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Research Article

Determinants of Diarrhea among Children under Age Five Using Generalized Linear Model with Bayesian Approach: The Case of Kuyu General Hospital, Oromia Region, Ethiopia

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ABSTRACT

Background: Diarrhea is a major health problem and the most common cause of illness and the second leading cause of child death in the world. Globally, an estimated 2 billion cases of diarrheal disease occur each year, and 1.9 million children under the age of 5 years, mostly in developing countries, die from diarrhea. The burden diarrhea is greatest in the developing world including Ethiopia.

Objective: This study was conducted to identify the influential determinants of diarrhea disease among children under age five in Kuyu General Hospital, North Shoa Zone, Oromia Region, Ethiopia.

Methods: A retrospective cross-sectional study was conducted on under-five children who were hospitalized with diarrhea at Kuyu General Hospital from September 2015 up to August 2018. A total of 612 under five children were included in the study. The statistical methods of data analysis used were Bayesian generalized linear model and Bayesian semi-parametric regression models and inference was made based on penalized likelihood.

Results: Among 612, under five children included in this study, 503 (82.2%) of them had diarrhea. The semi-parametric regression model with Bayesian approach was found to be the best model to fit the data. The study revealed that children who reside in rural areas, children have low weight-for height, stunting children, children who were not ever vaccinated, children who were not breastfed, children from households with no toilet facility and children from mothers who use unprotected source of drinking water were found to be significantly associated with increased risk childhood diarrhea.

Conclusion: Bayesian semi parametric regression model fitted the data better than the others. The study suggests supply of improved drinking water, expanded program on vaccination, and initiation to adopt the culture of breastfeeding their children to reduce the risk of diarrhea among under-five children in the study area.

Keywords: Diarrhea; Kuyu general hospital; Bayesian semi parametric regression model

Abbrevations: Akaike Information Criteria (AIC); Deviance Information Criterion (DIC); Highest Density Interval (HDI); Multiple Generalized Cross Validation (MGCV); Effective number of parameters in models (pD); National Center for Health Statistics (NCHS); Standard Deviation (SD); Weight for Age Z-Score (WAZ); World Health Organization (WHO)

INTRODUCTION

Diarrhea is the passage of three or more loose or watery stools per day or more frequently than normal. Globally, an estimated 2 billion cases of diarrhea disease occur each year and 1.9 million children under the age of 5 years die from diarrhea [1]. Diarrhea causes death by depleting body fluids resulting in profound dehydration. About 88% of diarrhea associated deaths are attributable to unsafe water, inadequate sanitation, and insufficient hygiene [2]. Diarrhea accounts for an estimated 3.6% of the global burden of disease [3]. Diarrhea is transmissible disease that can be spread rapidly in areas with inadequate treatment of sewage and drinking water. It has been established that the risk factors for diarrhea occurrences varied from one country to another; nevertheless the main risk factors among children included age of the child, quality and amount of water,

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availableness of bathroom facilities, housing conditions, level of education, household economic standing, place of residence, feeding practices and the general sanitary conditions around the house [4]. In addition, the demographic factors of a child which can play a role in the risk of diarrhea include age, immunization status, and gender and birth weight [5]. Diarrhea spreads from person to person aggravated by poor personal hygiene. Food is another major cause of diarrhea when it is prepared or stored in unhygienic conditions. Unsafe domestic water storage and handling is also an important risk factor. Fish and seafood from polluted water may also contribute to the disease [6]. It is usually a symptom of an infection in the intestinal tract, which can be caused by a variety of causative agents. These causative agents include viruses, bacteria and parasites [7,8].

In Africa, children experience five episodes of diarrhea and 800,000 of children lose their life annually, which accounts for 25% of all childhood death [9]. In Mbour, Senegal the prevalence of diarrhea among children under the age of five during the 2 weeks preceding the survey was 26% and there was significant associations between diarrhea diseases and no treatment of stored drinking water and use of shared toilets.

In Ethiopia, the 2 weeks prevalence of diarrhea disease ranges from 10% to 40%. According to the Ethiopian Demographic and Health Survey (EDHS 2016) report, 12% of under-five children in Ethiopia ever had diarrhea within 2 weeks preceding the survey. The same report has shown that in Oromia region the two week period prevalence of diarrhea in under-five children was about 10.7%. In the year 2016 alone, diarrhea killed almost fifteen thousand under-five children in Ethiopia [10].

Studies that have been done previously in Ethiopia show that socioeconomic status, monthly income, number of under-five children, nutritional status of child, methods of complementary feeding, types of water storage equipment, mother's/caregiver's educational status, lack of hand washing facilities, duration of breastfeeding, improper waste disposal practices, hand washing practice of mother's/caregiver's after latrine visit were significant factors for occurrences of diarrhea disease in under-five children [11,12]. The success of any policy or health care intervention depends on a correct understanding of the socio-economic, environmental, demographic, and behavioral factors which may influence the prevalence of disease. So, this study attempted to identify the influential determinants of diarrhea disease among children under age five in Kuyu General Hospital using Bayesian generalized linear model.

MATERIALS AND METHODS

Study design, area and period

A retrospective cross-sectional study design was employed on under-five children who had been registered and hospitalized with diarrhea at Kuyu General Hospital from September 2015 up to August 2018. Kuyu General Hospital is located in Kuyu District. Kuyu District is located in North Shoa Zone, Oromia Region, Ethiopia. Kuyu District is 155 km away from Addis Ababa, Capital of Ethiopia.

Target population and sample size

The target population of the study was all under-five children who had been registered and hospitalized with diarrhea at Kuyu General Hospital from September 2015 up to August 2018. The study used data on 612 patients for whom data for variables of interest are complete.

Data collection tool, procedures, and quality control

The data were extracted from the patients' identification card. One day training was given for supervisors and data collectors. Data quality was controlled by designing the proper data collection materials and through continuous supervision. The completed data collection forms were examined for completeness and consistency during data management, storage and analysis.

Inclusion and exclusion criteria

All under-five children who had been registered and hospitalized with diarrhea and had full information in the registration log book or in the patients' identification card were considered to be eligible for the study. Patients with insufficient information about one of the vital variables either in the registration book or in the cards were not eligible.

Variables of the study

Dependents variable: Dependent variable is the diarrhea status of child.

Independent variables: In this study demographic, socio-economic, environmental and nutritional/health characteristics were proximate determinants of diarrhea. In the study, height and weight measurements of children, taking age into consideration, were converted into Z-scores based on the National Center for Health Statistics (NCHS) reference population recommended by the World Health Organization (WHO). Thus, those below 2 standard deviations of the NCHS median reference for height-for-age, weight-for-age and weight-for-height are defined as stunted, underweighted, and wasted, respectively. All the three indicators are used to describe the level of child malnutrition/health problem. These factors include the child's age, sex of child, duration of breast feeding, mother education level, types of place of residence, source of drinking water, ever had vaccination, types of birth, received vitamin A and toilet facility.

Statistical models

The statistical analysis employed in this study is based on Bayesian approaches which allow a flexible framework for realistically complex models. These approaches allow us to analyze usual linear effects of categorical covariates and nonlinear effects of continuous covariates within a unified semi-parametric Bayesian framework for modeling and inference. Basically, we are interested in model fitting of generalized linear regression model to identify those variables which have linear effects on the childhood Diarrhea. Moreover, we have considered the semi-parametric regression model to look at both effects. Finally, we employed the model comparison criterion to choose the preferable model for the data analysis.

Bayesian generalized linear regression model

Bayesian generalized linear models [13] the response y, is not estimated as a single value, but is assumed to be drawn from a probability distribution. In this study, x successes are observed in N independent Bernoulli trials. Let θ denote the true but unknown probability of success, and suppose that the problem is to find an interval that covers the most likely location for θ given the data. The likelihood is the usual binomial probability formula, the same one used in frequentist analysis-

$$L(x/\theta)=P_i\{x\,successes\,in\,N\,trials\}=\frac{N!}{(N-x)!x!}\theta^x(1-\forall\theta)^{(N-x)}$$

In fact, all one needs to specify is that-

$$L(x/\theta)=P_i\{x\,successes\,in\,N\,trials\}\propto(1-\theta)^{(N-x)}$$

Since, $\frac{N!}{(N-x)!x!}$ is simply a constant that does not involve θ. In other words, inference will be the same whether one uses this constant or ignores it. Although any prior distribution can be used, a convenient prior family is the Beta family, since it is the conjugate prior distribution for a binomial experiment. A random variable, has a distribution that belongs to the Beta family if it has a probability density given by

$$f(\theta)=\begin{cases}\frac{1}{B(\alpha,\beta)}\theta^{\alpha-1}(1-\theta)^{\beta-1} & ,0\le\theta\le1,\alpha,\beta>0\,and \\ 0, & otherwise\end{cases} \quad (1)$$

Where, B(α,β) represents the Beta function evaluated at (α,β).

As always, Bayes Theorem says Posterior distribution ∝ prior distribution × likelihood function

In this case, it can be shown that if the prior distribution is $Beta(\alpha,\beta)$, and the data is x successes in N trials, then the posterior distribution is $Beta(\alpha+è,\beta+N-è)$.

Bayesian semi-parametric regression models

Semi-parametric Bayesian model for generalized linear models with correlated data and random effects are present, where the random effects have a non-parametric prior distribution. The assumption of a parametric linear predictor for assessing the influence of covariate effects on responses seems to be rigid and restrictive in practical application situation and also in many real statistically complex situation since their forms cannot be predetermined a priori. Hence, it is necessary to seek for a more flexible approach for estimating the continuous covariates by relaxing the parametric linear assumptions. This in turn allows continuous covariates to follow their true functional form. This can be done using an approach referred to as nonparametric regression model. To specify a nonparametric regression model, an appropriate smooth function that contains the unknown regression function needs to be chosen. The semi-parametric regression model is obtained by extending model as shown in equation 1:

$$\eta_i=f_1(x_{i1})+\ldots+f_p(x_{ip})+v_{i\gamma}^{'}$$

Here, $i=1,2,\ldots,n$ and p=4 $f_i(x_i)$ are smooth functions of the continuous covariates and $v_{i\gamma}^{'}$ represents the strictly linear part of the predictor.

Bayesian P-splines

Bayesian P-splines are a popular approach for fitting nonlinear effects of continuous covariates in semi parametric regression model. We have used in this study because it has the advantage of allowing for simultaneous estimation of smooth functions and smoothing parameters. Moreover, it can easily be extended to more complex formulations [14]. Any smoother depends heavily on the choice of smoothing parameter and for P-spline in mixed (fixed and continuous) framework. A closed related approach for continuous covariates is based on the P-splines approach [15,16]. The basic assumption of this approach is that the unknown functions f_j, can be approximated by a polynomial spline of degree l and with equally spaced knots $x_{j,min}=\xi_{j0}<\ldots<\xi_{j,kj-1}<\xi_{j,kj}=x_{j,max}$ over the domain of x_j.

Prior distributions

Suppose that $f=(f(1)+\ldots+f(n))^t$ be the vector of corresponding function evaluations at observed values of x. Then, the general form of the prior for f is [17]:

$$f/\tau^2\propto\exp\left(\frac{-1}{2\tau^2}f^tkf\right)$$

Here, K is the penalty matrix that penalizes too abrupt jumps between neighboring parameters. More often, K is not full rank and this implies that follows a partially improper Where, K−1 is a generalized inverse of a band-diagonal precision or penalty matrix K. It is possible to express the vector of function evaluations $f=(f(x_1),f(x_2),\ldots,f(x_n))^{'}$'a nonlinear effect as the matrix product of a design matrix x_j and a vector of regression coefficientsβ_j,f_j=x_j β_j [18].

RESULTS

Descriptive analysis of the data

In this study, a total of 612 under five-children were included. Among 612 children, 503 (82.2%) of them had diarrhea (Table 1). Among under-five children hospitalized with diarrhea at Kuyu General Hospital from September 2015 up to August 2018, 54.2 % of them were males and the remaining 45.8% of the children were females. More than nine-tenth (92.2%) of children's birth type was single and the remaining 7.8% of the children's birth type was multiple. Regarding place of residence, 49% of the children were from urban while the remaining 51% of them were from rural. About two-fifth (39.9%) of the children ever had vaccination while the remaining 60.1% of them ever had no vaccination. Regarding duration of breastfeeding, about one-tenth (10.6%) of the children were never breastfed, two-fifth (60%) of them were not current breastfed and the remaining 29.4% of them were still breastfed (Table 2).

Table 1: Prevalence of diarrhea among children under age five in Kuyu General Hospital.

	Had diarrhea		Total
	Yes	No	
Count	503	109	612
Percent	82.2	17.8	100

Table 2: Background characteristics of children and women.

Variable	Category	Count	Percent
Sex of child	Female	280	45.8
	Male	332	54.2
Place of residence	Urban	300	49
	Rural	312	51
Ever had vaccination	Yes	244	39.9
	No	368	60.1
Duration of breastfeeding	Never breastfeeding	65	10.6
	Not current breastfeeding	367	60
	Still breastfeeding	180	29.4
Source of water supply	Protected	283	46.2
	Unprotected	329	53.8

Maternal education	No formal education	139	22.7
	Primary	322	52.6
	Secondary and higher	151	24.7
Types of birth	Single	564	92.2
	Multiple	48	7.8
Received Vitamin A	No	257	42
	Yes	355	58
Toilet facility	No	318	52
	Yes	294	48

Regarding maternal education, majority (52.6%) of children were born to mothers with primary education level, nearly one-fourth (24.7%) of them were born from mothers with secondary or higher education and the remaining 22.7% of them were born from mothers with no education. More than half (53.8%) of mothers used unprotected source of water while remaining 46.2% of them used protected source of water. More than half (52%) of the children were from mothers who had no toilet facility and the remaining 48% of them were from mothers who had toilet facility. Nearly three-fifth (58%) of the children received Vitamin A while the remaining 42% of them did not receive Vitamin A (Table 2). Proportion of diarrhea of children varies by child's sex. The higher prevalence of diarrhea was observed among male children (84.3%) than the female children (79.6%). Similarly, the proportion of diarrhea differs by type of place of residence. The higher prevalence of diarrhea was observed children resided in rural areas (87.5%) than those resided in urban areas (76.7%) (Table 3). The prevalence of diarrhea was highest among under-five children born to mothers with no educated mothers (84.2%) and it was among under-five children born to mothers with secondary and above education level (78.1%). Similarly, children who received vitamin A drop had lower prevalence of diarrhea (82.5%) than children who didn't receive vitamin A drop (81.7%). The prevalence of diarrhea was higher in children who did not receive vaccination (87.2%) than children who received vaccination (74.6%) (Table 3). The prevalence of diarrhea among under-five children born to mothers who used protected source of water was (75.6%) which was lower than the prevalence of diarrhea among those who were born to mothers who used unprotected source of drinking water (87.8%). The prevalence of diarrhea among under-five children born to mothers who had no private toilet (88.1%) higher compared to those who born to mothers with toilet facility (75.9%) (Table 3).

Inferential analysis result

In this section, the statistical procedure was used in combination with the Bayes X stepwise selection method. This enabled us to select different covariates which contribute to diarrhea. Table 4 displays results for the fixed effects on the under-five childhood diarrhea in Kuyu general hospital. The output gives posterior means, posterior median along with their standard deviations and 95% credible intervals.

Table 3: Prevalence of diarrhea among children under age five by background characteristics in Kuyu General Hospital.

Variable		Category		Total	Percent
		Yes	No		
Sex of child	Female	223	57	280	79.6
	Male	280	52	332	84.3
Place of residence	Urban	230	70	300	76.7
	Rural	273	39	312	87.5
Ever had vaccination	Yes	182	62	244	74.6
	No	321	47	368	87.2
Duration of breastfeeding	Never breastfeeding	52	13	65	80
	Not current breastfeeding	303	64	367	82.6
	Still breastfeeding	148	32	180	82.2
Source of water supply	Protected	214	69	283	75.6
	Unprotected	289	40	329	87.8
Maternal education	No formal education	117	22	139	84.2
	Primary	268	54	322	83.2
	Secondary and higher	118	33	151	78.1
Types of birth	Single	465	99	564	82.4
	Multiple	38	10	48	79.2
Received Vitamin A	No	210	47	257	81.7
	Yes	293	62	355	82.5
Toilet facility	No	280	38	318	88.1
	Yes	223	71	294	75.9

Table 4: Results of Bayesian generalized linear regression model.

Parametric coefficients	Mean	SD	2.50%	50%	97.50%
Intercept	2.0349	0.5123	0.9903	2.0485	3.0799
Age	-0.0326	0.01	-0.0521	-0.0324	-0.0131
Sex (male)	0.686	0.2455	0.2172	0.6863	1.1575
Residence (rural)	0.5413	0.2454	0.0487	0.545	1.0185
WHZ	-0.3564	0.1826	-0.7052	-0.3596	-0.0097
HAZ	-0.255	0.1809	-0.619	-0.257	0.0932
WAZ	0.5295	0.2973	-0.0214	0.5197	1.0904

Vaccination (no)	0.7423	0.2342	0.3039	0.7445	1.2107
Breastfeeding (still)	-0.6193	0.3173	-1.2273	-0.627	0.0221
Water (unprotected)	0.6791	0.2384	0.1951	0.6759	1.142
Toile (yes)	-0.8924	0.2416	-1.3941	-0.8915	-0.4263

Bayesian generalized linear regression model

Age of child, sex of child, place of residence, wasting, vaccination, source of water and toilet facility were found to be statistically significant. One of the benefits of the Bayesian perspective is that, it allows us to make credible interval statements. Credible intervals are similar to confidence intervals, but in the Bayesian framework, the interval really is believed to contain the true population parameter. For instance, a 95% credible interval for a parameter being estimated is interpreted as; there is a 95% probability that the actual parameter is included in that interval. This is because the interval is based on information from the posterior distribution, for instance, one of the predictor's coefficient posterior distributions. For example, we can say there is a 95% probability that the true population value of the rural place of residence coefficient is between 0.0487 and 1.0185.

Bayesian semi-parametric regression model

This model allows us to analyze usual linear effects of categorical covariates and nonlinear effects of continuous covariates within a semi-parametric regression model introduced [16]. All computations to implement the methodology discussed here are carried out with Bayes X program, and with R using the MCMC package [19]. All empirical results are discussed first by using the mgcv (multiple smooth restricted maximum likelihood estimates) package with gam function. After investigating the influential factors for the childhood diarrhea, the fixed effects (linear effects) showed the high importance (highly effect) of toilet facilities. And again, child's sex, types of place residence, vaccination, source of water supply has a significance effect on childhood diarrhea. Besides in the smoothing effects of covariates child's age have slight significance smoothing effects, and wasting and underweight in a poor significance smoothing effect on childhood diarrhea.

Figure 1 displays nonlinear effects and estimated functions of child's age in month and weight for height for under-five year's old child data. The shaded region represents twice the point wise asymptotic standard errors of the estimated curve. The panels in Figure 1 show an interval marked as HDI, which stands for highest density interval. Points inside an HDI have higher probability density (credibility) than points outside the HDI, and the points inside the 95% HDI include 95% of the distribution. Thus, the 95% HDI includes the most credible values of the parameter. The 95%HDI is useful both as a summary of the distribution and as a decision tool. Specifically, the 95% HDI can be used to help decide which parameter values should be deemed not credible that is rejected. This decision process goes beyond probabilistic Bayesian inference, which generates the complete posterior distribution, not a discrete decision regarding which values can be accepted or rejected.one simple decision rule is that any value outside the 95% HDI is rejected. In particular, if we want to decide whether the regression coefficients are non-zero, we consider whether zero is including in 95% HDI. In Bayesian semi parametric regression model, child's age in month and weight for height variables show significant effect on underweight status of children under age of five years old. In figure 1, the negative linear effects on diarrhea at age of child respectively. It's showed that the nonlinear effects of child's age in month shows that the children face a risk of suffering from diarrhea during the first 40 months of their life and then it is slight thereafter.

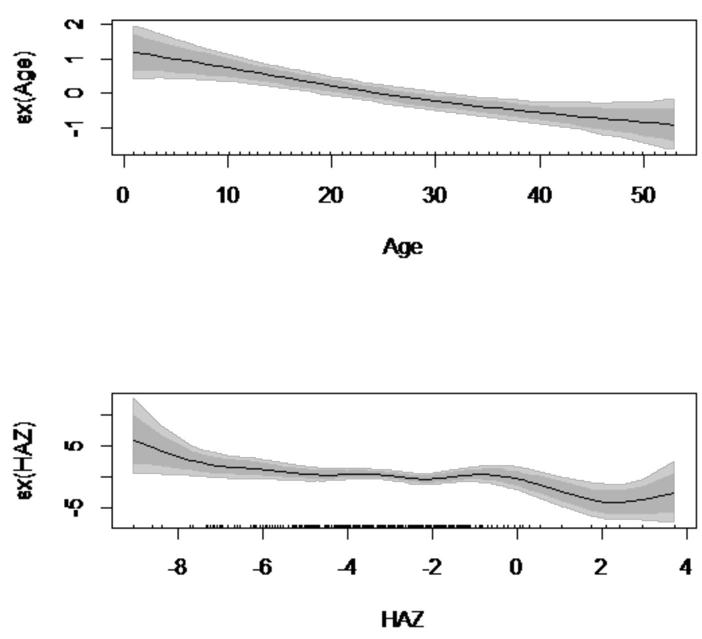

Figure 1: The nonlinear effects of continuous variables on diarrhea among under five years old children in Kuyu General Hospital.

Model comparison

In Bayesian, model selection is an important part of statistical analysis and indeed is a central to the pursuit of science in general. Many authors have examined this question from both Frequentist and Bayesian perspective and many tools selecting the "better model". The models proposed in this study are quite general and the model building process can be quite challenging. Currently, an automated procedure for Bayesian model selection is not available. However, a few recommendations are possible. Users should try to incorporate everything that is theoretically possible and different Bayesian models could be compared *via* the DIC [19]. Thus, at the first stage of this model comparison, the most interesting fact here is that it is the better model in terms of AIC. Model 2 (Generalized linear regression model with Bayesian approach) has less value (535.349), and it is chosen by the data analyst. The point is that model 2 is a better model than model 1 (Generalized linear regression model in classical approach). Also as mentioned the AIC value in Table 5, model 4 which is the Bayesian semi-parametric regression model clearly fits much better than model 3 (semi-parametric regression model in classical approach). Since, models 4 has less AIC value (531.949) than model 3 (540.7069) as shown in Table 5.

In this study, we explored determinants of childhood diarrhea in kuyu general hospital using generalized linear models. Compared to the results using Bayesian generalized linear model and Bayesian semi-parametric regression model, the results are included in Tables 6 and 7 respectively. And, the results seem similar. Our focus in comparison on the DIC and pD results of these models with the results obtained in Table 5, because the number of covariates used in both are the same, but the models are different. As we can be seen in Table 5, instead of less value of DIC (530.05309) and large value of pD (17.842869) than DIC (533.30366) and pD (10.96991), it is clear that the Bayesian semi parametric regression model is better fit than the Bayesian generalized linear model.

Table 5: Cumulative information for all models employed in the study.

Model	AIC	DIC	pD
Model 1	540.706	Not available	Not available
Model 2	533.183	533.30366	10.96991
Model 3	540.7069	Not available	Not available
Model 4	531.949	530.05309	17.842869

Table 6: Results of fixed effects estimation results of parametric coefficients.

Parametric coefficients	Mean	SD	2.50%	50%	97.50%
Intercept	2.0912	0.697	0.7193	2.0765	3.4967
Sex (male)	0.7173	0.2538	0.1983	0.7301	1.1938
Residence (rural)	0.5643	0.234	0.084	0.5632	1.0226
Vaccination (no)	0.8485	0.2381	0.3811	0.8491	1.3171
Breastfeeding (still)	-0.6807	0.3213	-1.2796	-0.6858	-0.0477
Water (unprotected)	0.6857	0.2449	0.2203	0.6772	1.172
Toilet (yes)	-0.943	0.2468	-1.4108	-0.9418	-0.4661
WHZ	-0.4865	0.2138	-0.9039	-0.4905	-0.0369
WAZ	0.713	0.3256	-0.0097	0.7299	1.3076

Table 7: Results in Bayesian approach of approximate significance of smooth terms.

Smooth terms	Lambda	Df
Sx (age)	563.135	1.957
Sx (HAZ)	0.5307	7.896

DISCUSSION

This study has been an attempt to identify demographic, socio economic, environmental and health/malnutrition related determinants of childhood diarrhea based among children under age five diarrhea patients who were under follow up in Kuyu General Hospital from September 2015 up to August 2018. The findings of this study showed that the overall prevalence of diarrhea among under-five children was 82.2%. This figure is quite higher compared to the prevalence of diarrhea 15% in Keffa Sheka Zone of southern Ethiopia, 18% in Mecha District of Northwest Ethiopia, 22.5% Kersa district of Western Ethiopia, 15% in North Gondar zone and 13.5% in 2011 report of EDHS [20-24]. The differences in prevalence might be attributed to the representativeness of the sample and the differences in the study set-up. The possible explanation for the above variation could be attributed to methodological variation in the assessment of prevalence. In addition, this finding is much higher than the Ghana's 2014 DHS, which suggests 12% of under-five children had diarrhea [25]. The difference in the prevalence of diarrhea between our study and other sub Saharan countries could be explained by the difference in socio demographics and sociocultural practices, which has a great impact on child feeding.

The descriptive results of the study indicated that the number of males with diarrhea cases (84.3%) was greater than the number of females with the same cases. Similarly, the study conducted in Farta Wereda in North West Ethiopia showed that, a total of 301 (56.1%) are males out of 537 children [26]. Sex of the child was significantly associated with diarrhea prevalence in the area of study with more males infected than females. Contrary to an earlier study conducted in Efoulan health district to evaluate the epidemiology of under-five children with diarrhea revealed that, there were more females than males [27]. Our finding disagrees with another study conducted in Burundi showed that, gender did not play a considerable role as regards diarrhea prevalence across the different age groups [28].

Age of the child was another factor associated with prevalence of diarrhea among under-five children in our study. Our finding is consistent with the finding of a study conducted in North Gonder Zone to determine the prevalence of diarrheal disease in under-five children [29].This could be due to that the children are at greater risk than adults of life-threatening dehydration as water constitutes the largest proportion of children's bodyweight. Our finding disagrees with finding of study conducted among children under five in Makurdi Benue state in Nigeria showed that age of children was not associated with prevalence of diarrhea [30].

Place of residence was also found to be significantly associated with under-five diarrhea. The urban children are less likely to had diarrhea than their rural counterparts. This finding has parallelism with some earlier findings [28,31]. This is because the quality of health environment and sanitation is better in urban areas, whereas, the living condition in rural areas are associated with poor health condition, use of unprotected water supplies, and lack of personal hygiene, which were the risk factors in determining diarrhea.

Type of toilet used by a household is an indicator of household wealth and a determinant of environmental sanitation. In this study, a type of toilet facility was found to be significant factor of childhood diarrhea. Children from households with no toilet facility were more likely to had diarrhea compared to those children from household with toilet facility. This result is consistent with the result of earlier study in Benishangul Gumuz regional state [32] which reported that toilet facility as has a statistical significant effect on childhood diarrhea. In our study, it was also found that household's source of drinking water is associated with childhood diarrhea. This finding is consistent with the previous study conducted in Assosa district, Serbo town, Tigray district and Ethiopia [33-37]. Children who were not breastfed were more likely to had diarrhea compared to those who were breastfeed. This finding is similar to a previous study which showed exclusively and predominantly that breastfeed children suffer less episodes of diarrhea than those who were not exclusively and predominantly breastfeed [32]. This could be because of that breastfeeding provides a significant protection against diarrhea disease. Additionally, childhood vaccinations are a lifesaving public health initiative and have made a tremendous contribution in controlling infectious diseases in children. In this study, vaccination is associated with childhood diarrhea. This nding has parallelism with some earlier findings [28,29].

This study found that under-five children diarrhea was significantly associated with nutritional status of under-five children. The prevalence of diarrhea was higher in stunting under-five children. This finding is supported by a study done in Ethiopia showed that the stunted children were more likely to have diarrhea than children of normal height and which had not severe malnutrition. In this study, under-five children who were wasting were more likely to experience diarrhea than under-five children who were not wasted. This present findings is in agreement with a study done in Uganda which showed that being wasted increases the probability of occurrence of diarrhea compared to well-nourished counterparts.

For model comparison, we preferred the Akaike information criterion, deviance information criterion and effective number of parameters in the models (pD) techniques because of theoretical reasoning and inclusive advantages of the method. For clarity purpose, AIC is used to compare the classical and the Bayesian approach. The classical approach to model comparison involves a tradeoff between how well the model fits the data and the level of complexity [21]. The results of AIC indicated that Bayesian Approach which was the generalized linear model and semi parametric regression model was better than the classical approach. Then, we compared the generalized linear model and semi parametric regression model with Bayesian approach by using the DIV and pD. Thus, since semi parametric regression model with Bayesian approach has the small DIC and large pD, it was selected as the relatively the best model to fit the determinants of diarrhea among under five children in Kuyu General Hospital. This finding has parallelism with some earlier findings.

CONCLUSION

This study aimed to identify the influential determinants of diarrhea disease among under five children in Kuyu General Hospital, North Shoa Zone, Oromia Region, Ethiopia. To identify the influential determinants of diarrhea among under ve children, generalized linear model with Bayesian approach and related model namely semi parametric regression model were used. By using Akaike information criterion, deviance information criterion and effective number of parameters in the models (pD) techniques, semi-parametric regression model with Bayesian approach was found to be a good fit model.

Using Bayesian semi parametric regression model, influential determinants of diarrhea disease among under five children have been identified and concluded that households using unprotected source of drinking water, household with no toilet facility and rural residence contribute to worsened diarrhea. And also, the continuous covariates such as age of child, weight for height, height for age and underweight affect childhood diarrhea.

DECLARATION

Ethics approval and consent to publication

Prior to data collection appropriate ethical clearance for this study was provided by Research Ethics Review Board of Jimma University and College of Natural Science Research Office has written an official support letter to Kuyu General Hospital. After explaining the purpose and benefit of the study, written permission was obtained from Kuyu General Hospital to collect data.

Consent for publication

Not applicable.

Availability of data and materials

The data used for analysis in this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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