9.9  | -7.6                | -7.2                | -0.5                | -15.3                |
|                    | =>24 month               | 24.9 | 18.4 | 14.3 | 11.6 | -6.5                | -4.1                | -2.7                | -13.3                |
| Age of child       | <1 year                  | 27.3 | 21.3 | 17.2 | 14.7 | -6                  | -4.1                | -2.5                | -12.6                |
|                    | =>1<2 year               | 37.2 | 28.4 | 22.8 | 17.8 | -8.8                | -5.6                | 5                   | -19.4                |
|                    | =>2<3 year               | 28.7 | 18.6 | 14.1 | 13   | -10.1               | -4.5                | -1.1                | -15.7                |
|                    | =>3<4 year               | 19.2 | 12.6 | 9    | 9.2  | -6.6                | -3.6                | 0.2                 | -10                  |
|                    | =>4<5 year               | 15.7 | 10.2 | 6    | 4.8  | -5.5                | -4.2                | -1.2                | -10.9                |
| Breast feeding     | Still feeding            | 31.2 | 23.2 | 18.4 | 12   | -8                  | -4.8                | -6.4                | -19.2                |
|                    | Ever feed but not now    | 20   | 12.7 | 9.1  | 11.9 | -7.3                | -3.6                | 2.8                 | -8.1                 |
|                    | Never feed               | 36.2 | 19.1 | 13.5 | 10.3 | -17.1               | -5.6                | -3.2                | -25.9                |
| Rotavirus vaccine  | Vaccinated               | -    | -    | -    | 12.5 | -                   | -                   | -                   | -                    |
|                    | Not vaccinated           | -    | -    | -    | 11.6 | -                   | -                   | -                   | -                    |
| Measles’ vaccine   | Vaccinated               | 22.6 | 20   | 14   | 13.2 | -2.6                | -6                  | -0.8                | -9.4                 |
|                    | Not vaccinated           | 26.7 | 17.7 | 13.3 | 18.2 | -9                  | -4.4                | 4.9                 | 8.5                  |
| Vitamin A supplemented | Yes                  | 24.9 | 19.4 | 13.6 | 12.8 | -5.5                | -5.8                | -0.8                | -12.1                |
|                    | No                       | 25.5 | 17.3 | 13.3 | 11.4 | -8.2                | -4                  | -1.9                | -14.1                |
| Mothers work status| Working                  | 26.7 | 18.5 | 13.2 | 11.3 | -8.2                | -5.3                | -1.9                | -15.4                |
|                    | Not working              | 24.8 | 18   | 14.1 | 13.3 | -6.8                | -3.9                | -0.8                | -11.5                |
| Wealth index       | Poor                     | -    | 19.1 | 13.8 | 12.6 | -5.3                | -1.2                | -                   | -                    |
|                    | Medium                   | -    | 19.8 | 13.2 | 12.5 | -6.6                | -0.7                | -                   | -                    |
|                    | Rich                     | -    | 15.9 | 13.5 | 12.6 | -2.4                | -0.9                | -                   | -                    |
| Health insurance   | Yes                      | -    | -    | 10.3 | 10.8 | -                   | -                   | 0.5                 | -                    |
|                    | No                       | -    | -    | 13.6 | 11.9 | -                   | -                   | -1.7                | -                    |
| Distance to health facility | Not long | - | 16.3 | 12.1 | 12.6 | -4.2                | 0.5                 | -                   | -                    |
|                    | Long                     | -    | 18.7 | 14   | 11.4 | -4.7                | -2.6                | -                   | -                    |
| Variables | Characteristic | Point difference in diarrhea prevalence |
|-----------|----------------|----------------------------------------|
|           |                | 2000 N=107 | 2005 N=10| 2011 N=10 | 2016 N=103 | Phase1 (2005-2000) | Phase2 (2011-2005) | Phase3 2016-2011 | Over all (2016-2000) |
| Residence | Urban          | 21.1       | 12.3    | 11.2    | 10.9    | -8.8            | -1.1            | -0.3            | -10.2            |
|           | Rural          | 26.2       | 18.6    | 13.9    | 12      | -7.6            | -4.7            | -1.9            | -14.2            |
| Region    | Tigray         | 17.9       | 12.9    | 13.4    | 13      | -5              | 0.5             | -0.4            | -4.9             |
|           | Afar           | 20.6       | 13.5    | 12.7    | 11.5    | -7.1            | -0.8            | -1.2            | -9.1             |
|           | Amhara         | 20.3       | 14.7    | 13.7    | 13.8    | -5.6            | -1              | 0.1             | -6.5             |
|           | Oromia         | 27.2       | 17.8    | 11.5    | 10.7    | -9.4            | -6.3            | -0.8            | -16.5            |
|           | Somali         | 22.8       | 12.4    | 20      | 6.1     | -10.4           | 7.6             | -13.9           | -16.7            |
|           | B/Gumuz        | 26.9       | 21.3    | 23.2    | 8.8     | -5.6            | 1.9             | -14.4           | -18.1            |
|           | SNNP           | 32.5       | 25.2    | 16.5    | 14      | -7.3            | -8.7            | -2.5            | -18.5            |
|           | Gambella       | 32         | 14.3    | 22.9    | 16      | -17.7           | 8.6             | -6.9            | -16              |
|           | Harari         | 26.1       | 19      | 11.5    | 12.5    | -7.1            | -7.5            | 1               | -13.6            |
|           | Addis Ababa    | 16.8       | 13.6    | 9.6     | 7.7     | -3.2            | -4              | -1.6            | -9.1             |
|           | Dire-Dawa      | 25.7       | 11.8    | 8.3     | 11.6    | -13.9           | 3.5             | 3.3             | -14.1            |
| Mother’s educational level | No formal education | 26.2       | 18.3    | 14      | 11.3    | -7.9            | -4.3            | -2.7            | -14.9            |
|           | Primary        | 24.1       | 19.5    | 12.8    | 13.3    | -4.6            | -6.7            | 0.5             | -10.8            |
|           | Secondary      | 19.4       | 10.7    | 10.6    | 14.7    | -8.7            | -0.1            | 4.1             | -4.7             |
|           | Higher         | 41.7       | 2.4     | 11.3    | 7.3     | -39.3           | 8.9             | -4              | -34.4            |
| Father’s educational level | No formal education | 25         | 18.2    | 13.7    | 10.5    | -6.8            | -4.5            | -3.2            | -14.5            |
|           | Primary        | 29.1       | 19.2    | 14      | 13.4    | -9.9            | -5.2            | -0.6            | -15.7            |
|           | Secondary      | 20.8       | 14.7    | 11.6    | 12.8    | -6.1            | -3.1            | 1.2             | -8               |
|           | Higher         | 22.1       | 6.3     | 10.6    | 10      | -15.8           | 4.3             | -0.6            | -12.1            |
| Sex of household head | Male            | 25.7       | 18.2    | 13.4    | 12.2    | -7.5            | -4.8            | -1.2            | -13.5            |
|           | Female         | 24.9       | 17.3    | 14.2    | 9.9     | -7.6            | -3.1            | 4.3             | -15              |
| Media exposure | Yes           | 24.3       | 16.1    | 13.4    | 14      | -8.2            | -2.7            | 0.6             | 10.3             |
|           | No             | 25.7       | 18.4    | 13.6    | 11.4    | -7.3            | -4.8            | -2.2            | -14.3            |
| family members | <=5           | 27.9       | 18.1    | 13.7    | 10.5    | -9.8            | -4.4            | -3.2            | -17.4            |
|           | =>6            | 23.9       | 18      | 13.4    | 13.6    | -5.9            | -4.6            | 0.2             | -10.3            |
| Number of U-5 children | <=2           | 25.8       | 18.9    | 13.6    | 12.6    | -6.9            | -5.3            | -1              | -13.2            |
|           | =>3            | 24.4       | 18      | 13.5    | 8.4     | -6.4            | -10.9           | -5.1            | -16              |
| Drinking water | Improved      | 25.1       | 16.6    | 12.6    | 12      | -8.5            | -4              | -0.6            | -13.1            |
|           | Not improved  | 25.7       | 19.9    | 14.6    | 11.4    | -5.8            | -5.3            | -3.2            | -14.3            |
| Child waste disposal | Safe         | 24.3       | 19.4    | 14.2    | 14.6    | -4.9            | -5.2            | 0.4             | -9.3             |
|           | Not safe      | 25.8       | 17.9    | 13.7    | 10.8    | -7.9            | -4.2            | -2.9            | -15              |
| Type of toilet | Improved     | 23.6       | 20.7    | 12      | 9.8     | -2.9            | -8.7            | -2.2            | -13.8            |
|           | Not improved  | 25.9       | 17.9    | 13.8    | 11.6    | -8              | -4.1            | -2.2            | -14.3            |
Decomposition analysis

Overall from 2000 to 2016, there has been a significant decline in prevalence of diarrhea in Ethiopia. The overall decomposition result showed that 97.1% of decline in prevalence of diarrhea over time was due to difference in the effects of characteristics between the surveys. About 2.9% of decline was due to difference in characteristics (compositional factors) but the change due to difference in characteristics (compositional factors) was not significant (Table 3).

Factors including mother’s education level, number of family members and mothers working status showed a significant effect for the decline of diarrhea prevalence. Keeping compositional changes constant, change in behavior of women who don’t have formal education contributed more than 100% for the decline of diarrhea prevalence over the past sixteen years. The behavioral change of mothers who have primary and secondary education level contributed 25% and 9.2% for the decline of diarrhea prevalence over the past sixteen years respectively. Compared with mothers who were working, behavioral change of mothers who were not working contributes 18% for decrement of diarrhea prevalence. Similarly, behavioral change of respondents who have more than six family members contributed 30% for the decline of diarrhea prevalence for the last sixteen years as compared to respondents who have less than five family members (Table 3).


Table 3: Decomposition of change in diarrhea prevalence among under-five children in Ethiopia, from 2000 to 2016

| Diarrhea | Coef | L- CI | U- CI | Pct. |
|----------|------|-------|-------|------|
| E        | -0.004 | -0.016 | 0.008 | 2.9  |
| C        | -0.13  | -0.15  | -0.11 | 97.1*|
| R        | -0.14  | -0.2   | -0.11 |      |

| Variables                        | Characteristics | Difference due to characteristics | Difference due to coefficient |
|----------------------------------|-----------------|-----------------------------------|------------------------------|
|                                  |                 | Coef                              | Pct.                         | Coef                         | Pct. |
| Residence                        | Urban (ref)     | 0.000 (-0.00, 0.00)               | -0.05                        | -0.000(-0.06, 0.064)         | 0.62 |
|                                  | Rural           |                                   |                               |                              |      |
| Mothers work status              | working (ref)   | -0.003 (-0.01, 0.005)             | 2.4                          | 0.03*(0.004, 0.05)           | -18  |
|                                  | Not working     |                                   |                               |                              |      |
| Mother's educational level       | No formal ed    | -0.05 (-0.02, 0.01)               | 3.7                          | 0.2 *(0.01, 0.4)             | -148.3 |
|                                  | Primary         | 0.01 (0.00, 0.05)                 | -3.24                        | 0.03*(0.004, 0.07)           | -25  |
|                                  | Secondary       | 0.000(0.000, 0.0001)              | 0.0002                       | 0.01*(0.002, 0.02)           | -9.2 |
|                                  | Higher (ref)    |                                   |                               |                              |      |
| Father's educational level       | No formal ed    | 0.001(-0.004, 0.005)              | -0.65                        | -0.05(-0.14, 0.05)           | 33.3 |
|                                  | Primary         | 0.001(-0.004, 0.006)              | -0.70                        | -0.02(-0.05, 0.02)           | 12.2 |
|                                  | Secondary       | -0.00 (-0.001, 0.001)             | 0.02                         | (-0.02, 0.11)                | 1.9  |
|                                  | Higher (ref)    |                                   |                               |                              |      |
| Family members                   | <=5 (ref)       |                                   | -0.002 (-0.005, 0.001)       | 1.2                          | 0.41*(0.02, 0.06)            | -30  |
|                                  | >=6             |                                   |                               |                              |      |
| Number of under-five children    | <=2 (ref)       | -0.001 (-0.002, 0.000)            | 0.47                         | -0.005(-0.011, 0.002)        | 3.7  |
|                                  | >=3             |                                   |                               |                              |      |
| Sex of household head            | Male (ref)      | 0.0003 (-0.000, 0.001)            | -0.22                        | -0.004(-0.1, 0.003)          | 2.6  |
|                                  | Female          |                                   |                               |                              |      |
| Media exposure                   | Yes (ref)       | 0.001(-0.008, 0.003)              | -0.87                        | -0.02(-0.07, 0.03)           | 16.7 |
|                                  | No              |                                   |                               |                              |      |
| Water source                     | Improved (ref)  | 0.07 (-0.004, 0.004)              | -0.005                       | 0.04(-0.017, 0.046)          | -10.4|
|                                  | Not improved    |                                   |                               |                              |      |
| Mothers work status              | working (ref)   | -0.003 (-0.01, 0.005)             | 2.4                          | 0.03*(0.004, 0.05)           | -18  |
|                                  | Not working     |                                   |                               |                              |      |
| Constant                         |                 | -0.37* (-0.58, -0.16)             |                               |                              | 266.6 |

(* = significant at 5% level of significance)
**Multilevel analysis based on Bayesian approach**

**Random intercept only model**

In this model Rhat value is one and all effective sample size (both Bulk_ESS and Tail_ESS) are greater than 1000. Therefore this model is converged. The variance between regions having diarrhea is 0.72 which is significant because the 95% credible interval didn’t contain zero. Therefore we reject the null hypothesis which states that the variation across the region was zero. So that the variation of having diarrhea among under-five children in Ethiopia between regions was none zero (Table 4). The results also displayed that the intraclass correlation coefficient (ICC) was 0.14, meaning that roughly 14% of the variability in prevalence of diarrhea among under-five children was attributable to the regional level (Table 4).

**Table 4: Model 1 without covariates**

|                       | Estimates | SE  | AOR | 95%CrI | Rhat | Bulk_ESS | Tail_ESS |
|-----------------------|-----------|-----|-----|--------|------|----------|----------|
| **Fixed effect**      |           |     |     |        |      |          |          |
| $\beta_0$= intercept* | -2.1      | 0.11| 0.1 | 0.09   | 0.2  | 1        | 1256     |
| **Random effect**     |           |     |     |        |      |          |          |
| $\sigma^2$           | 0.52      | 0.19| 0.1 | 1.1    | 1    | 1328     | 1901     |
| ICC                   | 0.14      | 0.11| 0.18|        |      |          |          |
| LOO                   | 74970     |     |     |        |      |          |          |
| WAIC                  | 74976     |     |     |        |      |          |          |

(*= significant at 5% level of significance)
Model with individual level factors only
As shown in table 6, this model Rhat value is one and all effective sample sizes (both Bulk_ESS and Tail_ESS) are greater than 1000 for each estimate values. In addition to this sex of the child, weight of the child, age of the child, breast feeding, sex of household head, wealth index, number of family members, number of under-five children, mothers working status, health insurance, vaccine for rotavirus and type of child waste disposal were significantly associated with diarrhea among under five children in Ethiopia (Table 5).
Table 5: Model 2 fitted by individual level factors only

| Fixed effect                  | Characteristics        | Estimate | SE   | AOR  | 95%CrI L-CrI U-CrI | Rhat | Bulk_ESS | Tail_ESS |
|-------------------------------|------------------------|----------|------|------|--------------------|------|----------|----------|
| β0-intercept*                 |                        | -5.79    | 0.66 | 0.00 | 0.00               | 0.01 | 1        | 7416     | 12213    |
| Sex of child                  | Male (ref)             |          |      |      |                    |      |          |          |
|                               | Female*                | 0.44     | 0.08 | 1.55 | 1.31               | 1.83 | 1        | 3800     | 3995     |
| Twin                          | Yes                    | 0.19     | 0.2  | 1.21 | 0.83               | 1.77 | 1        | 29375    | 13792    |
|                               | No (ref)               |          |      |      |                    |      |          |          |
| Weight of a child at birth    | Small                  | 0.17     | 0.11 | 0.84 | 0.69               | 1.03 | 1        | 25302    | 14351    |
|                               | Average (ref)          |          |      |      |                    |      |          |          |
|                               | Big*                   | 0.5      | 0.11 | 1.65 | 1.32               | 2.05 | 1        | 22959    | 15308    |
| Birth order                   | First (ref)            |          |      |      |                    |      |          |          |
|                               | 2 – 3                  | -0.32    | 0.26 | 0.73 | 0.45               | 1.22 | 1        | 11507    | 13120    |
|                               | 4 – 5                  | -0.35    | 0.28 | 0.71 | 0.41               | 2    | 1        | 10980    | 12821    |
|                               | >=6                    | -0.37    | 0.30 | 0.69 | 0.40               | 1.26 | 1        | 10423    | 11916    |
| Birth interval                | <=<23 month            | -0.12    | 0.08 | 0.89 | 0.76               | 1.04 | 1        | 24797    | 14898    |
|                               | =>24 month (ref)       |          |      |      |                    |      |          |          |
| Age of child                  | <=1<2 year             | 0.21     | 0.13 | 1.23 | 0.95               | 1.6  | 1        | 2813     | 4510     |
|                               | >=2<3 year             | 0.01     | 0.13 | 1.01 | 0.78               | 1.31 | 1        | 8782     | 6148     |
|                               | >=3<4 year*            | -0.51    | 0.15 | 0.6  | 0.45               | 0.8  | 1        | 4524     | 5085     |
|                               | =>4<5 year*            | -1.2     | 0.18 | 0.3  | 0.21               | 0.43 | 1        | 3485     | 4312     |
| Breast feeding                | Still feeding (ref)    | -0.13    | 0.08 | 0.87 | 0.75               | 1.02 | 1        | 29492    | 13970    |
|                               | Ever feed but not now |         |      |      |                    |      |          |          |
|                               | Never feed*            | -4.62    | 0.82 | 0.01 | 0.00               | 0.04 | 1        | 32438    | 12662    |
| Rotavirus vaccine             | vaccinated(ref)        | 0.37     | 0.13 | 1.45 | 1.13               | 1.89 | 1        | 24053    | 14971    |
|                               | Not vaccinated*        |          |      |      |                    |      |          |          |
| Measles' vaccine              | vaccinated (ref)       | -0.07    | 0.11 | 0.93 | 0.75               | 1.15 | 1        | 22111    | 14956    |
|                               | Not vaccinated         |          |      |      |                    |      |          |          |
| Vitamin supplemented          | Yes (ref)              | -0.19    | 0.09 | 0.83 | 0.66               | 1.04 | 1        | 25507    | 14935    |
|                               | No                     |          |      |      |                    |      |          |          |
| Mothers working status        | Working (ref)          | 0.24     | 0.12 | 1.27 | 1.01               | 1.6  | 1        | 24847    | 15706    |
|                               | Not working*           |          |      |      |                    |      |          |          |
| Wealth index                  | Poor*                  | .95      | 0.23 | 2.6  | 1.7                | 4.03 | 1        | 16045    | 14275    |
|                               | Medium                 | 0.09     | 0.24 | 1.1  | 0.68               | 1.74 | 1        | 14461    | 14475    |
|                               | Rich (ref)             |          |      |      |                    |      |          |          |
| Health insurance              | Yes (ref)              | 0.78     | 0.27 | 2.2  | 1.28               | 3.75 | 1        | 22749    | 13767    |
|                               | No*                    |          |      |      |                    |      |          |          |
| Distance to health facility   | Not long (ref)         | -0.9     | 0.07 | 0.92 | 0.80               | 1.35 | 1        | 39952    | 9417     |
| Fixed effect                  | Characteristic               | Estimates | SE | AOR  | 95% CrI | Rhat | Bulk_ESS | Tail_ESS |
|------------------------------|-----------------------------|-----------|----|------|---------|------|----------|----------|
| Mother’s educational level   | No formal education         | 0.12      | 0.45 | 1.13 | 9.47    | 2.72 | 1        | 10980    | 12821    |
|                              | Primary                     | -0.75     | 0.42 | 0.47 | 0.21    | 1.1  | 1        | 9007     | 12634    |
|                              | Secondary                   | -0.74     | 0.43 | 0.48 | 0.21    | 1.1  | 1        | 9079     | 12634    |
|                              | Higher (ref)                |           |     |      |         |      |          |          |          |
| Father’s educational level   | No formal education         | -0.55     | 0.37 | 0.58 | 0.28    | 1.21 | 1        | 9487     | 11643    |
|                              | Primary                     | 0.07      | 0.37 | 1.1  | 0.52    | 2.2  | 1        | 10376    | 13442    |
|                              | Secondary                   | -0.05     | 0.37 | 0.95 | 0.45    | 2    | 1        | 9326     | 11632    |
|                              | Higher (ref)                |           |     |      |         |      |          |          |          |
| Sex of household head        | Male (ref)                  |           |     |      |         |      |          |          |          |
|                              | Female*                     | -0.61     | 0.14 | 0.55 | 0.4     | 0.72 | 1        | 26077    | 14244    |
| Media exposure               | Yes (ref)                   | 0.11      | 0.19 | 1.11 | 0.8     | 1.61 | 1        | 22407    | 15301    |
|                              | No                          |           |     |      |         |      |          |          |          |
| Family members               | <=5 (ref)                   | 0.35      | 0.13 | 1.41 | 1.1     | 1.8  | 1        | 19389    | 14735    |
|                              | =>6                         |           |     |      |         |      |          |          |          |
| Number of U-5 children       | <=2 (ref)                   | 0.26      | 0.1  | 1.3  | 1.1     | 1.6  | 1        | 23311    | 15564    |
|                              | =>3                         |           |     |      |         |      |          |          |          |
| Drinking water               | Improved (ref)              |           |     |      |         |      |          |          |          |
|                              | Not improved                | -0.18     | 0.95 | 0.84 | 0.70    | 1.01 | 1        | 20154    | 14786    |
| Child waste disposal         | Safe (ref)                  | 1.44      | 0.14 | 4.2  | 3.2     | 5.6  | 1        | 22683    | 15326    |
|                              | Not safe                    |           |     |      |         |      |          |          |          |
| Type of toilet               | Improved *                  | 0.25      | 0.12 | 1.3  | 1       | 1.6  | 1        | 21514    | 15321    |
|                              | Not improved                |           |     |      |         |      |          |          |          |
| Random effect                | \( \sigma_{\mu_0}^2 \)     | 0.38      | 0.05 | 0.25 | 0.53    | 1    | 4116     | 7893     |
|                              | ICC                         | 0.11      | 0.10 | 0.1  | 0.13    |      |          |          |          |
|                              | LOO                         | 7968      |     |      |         |      |          |          |          |
|                              | WAIC                        | 7958      |     |      |         |      |          |          |          |

(Ref = reference category, *= significant at 5% level of significance)
**Model with only community level factors**

As shown in table 6, this model Rhat value is one and all effective sample sizes (both Bulk_ESS and Tail_ESS) are greater than three hundred times the number of chains.

**Table 6: Model 3 fitted by community level factors only**

| Characteristics | Estimates | SE  | AOR  | 95%CrI   | Rhat | Bulk_ESS | Tail_ESS |
|-----------------|-----------|-----|------|----------|------|----------|----------|
| Fixed effects   |           |     |      |          |      |          |          |
| β0-intercept*   | -2.2      | 0.21| 0.11 | 0.08     | 0.17 | 1        | 2798     | 5647     |
| Residence       | Urban (ref) |   |      |          |      |          |          |
| Rural           | 0.1       | 0.11| 1.1  | 0.90     | 1.35 | 1        | 3459     | 7155     |
| Random effect   |           |     |      |          |      |          |          |
| σμ*             | 0.52      | 0.19| 0.1  | 1.1      | 1    | 1        | 3805     | 7577     |
| ICC             | 0.14      |     | 0.11 | 0.18     |      |          |          |
| LOO             | 7998      |     |      |          |      |          |          |
| WAIC            | 7981      |     |      |          |      |          |          |

(Ref = reference category), (*= significant at 5% level of significance)
Model with both individual and community level factors

As shown in table 7, this model Rhat value is one and all effective sample sizes (both Bulk_ESS and Tail_ESS) are greater than 1000. Therefore this model was converged. This model has smallest Widely Applicable Information Criteria (WAIC =7904) as compared to random intercept only model (WAIC=74976), model with only individual level factors (WAIC=7981) and model with only community level factors (WAIC=7958). Therefore this model is the best fitted model for the data because it has smallest WAIC as compared to the rest models. So interpretation and reports were made based on this model. Of all the factors included in the full model (model with both individual and community level factors) for multilevel analysis, being twin, child’s age, weight of child at birth, vaccinated for measles and rotavirus, number of under-five children, number of family members, wealth index, distance to health facility, member of health insurance and child waste disposal method were significantly associated with under-five children diarrhea in Ethiopia.

Being twin, the odds of having diarrhea were 30% (AOR=1.3; 95% CrI 1.1-1.5) higher than those children who were single (AOR=1.3; 95% CrI 1.1-1.5). The odds of having diarrhea among children whose weight was big at birth were 63% (AOR=1.63; 95% CrI 1.62- 2.02) higher as compared to children whose weight was average (normal) at birth. The odds of developing diarrhea among children in the age group between 1–2 years were 1.3 times (AOR=1.3; 95 % CrI 1.06–1.47) higher than those children whose age was below one years. Children who were not vaccinated for rotavirus and Measles were 1.44 and 1.2 times (AOR= 1.44; 95 % CrI 1.12–1.9, AOR= 1.2; 95 % CrI 1.1–1.33) more likely to develop diarrhea than to those who were vaccinated for rotavirus and measles respectively. The odds of developing diarrhea in children living in households who were not a member of health insurance were 2.2 times (AOR 2.2; 95 % CrI 1.3–3.8) higher than children living in households who a member of health insurance. And also children living in households who travel long distance to health facility were 2.7 times (AOR 2.7; 95 % CrI 2.2–3.5) higher than children living in households who short distance to health facility. The odds of having diarrhea among children living in households with no safe child waste disposal methods were 4.2 times (AOR 4.2; 95 % CrI 3.2 –5.6) higher than in children living in households with safe child waste disposal methods (Table 7).
| Fixed effect                  | Category          | Estimates | SE  | AOR  | 95%CrI of AOR | Rhat | Bulk_ESS | Tail_ESS |
|------------------------------|-------------------|-----------|-----|------|---------------|------|----------|----------|
| \( \beta_0 \) intercept*    |                   | -5.8      | 0.7 | 0.00 | 0.00          | 0.01 | 1        | 5814     | 9217     |
| Sex of child                 | Male (ref)        |           |     |      |               |      |          |          |
|                              | Female            | -0.11     | 0.07| 0.89 | 0.78          | 1.02 | 1        | 10361    | 5807     |
| Twin                         | Yes*              | 0.26      | 0.07| 1.3  | 1.1           | 1.5  | 1        | 19613    | 8366     |
|                              | No (ref)          |           |     |      |               |      |          |          |
| Weight of child at birth     | Small             | -0.19     | 0.11| 0.83 | 0.67          | 1.02 | 1        | 19808    | 14137    |
|                              | Average (ref)     |           |     |      |               |      |          |          |
|                              | Big*              | 0.48      | 0.11| 1.63 | 1.62          | 2.02 | 1        | 20612    | 13727    |
| Birth order                  | First (ref)       |           |     |      |               |      |          |          |
|                              | 2 – 3             | -0.36     | 0.26| 0.7  | 0.43          | 1.2  | 1        | 10903    | 11827    |
|                              | 4 – 5             | -0.25     | 0.29| 0.78 | 0.44          | 1.38 | 1        | 10235    | 10907    |
|                              | =>6               | -0.29     | 0.3  | 0.76 | 0.42          | 1.35 | 1        | 10209    | 10942    |
| Birth interval               | <=23 month        | -0.03     | 0.08| 0.97 | 0.83          | 1.13 | 1        | 20381    | 13298    |
|                              | =>24 month (ref)  |           |     |      |               |      |          |          |
| Age of child                 | <1 year (ref)     |           |     |      |               |      |          |          |
|                              | =>1<2 year*       | 0.22      | 0.08| 1.3  | 1.06          | 1.47 | 1        | 9648     | 5850     |
|                              | =>2<3 year        | -0.15     | 0.09| 0.86 | 0.72          | 1.03 | 1        | 3604     | 4530     |
|                              | =>3<4 year*       | -0.54     | 0.1  | 0.6  | 0.48          | 0.71 | 1        | 3251     | 4625     |
|                              | =>4<5 year        | -1.23     | 0.12| 0.3  | 0.23          | 0.4  | 1        | 3377     | 4837     |
| Breast feeding               | Still breast feed |           |     |      |               |      |          |          |
|                              | (ref)             |           |     |      |               |      |          |          |
|                              | Ever breast feed  | -0.09     | 0.8  | 0.91 | 0.78          | 1.07 | 1        | 24022    | 13505    |
|                              | but not now       | -0.27     | 0.31| 0.80 | 0.42          | 1.42 | 1        | 22263    | 12015    |
|                              | Never breast feed |           |     |      |               |      |          |          |
| Rota vaccine                 | vaccinated (ref)  |           |     |      |               |      |          |          |
|                              | Not vaccinated*   | 0.32      | 0.13| 1.44 | 1.12          | 1.9  | 1        | 9367     | 6075     |
| Measles’ vaccine             | Yes (ref)         | 0.2       | 0.05| 1.2  | 1.1           | 1.33 | 1        | 14128    | 6067     |
|                              | No*               |           |     |      |               |      |          |          |
| Vitamin supplementation      | Yes (ref)         |           |     |      |               |      |          |          |
|                              | No                | -0.12     | 0.06| 0.88 | 0.78          | 1.01 | 1        | 25507    | 14935    |
| Wealth index                 | Poor*             | .95       | 0.23| 2.6  | 1.7           | 4.03 | 1        | 16045    | 14275    |
|                              | Medium            | 0.09      | 0.24| 1.1  | 0.68          | 1.74 | 1        | 14461    | 14475    |
|                              | Rich (ref)        |           |     |      |               |      |          |          |
| Mothers working status       | Working (ref)     |           |     |      |               |      |          |          |
|                              | Not working       | 0.24      | 0.2  | 1.3  | 1.0           | 1.6  | 1        | 8311     | 5878     |
| Health insurance             | Yes (ref)         |           |     |      |               |      |          |          |
|                              | No*               | 0.78      | 0.27| 2.2  | 1.3           | 3.8  | 1        | 7888     | 5393     |
Continuation of above table

| Fixed effect                        | Category                        | Estimates | SE  | AOR  | 95%CrI of AOR     | Rhat | Bulk_ ESS | Tail_ ESS |
|-------------------------------------|---------------------------------|-----------|-----|------|------------------|------|-----------|-----------|
|                                     |                                 | L-CrI     | U-CrI|      |                  |      |           |           |
| Distance to health facility         | Not long (ref)                  |           |     |      |                  |      |           |           |
|                                     | Long *                          | 1         | 0.12| 2.7  | 2.2              | 3.5  | 1         | 6206      | 5558      |
| Mother’s educational level          | No formal education             | -0.62     | 0.43| 0.54 | 0.23             | 1.23 | 1         | 8733      | 10849     |
|                                     | Primary                         | -0.5      | 0.43| 0.60 | 0.26             | 1.37 | 1         | 8748      | 10747     |
|                                     | Secondary                       | 0.58      | 0.47| 1.78 | 0.71             | 4.47 | 1         | 11355     | 12382     |
|                                     | Higher (ref)                    |           |     |      |                  |      |           |           |
| Health insurance                    | Yes (ref)                       | 0.78      | 0.27| 2.2  | 1.3              | 3.8  | 1         | 7888      | 5393      |
|                                     | No*                             |           |     |      |                  |      |           |           |
| Distance to health facility         | Not long (ref)                  |           |     |      |                  |      |           |           |
|                                     | Long *                          | 1         | 0.12| 2.7  | 2.2              | 3.5  | 1         | 6206      | 5558      |
| Father’s educational level          | No formal education             | -0.7      | 0.38| 0.5  | 0.24             | 1.04 | 1         | 8430      | 10462     |
|                                     | Primary                         | -0.09     | 0.38| 0.91 | 0.44             | 1.90 | 1         | 9386      | 12115     |
|                                     | Secondary                       | -0.16     | 0.38| 0.85 | 0.41             | 1.8  | 1         | 8416      | 10409     |
|                                     | Higher (ref)                    |           |     |      |                  |      |           |           |
| Household head                      | Male (ref)                      | -0.22     | 0.13| 0.81 | 0.61             | 1.05 | 1         | 8669      | 6074      |
|                                     | Female*                         |           |     |      |                  |      |           |           |
| Media exposure                      | Yes (ref)                       | 0.27      | 0.19| 1.30 | 0.89             | 1.9  | 1         | 17430     | 14082     |
|                                     | No                              |           |     |      |                  |      |           |           |
| family members                      | <=5(ref)                        | 0.35      | 0.13| 1.41 | 1.1              | 1.83 | 1         | 7623      | 5854      |
|                                     | =>6*                            |           |     |      |                  |      |           |           |
| No of under five children           | <=2 (ref)                       | 0.26      | 0.11| 1.3  | 1.1              | 1.61 | 1         | 9026      | 5453      |
|                                     | =>3*                            |           |     |      |                  |      |           |           |
| Source of drinking water            | Improved(ref)                   | -0.17     | 0.12| 0.84 | 0.66             | 1.06 | 1         | 19868     | 13216     |
|                                     | Not improved                    |           |     |      |                  |      |           |           |
| Child waste disposal                | Safe (ref)                      | 1.44      | 0.14| 4.2  | 3.2              | 5.6  | 1         | 7238      | 5718      |
|                                     | Not safe*                       |           |     |      |                  |      |           |           |
| Type of toilet                      | Improved(ref)                   | 0.21      | 0.13| 1.23 | 0.95             | 1.6  | 1         | 18719     | 13886     |
|                                     | Not improved                    |           |     |      |                  |      |           |           |
| Random effect                       | $\sigma_{\mu_0}^2$             | 0.36      | 0.05| 0.25 | 0.52             | 1    | 1500      | 2913      |
| ICC                                 |                                 | 0.11      | 0.10| 0.13 |                  |      |           |           |
| LOO                                 |                                 | 7931      |     |      |                  |      |           |           |
| WAIC                                |                                 | 7904      |     |      |                  |      |           |           |

(Ref = reference category), (* = significant at 5% level of significance)
**Discussion**

Diarrheal diseases are a major cause of child mortality and one of the main causes of medical consultation for children in Sub-Saharan African countries \(^\text{14}\). The aim of this study was to describe trends, identify the factors that contributed positively or negatively for the change in diarrhea prevalence among under five children for the last sixteen years and to identify determinants of diarrhea in Ethiopia based on data of 2016 Ethiopian Demographic and Health Survey.

In this study, the trend of diarrhea prevalence has been significantly declined from 26% in 2000 to 12% in 2016 (overall phase). This finding is compatible with the study done in democratic republic of Congo \(^\text{8,30}\). This could be due to the launching of the Health Extension Program (HEP), improving access to health care to meet the primary attention of the MDG agenda and the introduction of integrated community cause management program\(^\text{31,32}\). When we decompose this change, behavioral change of the respondents between the surveys contributed 97.1% for the decline of diarrhea prevalence over the last sixteen years. From decomposition analysis, surprisingly behavioral change of women who hadn’t formal education contributed more than 148% for the change of diarrhea prevalence among under-five children in Ethiopia. Similarly, behavioral change of women who were not working and households who had more than six family members contributed 18% and 30% respectively for the change. Comparable finding was also reported from the study conducted in Democratic Republic of Congo\(^\text{30}\). This could be due to Governments commitment to improve awareness of the community through health education and enabling them to use health services.

The multilevel binary logistic regression analysis based on Bayesian approach revealed that from child socio-demographic characteristics; being twin, weight of the child at birth and age of the child were significantly associated with diarrhea among under-five children. As indicated by related literatures; similarly, this finding showed that being twin were more risk to be infected by diarrhea as compared to children who were single. This finding is consistent with the study conducted in Bangladesh, Cameroon, Nigeria and Niger\(^\text{33-35}\). This might be due to children who are twin might not get exclusive breast milk at early ages and are not immune. Similarly, the quality of care and attention from parents decreased. So they are easily susceptible for different diseases. Children who were
obese at birth were more likely to develop diarrhea as compared to children who were normal at birth. This might be due to microbial metabolites, particularly short chain fatty acids, can lead to signaling changes in the host enterocytes and motility disorders and finally causes diarrhea. The odds of developing diarrhea among children in the age group between 1–2 years were higher than those children whose age was below one year. On the contrary, the odds of developing diarrhea among children in the age group between 3–4 years were less likely to be occur than those children whose age was below one year. This finding was supported by previous studies conducted from Ethiopia, Ghana, Cameroon, Bangladeshi, Niger and Nigeria. This could be due to, the age six month to two years are the time of crawling and at this time children eat whatever they get even their fecal matter if their care givers are irresponsible for their child care; but children whose age is greater than two years can differentiated dirty things and don’t eat whatever they get.

From Socio-economic and demographic characteristics of household; number of under-five children, family size, wealth status of the household, member of health insurance and distance to health facility were significantly associated with diarrhea among under-five children. Children from households who had greater than two under-five children were more risk to be infected by diarrhea as compared to children from households who had equal to or less than two under-five children. Similarly, children who were from households who had greater than six family members were more risk to develop diarrhea as compared to children who were from households who had less than five family members. This finding is concurrent with previous studies conducted in Ethiopia. If the number of under-five children and family members increased in the household, it is expected that children will be more vulnerable to diarrhea mainly because of the decreased quality of care and attention from parents. The odds of having diarrhea in children who were from poor household wealth status were higher than those who were from the rich households. This finding is supported by the study conducted in India. This is because in resource-limited settings, like Ethiopia; children can’t get balanced diets, improved type of drinking water and health care. The odds of developing diarrhea among children living in households who were not a member of health insurance and who travel long distance to health facility was higher as compared to children living in households who were a member of health insurance and who travel short distance to
health facility. This study was supported by a study conducted in Egypt, Nigeria and Tanzania.\textsuperscript{33, 35, 44} This might be due to the fact that households who hadn’t health facilities close to their area of residence and who have not community based health insurance may not access health care services easily.

Moreover, from the child care related factors, vaccinated for rotavirus and measles were associated with diarrhea among under five children. The study revealed that children who were not vaccinated for rotavirus and measles were more risk to experience diarrhea as compared to those children who were vaccinated. This finding was in agreement with the previous study conducted in Ethiopia.\textsuperscript{45} Measles is a highly contagious disease which disrupts the epithelial cells and suppresses the immune system leading to infection in various organ systems and protein losing enteropathy.\textsuperscript{46} Similarly, Rotavirus is the most common cause of severe gastroenteritis and diarrhea among young children worldwide.\textsuperscript{47} Due to this reason, rotavirus vaccine was introduced by WHO in 2006\textsuperscript{48} and after 7 year, our country Ethiopia has begun to give rotavirus vaccine in 2013.\textsuperscript{17} Once more, from the hygiene and sanitation related factors, unsafe disposal of child waste was significantly associated with diarrhea among under five children. Children who were from households who dispose waste unsafely were more likely to develop diarrhea as compared to children who were from households who dispose waste safely. This finding is consistent with the findings in Bangladeshi, Cameroon and sub-Saharan countries (Nigeria, Niger, and Burki-nafaso).\textsuperscript{37-41} This is because if they don’t disposed any waste materials properly including child’s wastes, children as well as adults are risk for feco-oral diseases through flies.\textsuperscript{49}

**Strengths and limitations of the study**

Fitting multilevel model using Bayesian approach to get fine estimates of the parameters and considering all the national regional states of Ethiopia by taking large sample size at different time points was the strength of this study. To show trends and to perform decomposition analysis, we can’t get some variables for each survey (for example health insurance, distance to health facility and wealth index).

**Conclusion and recommendations**

The prevalence of diarrhea was significantly declined over the last sixteen years and the decline was due to difference in coefficients between the surveys. From this, majority of the decline was due to behavioral change of women who hadn’t formal education. Based
on multilevel analysis being twin, age of the child, weight of child at birth, vaccinated for measles and rotavirus, number of under-five children, number of family members, wealth status, distance to health facility, health insurance and child waste disposal method were significantly associated with diarrhea among under five-children in Ethiopia. Therefore Ethiopian government and Ministry of Health should primarily focus on the strengthening and scaling up of behavioral change package strategies of the community to prevent diarrheal disease. Similarly the government should resolve structural related problems that precipitate diarrhea disease of under-five children. The Health Institutions should enforce the communities to implement diarrhea management strategies via the existing health extension packages with greatest tone than the previous by considering those modifiable factors of diarrhea. And also the community should be a member of health insurance, should vaccinate their children based on the national guideline, should practice safe waste disposal methods and implement all the components of health extension packages based on health professional’s order with a greatest tone than the previous trend.

Abbreviations

AOR: Adjusted Odds Ratio; CrI: Credible interval; DHS: Demographic Health Survey; EA: Enumeration Area; EDHS: Ethiopian Demographic and Health Survey; HMC: Hamiltonians Monte Carlo; LOO: Leave-One-Out Cross-Validation; WAIC: Widely Applicable Information Criteria; WHO: World Health Organization.

Declarations

Ethics approval and consent to participate
Not applicable

Consent for Publication
Not applicable

Availability of Data and Materials
The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interests
The authors declare that they have no competing interests.

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We did not receive any fund for this research.

**Authors’ Contribution**

YN, AA, AN and TA were involved for this study from the inception to design, acquisition of data, data cleaning, data analysis and interpretation and drafting and revising of the manuscript. TA prepared the final draft of the manuscript. All authors read and approved the final manuscript.

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