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Spatial analysis of childhood diarrhea among children in two selected regional states of Ethiopia

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Abstract

The main aim of this study was to identify determinants of prevalence of diarrhea, to describe spatial dependence of diarrhea and develop models specifying risk factors used to diagnosis of diarrhea among districts in SNNPR and Oromia Regional States of Ethiopia by using 2011 EDHS collected for 144 weredas/districts by employing spatial models. Spatial lag and spatial error model were fitted to the data, though spatial lag model specification was taken as the best fit for diarrhea prevalence rate. Accordingly, from global and local spatial analysis it was found that diarrhea prevalence rate in one district was directly affected by that of its neighbors. The results revealed that water closet, proportion of children under five, toilet availability, and mother's basic education attainment, vaccination coverage, size at birth, mother current working status, ORS information, altitude, stunting score and wasting score of children were significant determinants of diarrheal infection rate. Thus, it is suggested that the geographically targeted preparation on accumulation of treatment that can be useful to control and stabilize spillover (nearest area spread) of disease over space. It can be suggested for this states that the government needs to make intervention to mitigate the spatial variation of the diarrhea prevalence across regions.

Keywords: diarrhea prevalence, GIS, geode, spatial dependence, ESDA, spatial modeling, Ethiopia

1. Introduction

1.1 Background

Childhood diarrhea is among the most serious health issues facing developing countries. High infant and childhood mortality rates obviously induce low life expectancy in many developing countries and have severe negative impact on future development. Thus, investigation of proximate determinants that influence the risk of diseases and the outcome of disease prevalence is highly important. It is widely recognized that exposure to diarrhea pathogens in developing countries is determined by age of the child, quality and quantity of water, availability of toilet facilities, housing conditions, level of education, household economic status, place of residence, feeding practices and the general sanitary conditions (personal or domestic hygiene) around the house (Stephen, 2005).Diarrhea accounts for approximately 1.34 million deaths among children aged 0-59 months and continued as the second leading cause of death (Black et al., 2008). Diarrhea can last several days, and can leave the body without water and salts that are necessary for survival. Most people who die due to diarrhea actually die as a result of severe dehydration and fluid loss. Children who are malnourished or have impaired immunity are the most vulnerable for life threatening diarrhea (WHO, 2009). In Africa, a child experiences five episodes of diarrhea per year, and 800,000 children die each year from diarrhea related dehydration (Woldemichael *et al*., 2001). A more recent estimate indicates the two-week period prevalence of diarrhea in under-five children was about 30.6% and 17.7% in Ethiopia and Oromia region, respectively (EDHS, 2005).The 2000 Ethiopia DHS reported that 24 percent of under-five children have experienced diarrhea in the two weeks prior to the survey (FMOH, 2005). The 2005 Demographic and Health Survey (DHS) in Ethiopia collected national data on diarrheal prevalence, and reported the following results: Nationally, 18 percent of children under-five years of age had diarrhea in the last two weeks before the survey; 6 percent had blood in their diarrhea. Twenty percent of children with symptoms were taken to a health provider. Oral rehydration therapy (ORT) was given to just over a third (37%) of children with symptoms (CSA, 2006).

1.2 Statement of the Problem

The success of any policy or health care intervention depends on a correct understanding of the socioeconomic, environmental and cultural factors which may influence the prevalence of diarrhea. This study had been attempted to investigate the major socio-economic, demographic, health and environmental proximate factors including spatial effect as surrogate for unobserved covariate that might influence childhood diarrhea prevalence in SNNP and Oromia Regional States of Ethiopia. In this regard, the research questions of the interest were:

1. Does prevalence of diarrhea have spatial correlation?
2. Are socio-economic, demographic, environmental, and health related factors proximate characteristics related to experiencing of diarrheal among children in the regions?
3. Do the effects of factors on prevalence of diarrhea among children differ among districts?

1.3 Objectives of the Study

The main objective of this study is to identify determinants of prevalence of diarrhea, to describe spatial dependence of diarrhea and develop spatial models specifying risk factors used to diagnosis of diarrhea in Oromia and SNNP Regional States.

Specific objectives are

- To determine important socio-economic and bio-demographic and environmental factors that contribute to diarrheal prevalence including geographical effects as a surrogate for unobserved covariates with spatial information.

- To assess whether spatial association of diarrhea prevalence rate and its determinants exist in districts and also to identify territories of high risk.
- To relate issues of proximate determinants to diarrhea prevalence among children.
- To provide scientific information to decision/policy based on empirical results.

2. methodology

2.1 Description of Study Area and Population

Oromia Regional State

The State of Oromia sprawls over the largest part of the country and at present comprises of 17 administrative zones, 245 were as (districts), and 36 town administrations with 6500 kebeles subdivisions. Based on the 2007 census Oromia has a total population of 27,158,471, consisting of 13,676,159(50.4%) male and 13,482,312 (49.6%) female (CSA, 2008).

SNNP Regional State

Based on ethnic and linguistic identities the SNNPR was divided into 13 zones sub-divided in to 126 were as (districts), 22 administration town, and 8 specials were as with 3678 rural kebeles and 238 urban kebeles. Based on 2007 census the region total population is about 15,042,531 accounting nearly 20% of the total population of the country; of population 49.7 % are male and 50.3% are females (CSA, 2008).

2.2Data Collection Procedure

This work was based on data available from the 2011 EDHS. EDHS data records information on household living conditions, such as housing characteristics and information on fertility, mortality and child health obtained by asking mothers in reproductive ages (15-49). Individual data records were constructed for 10883 children in Ethiopia out of these children about 33.46% were taken from Oromia and SNNP Regional State (EDHS, 2011). Each record consists of disease information and the list of covariates that could affect the child’s health with corresponding district where the children is come from.

Spatially aggregated data across SNNP and Oromia Regional States on all variables were extracted and used to conduct the investigation. Information for the study was extracted from 2011 EDHS, and shape file map was obtained from Finance and Economic Development Offices of SNNPRS and Oromia Regional State.

2.3 Descriptions of Variables Considered Under the Study

- **Dependent Variables:** Rate for binary target variables for the occurrence of childhood diarrhea using records based on EDHS results was computed in each district.
- **Independent Variables**: All variables under this study comprise aggregate value of the interest in each weredas (district) that is expressed in the form of averages, rates, percentages and ratios for proximate environmental demographic and health related determinants that are expected to exert impacts were used. The following variables were included in study.
- Sex: Child's sex: male or female
- WC: Water closet; distance to drinking water source from home in minute.
- EDAT_100: Mother's educational attainment: percentage of mother attained basic education.
- TOILET_100: Proportion of households having protected toilet.
- VACOV_100: Proportion of children ever vaccinated.
- BIRTH INT: Sum of preceding and succeeding children birth time in month.
- DISPOSAL YOUNG: Proportion of households disposing younger children stools when not using toilet.
- ORS HEARD: Proportion of respondentwho heard about ORS.
- MOTHER WORK: Percentage of proportion of mother currently working.
- PCBAV SIZE: Proportion of children born below average size.
- WIF SCORE: Wealth index factor score.
- NHHD MEMBERS: Number of household members.
- NCU5: Number of children under five.
- PCU5: Proportion of children under five.
- ALTITUDE: Altitude of given district above sea level in meter.
- STUNT SCORE: Height to standardized age.
- WASTE SCORE: Weight to standardized height.

In addition to these explanatory variable’s geographical regions (place of residence) where the children reside were considered in study. A rationale here is that a spatial effect is usually a surrogate of many unobserved influential factors, some of them may obey a strong spatial structure while others may exist only locally.

2.4Spatial Data Analysis

In classical linear regression model Y=Xβ+ε, the response variable Y is assumed to be independent normal or Gaussian distributed and covariates, $X_1 \ldots X_P$ act linear on the response. By assumption the conditional expectation of Y is

$$\mu = E(Y / X_1, X_2 \ldots X_p) = \beta_0 + x_1\beta_1 + \ldots + x_p\beta_p \quad (1)$$

Where Y is vector of dependent variable, X is designed matrix of predicators, β is vector of parameters (coefficient)and **ε** is vector of independently and identically distributed error terms.

$$Y = \begin{pmatrix} y_1 \\ y_2 \\ . \\ . \\ . \\ y_n \end{pmatrix}, \quad X = \begin{pmatrix} 1 & x_{11} & x_{12} & . & . & . & x_{1k} \\ 1 & x_{21} & x_{22} & . & . & . & x_{2k} \\ . & . & . & . & & & . \\ . & . & . & & . & & . \\ . & . & . & & . & & . \\ 1 & x_{n1} & x_{n2} & . & . & . & x_{nk} \end{pmatrix},$$

$$\beta = \begin{pmatrix} \beta_o \\ \beta_1 \\ . \\ . \\ . \\ \beta_k \end{pmatrix}, \text{ and } \varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ . \\ . \\ . \\ \varepsilon_n \end{pmatrix}$$

Andthe regression coefficient $\beta_1 \ldots \beta_p$determines the strength of influence of the covariate, and the linear predictor μ is the sum of the covariate effect. Here each observation has an underlining mean of $\sum x_{ij}\beta_i$ and normally distributed random error term ε. Generally, the random error term $\varepsilon_1\ \varepsilon_{2\ldots}\varepsilon_p$ has zero mean and uncorrelated variance covariance matrix$\varepsilon \sim N(0,\delta^2 I)$where δ^2I=Var(y) and an I is pxp identity matrix the assumption of independent observation also implies that $E(\varepsilon_i \varepsilon_j) = E(\varepsilon_i)E(\varepsilon_j)$.

2.4.1Quantification of Locations/Positions

Contiguity information is quantified as contiguity (spatial neighbors) matrix that contains the elements 1and 0.

$$C = \begin{pmatrix} c_{11} & c_{12} & . & . & . & c_{1n} \\ c_{21} & c_{22} & . & . & . & c_{2n} \\ . & . & . & & & . \\ . & . & & . & & . \\ . & . & & & . & . \\ c_{n1} & c_{n2} & . & . & . & c_{nn} \end{pmatrix}$$

where: n is number of districts /locations under study c_{ij} is element of C represents quantity local position of ith and jthdistricts for i, j =1, 2…n.Contiguity matrix C is constructed based on linear contiguity: define asc_{ij}=1 for entities that share common edge to the immediate right or left of region of interest otherwise 0.

2.4.2 Spatial Regression Model

In the spatial linear regression model, spatial dependence can be incorporated in two distinct ways: as an additional regresor in the form of a spatially lagged dependent variable (C*Y) provide spatial lag model, or in the error structure (Cε) provides spatial error model. To test for spatial effects in models, spatial weights matrices are constructed and then included in a specified regression model. Thus, inference on the parameters allows one to explain the pattern for all locations as a function of exogenous variables (Cressie, 1993).

2.4.3Spatial Lag Model

This is type of spatial regression which appropriate when the focus of interest is the assessment of the existence and strength of spatial interaction; suitable to filter out spatial dependence that comes from spatial spillovers. The matrix notation of the model is

$$Y = \rho C * Y + \mathbf{X}\beta + \varepsilon \qquad (2)$$

where ρ is a spatial autoregressive coefficient of the lag variable CY called spatial lag operator and given as $CY = \sum_j C_{ij} Y_j$ where C_{ij} is row standardized weight matrix corresponding to community pair i,j hence $\sum_j C_{ij} = 1, \forall i$. A random vector of error terms; ε is independent and identically normally distributed with mean zero and constant variance $\delta^2 I_n$, for all I, Yis vector of dependent variables, X is a designed matrix of explanatory variables and β is vector of coefficients of regression model. The single notation of the model is $Y_i = \rho c_i Y + x_i\beta + \varepsilon_i$, where c_i is the ith row of C. Parameters (β, δ^2) are estimated using maximum likelihood method of log likelihood function of transformed model and regressions was carried out along with a univariate parameter optimization of the concentrated likelihood function over values of the autoregressive parameter ρ.

Given the above model as Y = ρC*Y + Xβ + ε, then the transformed model:$A*Y = X\beta + u$ implies $Y= A^{-1}X\beta + A^{-1}u$
With $\varepsilon \sim N(0, \delta^2 I)$, A=(I- ρC) and C is row standardized spatial weights matrix. The log likelihood functions of transformed equation.

$$\ln L(\beta,\rho,\sigma) = -\left(\frac{n}{2}\right)\ln 2\pi - \left(\frac{n}{2}\right)\ln\sigma^2 + \ln\|A\| - \frac{1}{2\sigma^2}\left[(A*Y - X\beta)'(A*Y - X\beta)\right]$$

Where, $\|A\|$ is determinant of matrix A, and n is number of districts under study.
Or

$$L(\beta,\delta,\rho) = \ln|I - \rho C| - \frac{n}{2}\ln(2\pi) - \frac{n}{2}\ln(\delta^2) - \frac{1}{2\delta^2}\left((Y - \rho C*Y - X\beta)'(Y - \rho C*Y - X\beta)\right)$$

Maximizing the likelihood with respect to β, δ, and ρ gives the values of parameters that provide the highest likelihood of the joint occurrence of the sample dependent variable. Anselin (1988) suggest a way to maximize the log likelihood and get estimator for β:

$$\hat{\beta}_{sl} = (X'X)^{-1}X'A*Y = (X'X)^{-1}X'X*Y - \rho(X'X)^{-1}X'C*Y$$

$$\hat{\beta}_{sl} = \hat{\beta}ols - \rho\hat{\beta}_L = (X'X)^{-1}X'(Y - \rho C*Y)$$

Where, $\hat{\beta}_{ols} = (X'X)^{-1}X'X*Y$ is coefficientvector from OLS regression of Y on X with corresponding residual e_{ols}=Y-X$\hat{\beta}_{ols}$, and $\hat{\beta}_l$ -is the from OLS regression of C*Y=Y' on X and its corresponding residual **e**$_L$=Y'-X$\hat{\beta}_l$.

Maximum likelihood estimator of δ^2 is $s^2 = \frac{1}{n}(e_{ols} - \rho e_L)'(e_o - \rho e_L)$ when ρ is known.

We can now use all these to write down a version of the log-likelihood function in terms of ρ only, the result is the Concentrated log-likelihood (lnL*)

$$\ln L^* = CO - \frac{n}{2}\ln\left[\frac{1}{n}(e_{ols} - \rho e_L)'(e_{ols} - \rho e_L)\right] + \ln\|A\|$$

CO doesn't involve unknown parameters and estimate of ρ is obtained by maximizing lnL* with respect to ρ. And also, covariance-variance matrix of estimated parameters is estimated by maximum likelihood for large sample that attains Cramer's Rao lower bound. Moreover, clearly, we should be hesitant to make inferences about the effects of a covariate x_i in a spatially lagged Y model without considering the spatial multiplier and the variation that will exist across spatial units (Ertur et al., 2007).

3. Results and Discussion

The main goals of this study were to identify determinants of prevalence of diarrhea, to describe spatial dependence of diarrhea and develop models specifying risk factors used to diagnostics of diarrhea among districts in SNNP and Oromia Regional States of Ethiopia by using 2011 Ethiopia Demographic and Health Survey data collected for 144 weredas/districts. Individual data records were constructed for 3316 children in two Regional States of which 1719 and 1597 records, respectively for Oromia and SNNP Regional States (EDHS, 2011). Each individual record consists of diarrhea disease infection information and the list of covariates that could affect the child's health with corresponding district where the children come from. Therefore, within each district/woreda, the response variable diarrhea disease rate and certain factors expected to exert director indirect impacts were computed. The analysis has been performed for 144 woredas where data have been collected of which 71 woreda in SNNPRS and 73 woreda in Oromia Regional State. To undertake these tasks, SPSS (for descriptive and correlation analysis), ARCGIS (for mapping and variable selection), and the GeoDa open source software for spatial data analysis were used.

3.1 Descriptive Statistics

Table1 below displays descriptive statistics for variables considered under study. The diarrhea prevalence rate ranges from 0.00% (no cases occurred in woreda) to 54.55 % (highly infected woreda/district) with mean 14.2 children infected by diarrhea out of 100 children and standard deviation of 10.58%in the Regional States. The drinking water closet in district varies from 2 minute to 996 minutes with mean 123.81minutes and standard deviation of 186.71 minutes. Percentage of mother who attended basic education ranges from 1% to 98% with mean 38.77% and standard deviation 26.63%. Proportion of children ever vaccinated among district varies from 2.63% to 84.21% with mean 34.38% and standard deviation16.36%. Birth interval time from preceding and succeeding children ranges from 41.50 month to 88.00 month with mean birth interval 62.16 month and standard deviation 9.68 month. Table 1 also provided maximum, minimum, mean and standard deviation in percentage for factors: Proportion of household having protected toilet ,Proportion of households disposing younger children stools when not using toilet, Proportion of children whose size at birth is below average, Proportion of children under five, Proportion of respondents heard about ORS , Percentage mother employed , Percentage mother currently working among districts.

Table 1: Descriptive Statistics of Diarrhea Prevalence and Variables Considered Under Study (EDHS, 2011).

Variables	N	Minim	Maxim	Mean	Std. Dev
Diarrhea Rate	144	.00	54.55	14.20	10.59
Water closet in minutes	144	1.92	996.29	123.81	186.71
Mother basic education attainment	144	1.00	98.00	38.77	26.63
Proportion of Children vaccinated	144	2.63	84.21	34.38	16.36
Proportion of hhd having toilet	144	0.50	100.00	65.82	30.11
Proportion of hhd disposing stools	144	5.88	100.00	65.242	22.01
Birth interval	144	41.50	88.00	62.16	9.68
Proportion of respondent heard ORS	144	0.50	99.50	59.72	24.85
Mother employed	144	0.50	99.00	39.77	22.02
Wealth index factor score	144	-78405.00	255416.60	-32043.70	58895.95
Percentage of mother currently working	144	2.00	90.60	32.77	31.02
Proportion of children below average size	144	1.00	62.10	23.91	12.36
Proportion of children under five	144	14.58	41.07	29.61	4.84
Number of hhd members	144	3.73	7.89	5.94	.78
Number of children under five	144	1.50	2.67	1.75	.33
Altitude	144	979.00	3012.00	_	_
Stunting score	144	-2.28	3.70	-1.13	0.57
Wasting score	144	-1.99	3.54	-1.11	0.78

From nutritional factor point of view stunting score and wasting score shows that stunting score ranges from -2.28 (severely stunted area) to 3.70 (normal) with overall mean -1.124 and variance 0.57, and wasting score ranges from -1.99(severely wasted area) to 3.5416(normal) with mean -1.11 and standard deviation 0.77. Woreda's altitude also varies from 979 meter (low altitude) to 3012 meters (high altitude). And Mean wealth index factor score ranges from -78404.00 to 255217 with mean -32043.64 and standard deviation 58895.95.

3.2 Exploratory Spatial Data Analysis (ESDA) Results

As shown in Figure 1 the upper right quadrant of the Moran's I scatter plot for diarrhea infection shows those districts with above average disease rates which share boundaries with neighboring districts that also have above average infection rates (High-High). The bottom left quadrant highlights districts with below average diarrhea prevalence rate, which have neighboring districts that also have below average diarrhea infection rates (Low-Low). The bottom right quadrant displays districts with above average diarrhea prevalence rate surrounded by districts that have below average disease rate (High-Low) and the upper left quadrant shows the opposite (Low-High). Slope of the plot is positive and most of districts were cluster around the line which indicates the high and lowvalues of diarrhea ratein upper right and bottom leftcluster together refer to positive spatial autocorrelation. Hence, leads us to conclude there is spatial clustering of diarrhea infection; the visual interpretation of Figure 1 is supported with the quantitative results of Table 2, and leads us to believe that there is spatial autocorrelation in diarrheal rates in the regions.

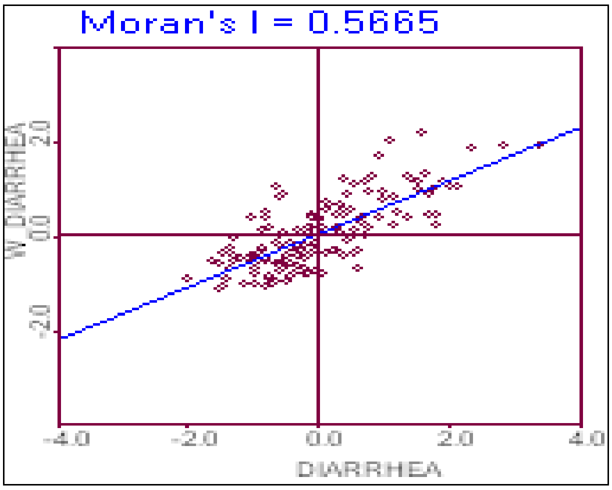

Fig 1: Univariate Moron's Scatter Plot of Diarrhea Prevalence Rates.

Table 2: Moron's Statistics of Diarrhea Prevalence Rate.

Variable value	**Moron's *I* P-value**	**standardized**
Diarrhea Rate 0.001	0.5665	11.73211

The theoretical mean of moron's stat is -0.072 and standard dev. 0.0489 for all variable obtained by -1/N-1

3.3 Spatial Regression Analysis Results

In this section we described a statistical model that incorporates spatial dependence raised from spatial lag explicitly by adding a spatially lagged dependent variable $Y'=CY$ on the right-hand side of the OLS regression equation $Y=X\beta+\varepsilon$ where C is spatial weight matrix. As a consequence, findings of this section allow us to understand which variable among the independent variables are related to the variation in diarrhea prevalence rates, and to explore the forms of these relationships.

Table 3 reported maximum likelihood estimate for determinants of diarrhea prevalence rate in spatial lag model, test statistic with corresponding p-value, and their standard errors that come from the heteroskedasticity consistent estimator of the covariance matrix of the maximum likelihood parameters. The significance of the coefficient of the spatially lagged dependent variable (ρ) suggests that neighboring districts prevalence rates are important determinants of a given district's infection by diarrhea. This result is consistent with the findings of Frank (2006). More specifically, geographic spillover effects are important in our model of diarrhea prevalence rate variation.

Variables with positive and statistically significant effect on diarrhea prevalence are water closet (WC) ,proportion of children under five(PCU5),proportion children born below average size (PCBAV SIZE), whereas variables with negative effect and statistically significant coefficients at 5% level of significance are proportion of children ever vaccinated(VACOV_100),proportion of household having controlled toilet(TOILET_100),proportion of households disposing younger disposal when not using toilet(DISPOSAL YOUNG_100), proportion of respondent heard about ORS(HEARD ORS),stunting score ,wasting score and altitude.

Positive effect means that for unit change in explanatory variable increase diarrhea prevalence rate in certain district by magnitude of estimate of parameter for that explanatory variable controlling for the effect of neighbor districts and other variable, whereas negative effect mean that for unit change in explanatory variable decrease diarrhea prevalence rate in district by magnitude of estimate of parameter for explanatory variable conditioning the neighbor districts infection rate effect and other variable constant. For example, for one-minute increase in time to get drinking water (WC) in certain district increase diarrhea infection rate in that district by 0.00417%keeping other variable fixed. In another word, as the distance to drinking water in a particular district increases by one-minute possibility of occurrences of diarrhea in that district increased by 0.00417 %.

The change in water closet was found to be positive and significant (at the 5% level); the reason for this can be attributed to the fact that diarrhea prevalence rate is high where distance to source of drinking water is far. This result is similar with study conducted in Nekemte town, western Ethiopia, by Girma et al. (2008) and Chabala and Mamo (2001) that showed risk factors including distance of drinking water source (time taken to-and-from the source) appeared to be significantly associated with under-five childhood diarrheal morbidity.

The change in proportion of house hold having protected toilet and disposing young children stools were found to be negative and significant (at 5% level). Our result is similar with findings of Girma et al. (2008) and study done in SSA countries which showed that children in SSA living in households with some kind of toilet facility are less likely to experience diarrhea than children in households that do not have toilet facilities.

The parameter estimates 0.0542 for proportion of children under five (PCU5) indicates that a unit increase in proportion of children under five in district increase diarrhea infection in that district and its neighbor by 0.0542% keeping the effect of another independent variable constant. The sign tells that high proportion of children (below 5) in one district may aggravate population in the same area to participate in productivity discharge their responsibility to care them. These results share idea of (Berisha, 2011; Fahrrmeir and Khatab, 2007).

The coefficient estimates -0.0121 indicates that 1% increase proportion of household having protected toilet (TOILET_100) decreases diarrhea infection in district and its neighbor by 0.0121% remaining other variable influence constant.

The parameter estimates -0.005 for proportion of children ever vaccinated indicates that for 1% increase in proportion of children ever vaccinated in certain district decrease diarrhea infection rate in that particular district by 0.005% keeping others variables fixed. And Proportion of children born below average size (PCBAV SIZE) is significant and has positive effect on diarrhea prevalence rate of districts. This is due to the greater the proportion of the children born below average size in district, the higher rate of infection/ or easily attacked by diarrhea. Low birth weight/size children suffered a higher prevalence of diarrhea than appropriate birth size/weight children. Children who had low birth weight were more likely to be sick longer with diarrhea than infants who had appropriate birth weight or children born below average size can't defend childhood disease such as diarrhea. This result is consistent with study done Teshager (2011) using 2005 EDHS and similar with the study done in Northeast Brazil by Lira et al. (1996) showed that low birth size infants experienced 33% more days with diarrhea and 32% more days with vomiting (P-value = 0.003).

In basic knowledge point of view proportion of mothers who attained basic education (EDAT_100), proportion of respondents who heard about ORS (HEARD_ ORS) both have negative and significant effect among district. These indicate all mothers have no basic knowledge in order to treat their children before occurrence of disease. Nevertheless percentage mother educated primary and above determine occurrence of diarrhea in certain district, some mother mothers have no basic education skills which of course necessarily need education for mother.The same interpretation for ORS information, greater proportion of respondents heard about ORS, the less possibilities of occurrence of diarrhea in given district as we expected indicating ORS given to children is functioning well, but there is difference in ORS information preference that leads diarrhea infection difference among district significant.

The negative coefficient and significant value for stunting score and wasting score indicates that the less stunt score or waste score the higher rate of infection/ or easily attacked by diarrhea. Most literature shows that stunting and wasting are problem that highly correlated with childhood diarrhea infection. A vicious cycle between diarrhea and stunting means that children with stunted growth are more likely to attacked by diarrhea. The results may be due to shortage of nutrition leads to non-health (more vulnerable to diarrhea).

For altitude interpretation is slightly different because it is fixed for certain district and is fixed effect to diarrhea prevalence in certain district; therefore, coefficient can be interpreted as districts with high altitude are less likely to be infected by diarrhea. This is may be due to polluted water flow from high to low (see discussion part for more details).

Table 3 also present measures of fit for models in discussion part. R-square = 0.5682 which tells us that 56.82% of variation in diarrhea prevalence rate was explained due to variation in the explanatory variable in the model and spatial lag dependent variable.

Table 3: Maximum Likelihood Estimate for Factors of Diarrhea Prevalence Rate in Spatial Lag Model (EDHS, 2011).

Variable	Coefficient	Std. Error	z-value	probability
C-Y(ρ)	0.7694	0.06381	12.058	0.000
CONSTANT	-0.5934	0.34348	-1.729	0.042
WC	0.00417	0.00038	10.887	0.0000
TOILET_100	-0.0121	0.00116	-10.431	0.0000
DISPOSAL YOUNG_100	-0.0142	0.157	-9.045	0.0000
VACOV_100	-0.0050	0.00064	-7.723	0.0030
PCBAV SIZE	0.0100	0.00240	4.170	0.0001
PCU5	0.0542	0.00438	12.383	0.0000
HEARD ORS	-0.0179	0.00726	-2.458	0.006
EDA_100	$-1.59X10^{-5}$	$4.9X10^{-6}$	-3.245	0.004
STUNT_SCORE	-0.0447	0.01260	-3.454	0.0002
WASTE_SCORE	-0.0464	0.01560	-2.975	0.0014
ALTITUDE	-0.0284	0.00940	-3.021	0.0013

Number of Observations (N):	144	Degrees of Freedom:	131
R-squared:	0.5682	Log likelihood:	-60.830
S.E of regression:	0.3422	Akaike info criterion:	147.653
Sigma-square:	0.1172	Schwarz criterion:	186.261

Finally, Table 3 contains Diagnostics Tests Spatial lag Model of diarrhea prevalence. Three measures that are included to maintain comparability with the fit of spatial lag models that are the log likelihood (-60.83), the Akaike information criteria (147.653) and Schwarz criteria (186.261). These three measures are based on assumption of multivariate normality and corresponding likelihood function for standard regression model. The higher log likelihood, the better the fit (less negative). For the AIC and SC information criteria the direction is opposite, the smaller the measure, the better the fit.

4. conclusions and recommendations

4.1 Conclusions

Geographically close districts with similar socio-economic and demographic characteristics and vulnerability dimensions are more conducive to grouping forces, such as using of unprotected drink water. The clustering of underlying disease dimensions might be due to a number of reasons including sanitation that has been applied to groups of areas or socio-economic issues that lead to spatial clustering of diarrhea rate.

Our estimation results of spatial lag model for diarrhea prevalence rate indicate that water closet, proportion of children under five, protected toilet availability, mothers basic education attainment, vaccination coverage, size at birth, mother current working, ORS information, altitude from sea level, stunting score and wasting score of children have significant influence in explanation of diarrhea prevalence rate differentials across districts in the regions.

4.2 Recommendations

Based on findings and other related literatures study we forward the following recommendations to improve regional prevalence of diarrhea spread.

- The expanded program on immunization should be spread out to reduce the prevalence of diarrhea among children.
- The study suggests that efforts should be made to build public and private toilet facilities.

- Improvements in access to clean water and adequate sanitation, along with the promotion of good hygiene practices (particularly hand washing with soap) can help to prevent childhood diarrhea.
- The study also suggests that basic education to mother, improve the nutritional status of children, community participation on hygiene and sanitation will be important measure in geographically targeted preparation to reduce possibilities of occurrence of diarrhea.
- Further study will recommend to be conducted by incorporating time or employing other forms of spatial models and including other excluded districts.

The implication spatial dependence in result is policy directed towards reducing diarrhea prevalence rate needs to have a spatial dimension; for low local significance area specific policy would support and for high clusters policy to be targeted towards not simply the specific area but also the group of contiguous areas. Thus, we suggest that the most effective policy mix for alleviating differences in diarrhea infection amongst the regions districts, balancing hospital composition and providing sanitation, and encouraging community to participatein sanitation and environment protection. Furthermore, reducing average family, encouraging mother to take basic education in regions may reduce diarrhea infection.

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