Geographical disparities and determinants of childhood diarrheal illness in Ethiopia: Further Analysis of 2016 Ethiopian Demographic and Health Survey

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Abstract

Background: Childhood diarrheal illness is the second leading cause of child mortality in Sub Saharan Africa, including Ethiopia. Studies hypothesized that there are regional variations. Thus, the study aimed to examine the spatial variations and to identify the determinants of childhood diarrhea in Ethiopia.

Methods: Data from the 2016 Ethiopia Demographic and Health Survey (EDHS) was analyzed. This nationwide survey involved 10,337 children below 5 years old. The survey was carried out using a two-stage stratified sampling design. Moran's I and LISA were used to detect the spatial clustering of diarrhea cases and to test for clustering in the data. Descriptive statistics followed by a mixed-effect logistic regression was used to identify the factors associated with the prevalence of diarrhea.

Results: Overall, 11.87% of children were experienced childhood diarrheal illness. The study reveals high-risk areas were Southern and central Ethiopia, while eastern and west were indicated as low-risk regions. Younger children were more likely to suffer from childhood diarrhea than their older counterparts: age 6 to 12, 12 to 23, and 24 to 35 months were (AOR = 2.66, (95% CI 2.01, 3.52)), (AOR = 2.45, (95% CI 1.89, 3.17)), and (AOR = 1.53, (95% CI 1.17, 2.01)), respectively. Children living in Tigray (AOR= 1.69 (95% CI, 1.01, 2.83)), Amhara (AOR = 1.80, (95% CI, 1.06, 3.06), SNNPR (AOR = 2.04, 95% CI 1.22, 3.42), and Gambela (AOR = 2.05, (95% CI 1.22, 3.42)), faced greater risk than Addis Ababa city. The odds of getting diarrhea is decreased by 24% among households having ≥3 under-five children as compared to households having only one under-five child (AOR = 0.76 (95% CI: 0.61, 0.94)). The odds of children getting diarrheal illness among working mothers increase by 19% as compared to not working (AOR = 1.19 (95% CI 1.03, 1.38)).

Conclusions: childhood diarrheal illness is highly prevalent among under-five children, particularly in SNNP, Gambella, Oromia, and Benishangul Gumuz regions. Capacity building programs with best experience sharing and better household environment may prove effective in reducing the incidence of childhood diarrhea in Ethiopia.

Keywords: Spatial statistics, Ethiopia, under-five children, Diarrhea, Generalized Mixed Model

Background

Across low-income and middle-income countries, diarrhea is responsible for over half a million childhood deaths annually [1–4]. Diarrheal diseases are the leading cause of death in children younger than 5 years of age and are responsible for killing around 525 000 children every year [5–7]. Most deaths from diarrhea occur among children in Africa. For example, according to the Global Burden of Disease study in 2016, 9.4% of all the severe cases of diarrhea in 2015 occurred in two countries: Ethiopia and the Democratic Republic of the Congo. In the Central African Republic, Gabon, Ivory Coast, Nigeria, and Zimbabwe saw disease increases over the 15 years [1, 8, 9].

Diarrheal disease is the principal cause of mortality and morbidity in children aged < 5 years in Ethiopia. It is the second leading cause of death in children under five years old where it is responsible for 30% of all annual deaths mainly by diarrhea, malaria, and pneumonia [10, 11]. The distribution of childhood diarrhea diseases are heterogeneous within different regions of Ethiopia even though dedicated investment and campaigning against epidemics in terms of education, and treatment [12–14].

In Ethiopia, many of the young children have died of pneumonia and diarrhea, which could be easily prevented by simple public health interventions. As indicated by national and regional facilities reports diarrhea is one of the top five causes of morbidity and mortality among under-five children [10]. Moreover, community-based studies revealed that the pooled prevalence of diarrhea among under-five children in Ethiopia was 22% [15–19]. The recent population-based survey also found that the prevalence of diarrhea was 12% [20]. Studies also showed unequal distribution of the burden of childhood disease in different regions of the country [12, 21]. Existing empirical evidence emphasized the prevalence of diarrhea, and an individual's characteristics associated with diarrhea using standard logistic regression, which ignores clustering effects [22–26]. However, observations within a cluster tend to be more alike than observations from different clusters and ordinary analyses that ignore this may be inappropriate [27]. Ignoring clustering in analyses may overstate or understate the precision of results; risk factors may be incorrectly stated as significant [28].

Thus, considering the limitations of existing studies this analysis has been conducted to identify the factors that are associated with diarrhea using a generalized linear mixed model (GLMM). The GLMM considers the correlation between responses of interest for respondents from within the same cluster [29].

The spatial techniques also help us identify the hotspots and provide the information on significant clusters. The spatial evaluation will enable public health officers and policymakers for strategic planning to reduce the prevalence of diarrhea [30]. Local estimates of diarrheal burden can be used to prioritize diarrheal care and prevention interventions for marginalized populations that live in remote regions or areas of conflict.

To the best of our knowledge, we found a scarcity of published information on the risk factors of diarrhea in children with triangulation in the spatial analysis of diarrhea prevalence in Ethiopia. This study aims at addressing the social determinants and burden of diarrheal diseases among Under 5 years of age in Ethiopia.

Methods

Study design, Data sources, population

The study uses data from the nationally representative, cross-sectional Ethiopia Demographic and Health Survey (EDHS) conducted in 2016. EDHS consists of a sample of households obtained through a two-stage stratified sampling procedure [20].

In the first stage, the country was divided into 21 strata and a sample of 645 Enumeration Areas (EAs, those which are considered as the Primary Sampling Units) were selected independently from each stratum using probability proportional to the size technique. In the second stage, a systematic sampling technique was employed to select 30 households from each of these EAs. Finally, ever-married women aged between 12 and 49 years living in the selected households were approached for an interview. This study uses information from 10,641 children under the age of 5 years born to women living in these households.

The morbidity data contained in the survey come from the mother ’s responses to questions on recent episodes of various forms of morbidity. Mothers were asked if their child had a fever, cough, short rapid breaths or diarrhea in the 2 weeks preceding the survey [20].

Variables of study

In this study, we used the data for birth history information of all women aged 15 to 49 interviewed for the different surveys. The birth history data set contains information on the date of birth of all the children a woman has had in her life, starting from her first child until the time of the survey. Information on child survival (dead or alive) was also collected.

The outcome variable from the EDHS 2015/16 used for this study was diarrhea episodes in children under 5 years of age during the two weeks before the interview. Diarrhea was measured using the definition of a child having loose stools more frequently than usual in the two weeks preceding the survey [20]. We constituted a binary variable denoting one if present and zero if absent.

The exposure variables include the information regarding the socio-demographic and economic characteristics of children of less than 5 years of age was obtained from interviews with their mothers/caregivers. This study selected explanatory variables based on prior studies, epidemiological information, review of published demographic studies and the information in the EDHS datasets.

Location data (latitude and longitude coordinates) were also taken from selected enumeration areas. The survey datasets and location data were accessed through the web page of the International DHS Program after subscription and being an authorized user. Among a total of 643 clusters, 429 clusters were considered for the spatial analysis of childhood diarrhea (21 clusters dropped because of had no coordinate data set and 193 clutters dropped because of clusters had no diarrhea cases).

Data analysis

Spatial analysis

Spatial cluster detection was performed to identify the cluster of locations with a higher prevalence of diarrhea. Global spatial autocorrelation Moran ' s I was used to measuring the overall clustering of the data and to project the strength and pattern of spatial autocorrelation [31]. Incremental autocorrelation was done for identifying distance band where spatial processes promoting clustering are most pronounced.

Getis-Ord-Gi* statistics was used to detect the hot spots of the enumeration area percentage of children suffering from diarrhea. Hotspots are the geographical units with high diarrhea prevalence and are surrounded by other geographic units with high diarrhea prevalence. Similarly, a cold spot is a geographic location with low diarrhea prevalence surrounded by other geographic units with low diarrhea prevalence. High-high and low-low districts suggest the clustering of geographies with similar values of diarrhea prevalence whereas the high-low and low-high districts indicate spatial outliers. A $p < 0.05$ was considered significant throughout.

The spatial interpolation technique was also used to predict childhood diarrhea in the un-sampled areas in the country based on sampled EAs. Ordinary Kriging spatial interpolation method was used for this study for predictions of childhood diarrhea in unobserved areas of Ethiopia.

The SaTScan spatial statics analysis was also used to identify purely spatial clusters of childhood diarrhea. Scan statistics did scan gradually across the space to identify the number of observed and expected observations inside the window at each location. The scanning window with the maximum likelihood was the most likely high performing clusters, and a p-value was assigned to this cluster [32].

Regression Analysis

In exploring the association between these variables and the incidence of childhood diseases, both bivariate and multivariate approaches were pursued. In consideration of the DHS survey design, we accounted for the clustering of diarrhea by primary sampling units and included a random effect in the analysis. Thus, a mixed effect logistic regression was fitted, a model that is most appropriate for a correlated dependent variable in a multivariate setting. For analysis, the risk (adjusted OR (AOR)) of diarrhea was assessed concerning the socioeconomic variables. P-values less than 0.05 were considered significant variables in the model. Analysis of the data was performed using STATA, ArcGIS and SaTScan.

Results

Socio-economic characteristics

A total of 10,377 under-five children were included in the study. Table 1 highlights the distribution of participants across different characteristics. The majority of the children, 9,187 (88.87%) were from rural areas. The mean age of their mothers was 29.56 (± 6.59), 53% of whom were between the age of 25–34 years. More than half of the mothers, 5744 (55.56%) had no work with 6809(65.87%) had no formal education. Only 55.42% of respondents were access to an improved source of water. Among respondents, only 10% of then access improved toilet facilities. Only 20% of respondents were exposed to media

(Table 1). Results suggest that overall, 11.87% of children in Ethiopia experienced childhood diarrheal illness in the 2 weeks before the Survey.

Table 1
Socio-demographic characteristics of mothers, parents, and children under five years of age, DHS 2016, Ethiopia

Characteristics	Categories	Weighted Frequency (n = 10,377)	Weighted %
Region	Tigray	682	6.60
	Afar	104	1.00
	Amhara	1954	18.90
	Oromia	4537	43.89
	Somali	473	4.57
	Benishangul	113	1.10
	SNNP	2149	20.79
	Gambela	25	0.24
	Harari	24	0.23
	Addis Adaba	233	0.26
	Dire Dawa	43	0.42
Mothers education level	No education	6809	65.87
	Primary	2777	26.87
	Secondary/Higher	751	7.27
Partner's education status	No education	5280	51.08
	Primary	3849	37.24
	Secondary/Higher	1208	11.69
Mother's age in years	15–24	2288	22.14
	25–34	5501	53.22
	35–49	2548	24.65
Residence	Urban	1151	11.13
	Rural	9187	88.87
The current age of children (years)	< 6	1195	11.56
	6–11	1069	10.34
	12–23	2001	19.35

Characteristics	Categories	Weighted Frequency (n = 10,377)	Weighted %
	24–35	1927	18.64
	36–47	1980	19.16
	48–49	2166	20.95
Number of Children under five years	1	3901	37.74
	2	4640	44.74
	≥ 3	1796	17.37
Mother's Occupation	Not working	5744	55.56
	Working	4593	44.44
Wealth Index	Poor	4848	46.89
	Middle	2139	20.69
	Rich	3350	32.41
Source of Drinking water	Improved water	5728	55.42
	Unimproved water	4609	44.58
Toilet facilities type	Improved	1036	10.02
	Unimproved	9301	89.97
Child stool disposal	Safe	2797	27.06
	Unsafe	7540	72.94
Sex of child	Male	5307	51.34
	Female	5030	48.66
Marital Status	Married	9715	93.98
	Not Married	622	6.02
Duration of breastfeeding	Ever breastfed, not currently breastfeeding	5159	49.90
	Never breastfed	376	3.64
	Still breastfeeding	4802	46.46
Media exposure	Exposed	2101	20.33
	Not exposed	8236	79.67

Characteristics	Categories	Weighted Frequency (n = 10,377)	Weighted %
Diarrhea status of under-five children	No	9110	88.87
	yes	1227	11.87

Distribution of Childhood Diarrhea

Overall, childhood diarrhea shows the patterns in the country. Generally, a high proportion of childhood diarrheal cases (red dot) and a low proportion of childhood diarrhea (green dot) were observed among under-five year's children in Ethiopia (Fig. 1).

Spatial patterns of childhood diarrhea

The spatial patterns of childhood diarrhea were found in the study period. The Global Moran's I value (0.044591) indicated that there was significant clustering of childhood diarrhea in the country. There is a statistically significant spatial variability in childhood diarrhea among under-five children in Ethiopia (Fig. 2).

Hot Spot Analysis of Childhood Diarrhea

Figure 3 indicates the geographical distribution of childhood diarrhea. The hot spot regions were SNNP, Amhara, Addis Ababa, and Oromia regions. Whereas, the eastern Oromia Benshangul-Gumuz; Harari; Somali, Gambella, Afar and northern Tigray regions were indicated as cold spot regions.

Spatial Interpolation

The red prediction areas show predicted risk regions and the children living in those areas were vulnerable to childhood diarrhea. In the first panel, western Tigray, Amhara, eastern Oromia, and northern SNNP regions were predicted as more risky areas compared to other regions. In the middle panel, the Afar, southern Oromia, and SNNP, eastern Somali were identified as risk areas (Fig. 4).

Spatial SaTScan analysis

A total of 21 significant clusters were identified. Of which, 3 were most likely (primary) clusters and 18 were secondary clusters. The primary cluster's spatial window was located in the west SNNP, which was centered at (7.146476 N, 37.651928 E) / 24.44 km, RR = 2.57 and Log-Likelihood ratio (LLR) of 17.84 at $p < 0.001$. It showed that children within the spatial window had 2.57 times higher childhood diarrhea than outside the window. The secondary clusters' spatial window was located in Gambella, Oromia and Benishangul Gumuz regions which were centered (8.989285 N, 34.767792 E) / 243.09 km, RR = 1.50 and Log-Likelihood 14.39 with p-vale < 0.001 (Table 2, Fig. 5).

Table 2
SaTScan analysis result of childhood diarrhea among under-five children in Ethiopia, 2016

Cluster	EA (enumeration Area)	Coordinate or Radi	RR	LLR	P-value
Primary (3)	565,126 360	(7.146476 N, 37.651928 E) / 24.44 km	2.57	17.84	< 0.001
Secondary (18)	248, 462, 558, 304, 433, 349, 165, 407, 555, 88, 285, 177, 586, 294,62, 437, 489, 325	(8.989285 N, 34.767792 E) / 243.09 km	1.60	14.39	< 0.001

Factors associated with childhood diarrhea

From the multilevel multivariable logistic regression analysis result age of the child, the number of under-five children in the household, mother's occupation, and region were statistically significant factors of childhood diarrhea.

Regarding regions, children live in Tigray region (AOR = 1.69 95% CI, 1.01, 2.83), Amhara AOR = 1.80, (95% CI, 1.06, 3.06), SNNPR AOR = 2.04, (95% CI 1.22, 3.42), and Gambela (AOR = 2.05, (95% CI 1.22, 3.42)), had highest odds of getting diarrhea as compared to children live in Addis Ababa.

The age group of children in a month was a significant factor affecting childhood diarrhea. The odds of developing diarrheal disease among children age 6 to 12 month, 12 to 23 month, and 24 to 35 month, were (AOR = 2.66, (95% CI 2.01, 3.52)), (AOR = 2.45, (95% CI 1.89, 3.17)), and (AOR = 1.53, (95% CI 1.17, 2.01)), times higher than children age less than 6 month respectively. The odds of getting diarrhea among children age 48 to 59 month was decreased by 51% as compared to children aged less than 6 months (AOR = 0.49 (95% CI: 0.35, 0.66)). The odds of getting diarrhea decrease by 24% among households having 3 and above under-five children as compared to households having only one under-five child (AOR = 0.76 (95% CI: 0.61, 0.94)). The odds of children getting diarrhea among working mothers increase by 19% as compared to not working mothers (AOR = 1.19 (95% CI 1.03, 1.38)) (Table 3).

Table 3
Multilevel Multivariable logistic regression analysis of childhood diarrhea among under-five children in Ethiopia, 2016.

Characteristics	**Categories**	**Crude OR (95%CI)**	**Adjusted OR (95%CI)**
Region	Addis Adaba	1	1
	Tigray	1.84(1.16, 2.91)	1.69(1.01, 2.83) *
	Afar	1.56(0.97, 2.49)	1.66(0.97, 2.85)
	Amhara	1.94(1.23, 3.08)	1.80(1.06, 3.06) *
	Oromia	1.57(1.01, 2.47)	1.52(0.90, 2.55)
	Somali	0.82(0.51, 1.32)	0.91(0.53, 1.55)
	Benishangul	1.24(0.76, 2.03)	1.19(0.68, 2.08)
	SNNP	2.08(1.33, 3.26)	2.04(1.22, 3.42) *
	Gambela	1.93(1.19, 3.14)	2.05(1.22, 3.42) *
	Harari	1.46(0.87, 2.44)	1.46(0.84, 2.54)
	Dire Dawa	1.63(0.97, 2.75)	1.70(0.98, 2.94)
Mothers education level	No education	1	1
	Primary	1.21(1.04, 1.42)	1.05(0.89, 1.25)
	Secondary/Higher	0.99(0.78, 1.25)	0.84(0.64, 1.11)
Mother's age in years	15–24	1	1
	25–34	0.89(0.77, 1.05)	1.05(0.88, 1.24)
	35–49	0.71(0.58, 0.87)	0.86(0.70, 1.06)
Residence	Urban	1	1
	Rural	1.17(0.95, 1.13)	1.11(0.83, 1.49)
Current age of children (month)	< 6	1	1
	6–11	2.66(2.02, 3.52)	2.66(2.01, 3.52) *
	12–23	2.53(1.96, 3.26)	2.45(1.89, 3.17) *
	24–35	1.61(1.24, 2.10)	1.53(1.17, 2.01) *
	36–47	1.05(0.79, 1.38)	1.01(0.76, 1.34)
	48–49	0.50(0.37, 0.67)	0.49(0.35, 0.66) *

Characteristics	Categories	Crude OR (95%CI)	Adjusted OR (95%CI)
Number of Children under five years	1	1	1
	2	0.84(0.72, 0.97)	0.86(0.74, 1.01)
	≥ 3	0.68(0.55, 0.82)	0.76(0.61, 0.94) *
Mother's Occupation	Not working	1	1
	Working	1.18(1.02, 1.35)	1.19(1.03, 1.38) *
Wealth Index	Poor	1	1
	Middle	1.15(0.95, 1.41)	1.07(0.87, 1.33)
	Rich	1.05(0.89, 1.23)	1.08(0.88, 1.33)
Source of Drinking water	Improved water	1	1
	Unimproved water	1.04(0.89, 1.21)	1.06(0.90, 1.25)
Toilet facilities type	Improved water	1	1
	Unimproved water	1.15(0.95, 1.39)	1.04(0.82, 1.32)
Child stool disposal	Safe	1	1
	Unsafe	0.83(0.71, 0.96)	1.07(0.9, 1.26)
Media exposure	Exposed	1.04(0.88, 1.23)	1.02(0.85, 1.23)
	Not exposed	1	1

Discussion

The present study findings provide valuable insights on factors affecting diarrhea prevalence. This study also highlights the substantial burden of diarrheal diseases across regions, with an especially profound impact on the presence of spatial inequalities.

The national prevalence of childhood diarrhea (11.87%) is somewhat lower than the previous survey conducted in 2011 (15%) [12, 16], this might be due to differences in the study period. There was a significant variation in the prevalence of diarrhea in children between different regions and places of residence, specifically concentrated in SNNP, Amhara, Oromia, Tigray and Gambella regions [12, 19]. This disparity might be due to study sample size, study period, coverage of latrine and utilization, access to safe water for drinking. However, this finding is consistent with the findings in other sub-Saharan and South Asian countries, a study in Tanzania and India [8, 33–35]. The results signify that the strategic approach of the government is fruitful and the sweats of focusing on low performing states are paying off. These remarkable achievements are the result of various initiatives of the Government. Since diarrhea in children is affected by multiple factors, the major contributing factors to diarrhea in children in different regions found in this study might be different.

In this study, three or more children under five years old were statistically significant for the occurrence of diarrheal disease in Ethiopia. As the number of children increased, the frequency of diarrhea decreased significantly. This finding is different from previous studies done in North-West Ethiopia [19] and other Sub-Saharan Africa countries [9]. It is expected that when the number of children in households increases, it is expected that children could be more vulnerable to contamination because the quality of care and attention from parents decreases. However, our study suggests that national policy could potentially impact upon the decline of the childhood illness at the level of the individual, affecting day–to–day clinical practice. Recently implemented measures that have been associated with such changes may be reducing the adverse health effects [36]. This might be due to multisectoral collaboration projects that were undertaken (such as UNICEF) on childhood education and family health, which creates a high awareness of mothers/caregivers to childcare. Moreover, recall bias could potentially affect the results.

In this study, parental occupational status was correlated with childhood diarrheal disease occurrence compared to parents without occupation. This study finding is in line with the study results in sub-Saharan countries [33] and studies in Northwest Ethiopia [37]. This could be justified that mothers/caregivers without work could have sufficient time to spend with her child, feed the child, and overall control of the child which could have led to diarrhea. Moreover, the caregiver/mother has the opportunity to get information from different sources as they have sufficient time to gain information from different sources and to practice it. In contrast, the working mother could have limited time to control her child and spend much time on economic activities to increase the income of the family than take care of their children.

This study also revealed the significant association between the age of the child and the occurrence of diarrheal disease. The finding was similar to other study findings conducted in Ethiopia and elsewhere [19, 33, 35]. Children with age of 0–5 months have a low risk of diarrhea, it could be justifying, during this time all the mothers are advised to give exclusive breastfeeding, which minimizes the exposure of children to contaminated agents since most children do not usually start complementary feeding before six months. However, children between the ages of 6–23 months revealed the highest risk of diarrhea compared to 0–5 months. The possible reason for having this could be at this age children are trying to crawl or the age of crawl, so due to crawling on the ground or walking they may have an increased chance of getting and contracting with filth materials that may expose to pathogenic microorganisms. Moreover, since complementary feeding is common after six months and if the food handling and preparation could not be done hygienically it might increase the chance of diarrheal disease. The possible reason for decreasing diarrhea subsequently after 23 months may be due to the development of immunity to pathogens after repeated exposure and immunization.

One of the strengths of this study is the use of nationally representative data at the national level and allows for findings to be generalized across the entire country. Therefore, the study findings can be used to inform policy and program managers for further evidence-based policy and program preparation. Some of the shortcomings of our study include sampling and measurement errors, recall and misclassification bias, self-reported issues and lack of pathogen testing. Moreover, there is the warning that some regions had a small sample size, which questions the accuracy of prevalence estimates per region, so findings should be interpreted with caution.

Conclusion

Generally, the overall two-week diarrhea prevalence was clustered in Ethiopia. Further, this study shows that having two or more children under five years old, mother occupation status, the current age of children and region were the important factors for diarrhea occurrence. Thus, this result suggests that Ethiopia needs to be further supported to further prevent the incidence of childhood diarrhea globally. Moreover, promote experience sharing, and a better household environment could have been contributing to reducing childhood burden in Ethiopia.

Abbreviations

AOR	Adjusted Odds Ratio
EAs	Enumeration Areas
EDHS	Ethiopia Demographic and Health Survey
GLMM	Generalized Linear Mixed Model
LLR	Log-Likelihood ratio
RR	Relative Risk
SNNPR	South Nation Nationalities People Region

Declarations

Ethics approval and consent to participate

Ethics approval for this study was not required since the data is secondary and is available in the public domain.

Consent for publication

Not applicable.

Availability of data and materials

All relevant data are within the paper. However, data are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

AA participated in the conception and design of the study and coordinated the study. ZT, MM, GD and AA were involved in data cleaning and analysis, interpretation, drafting, and revision of the manuscript. All authors read and approved the final manuscript.

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Figures

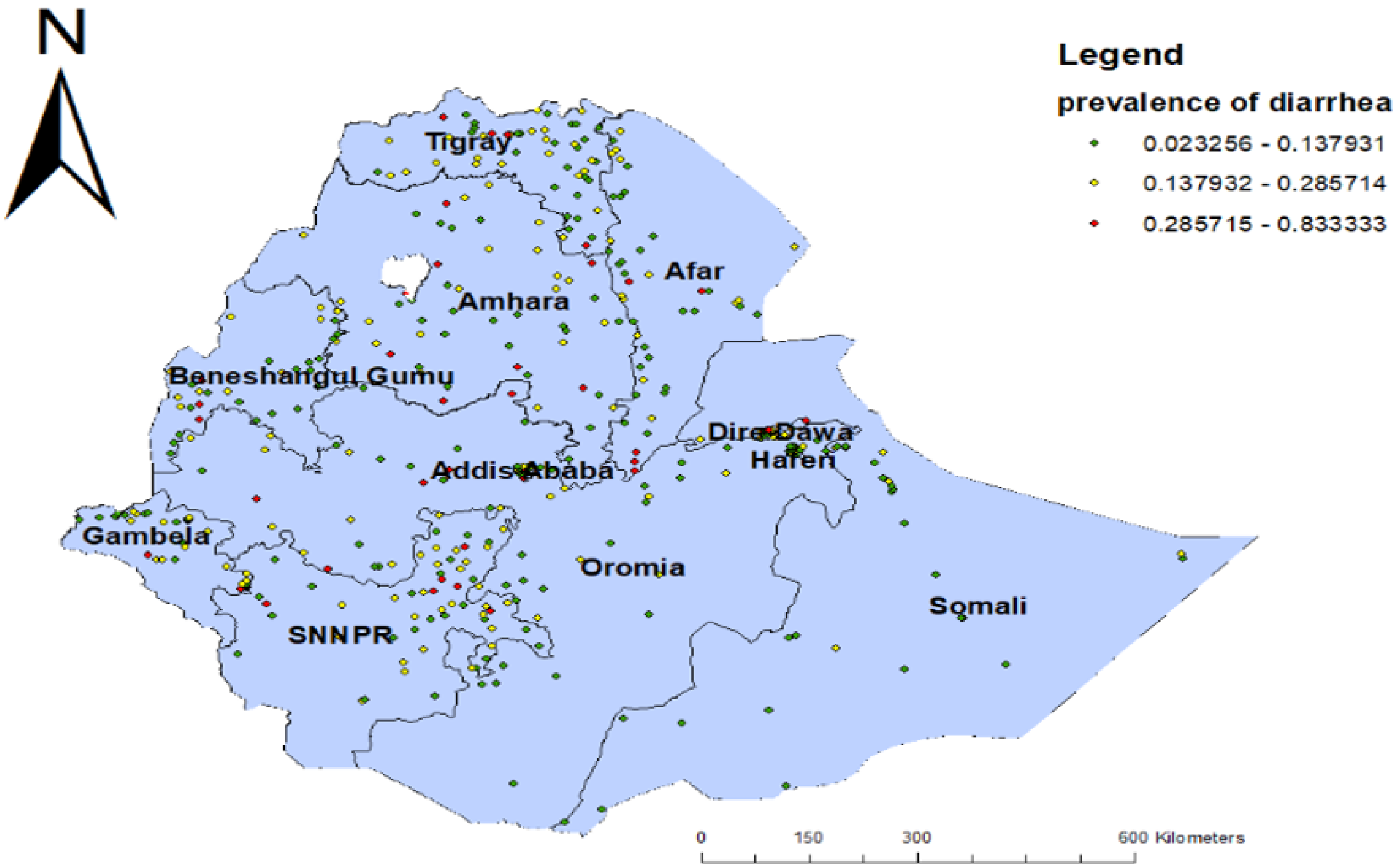

Figure 1

Spatial Distribution of Childhood Diarrhea disease among under-five children in Ethiopia, EDHS 2016

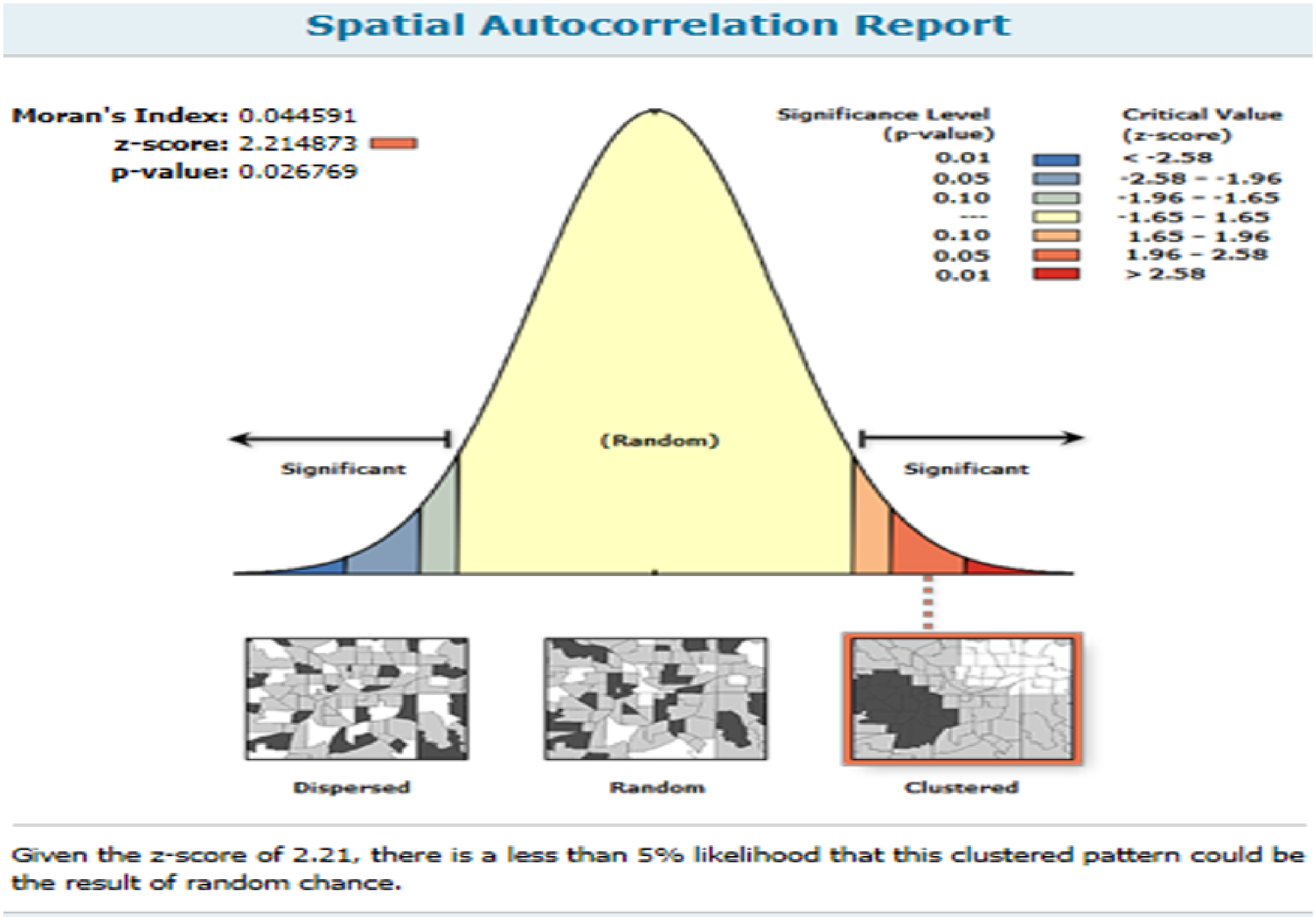

Figure 2

Spatial Autocorrelation of Childhood Diarrhea disease among under-five children in Ethiopia, EDHS 2016

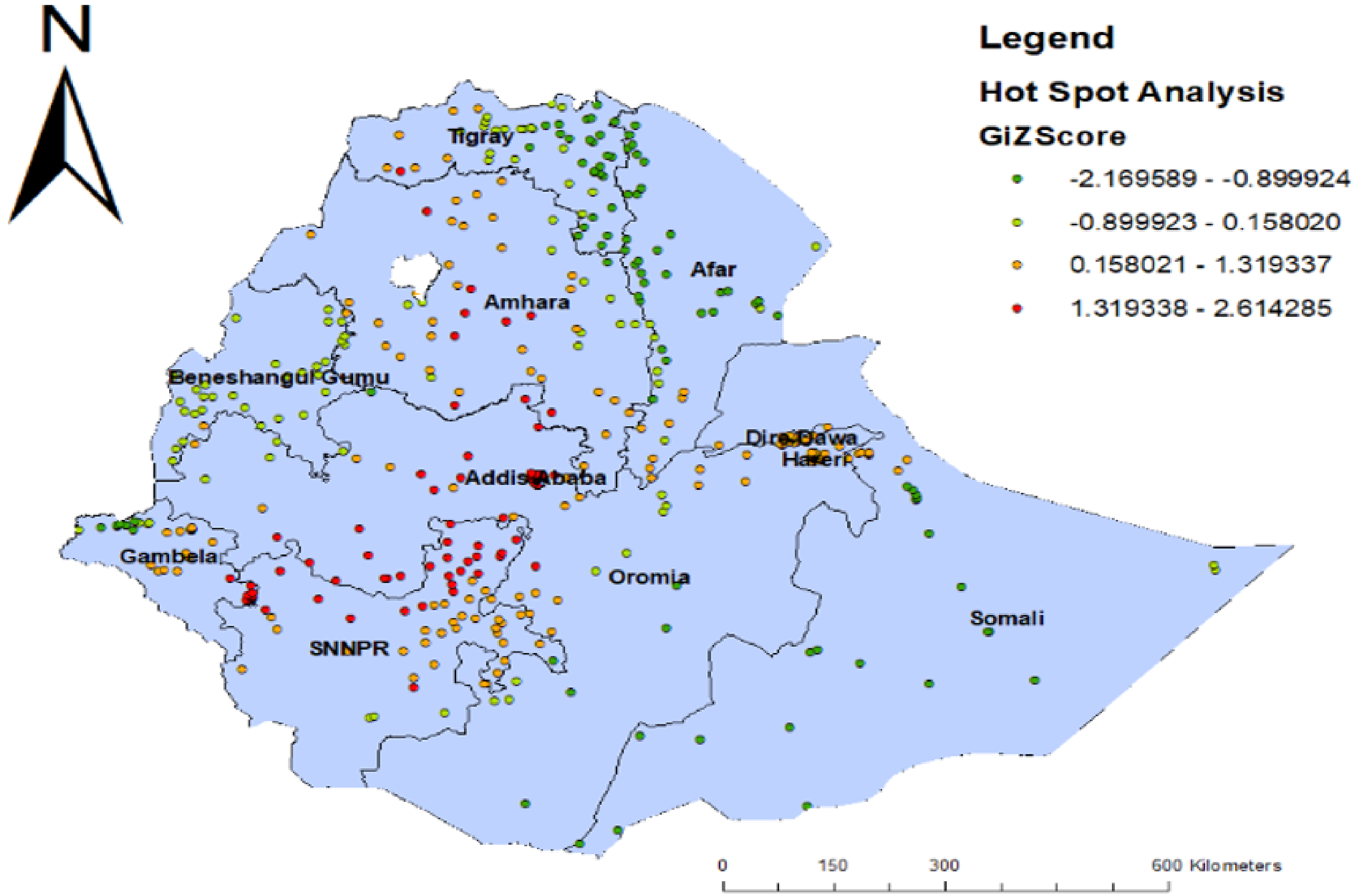

Figure 3

Hot Spot Analysis of Childhood Diarrhea disease among under-five year's children in Ethiopia, EDHS 2016

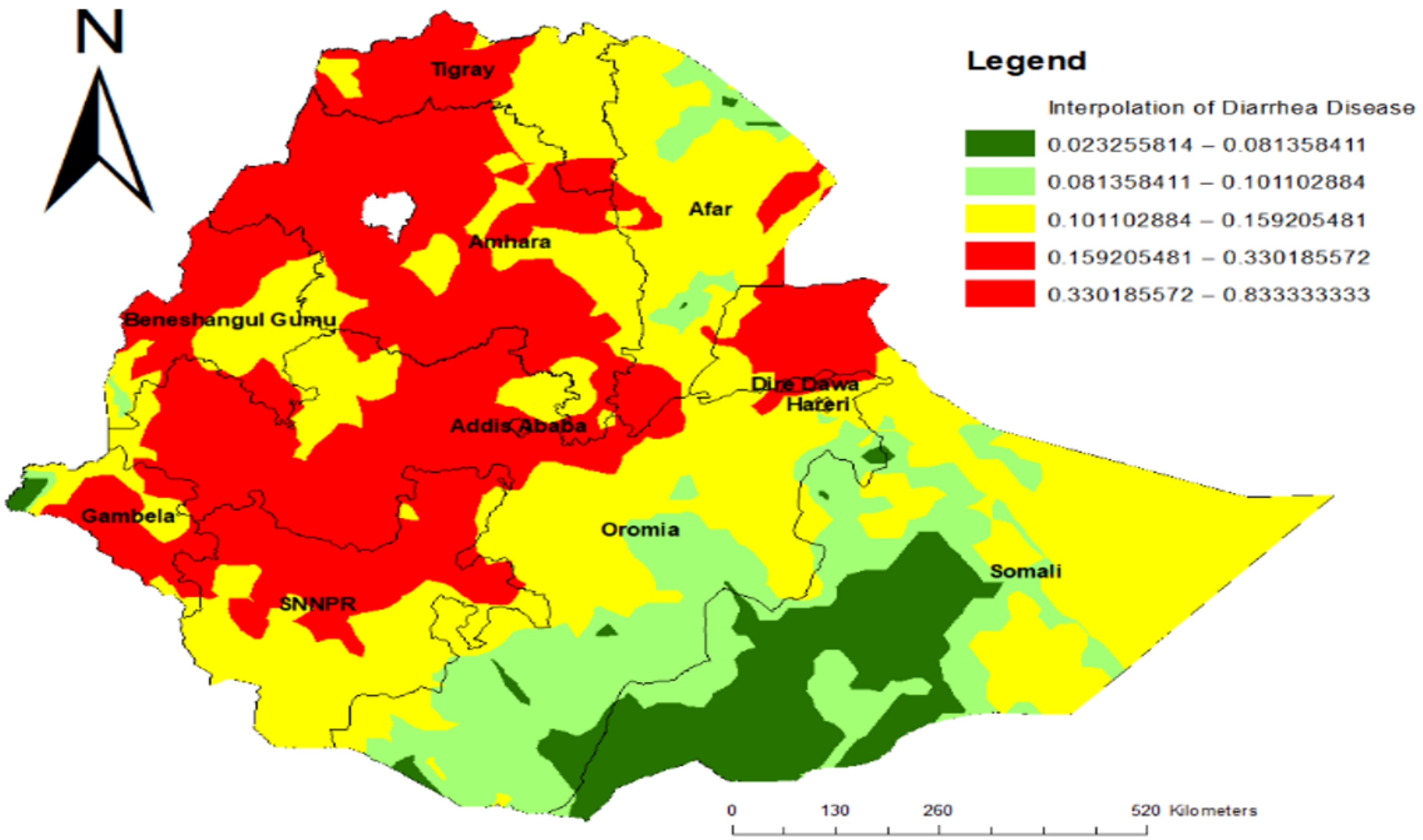

Figure 4

Spatial Interpolation of Childhood Diarrhea disease among under-five children in Ethiopia, EDHS 2016

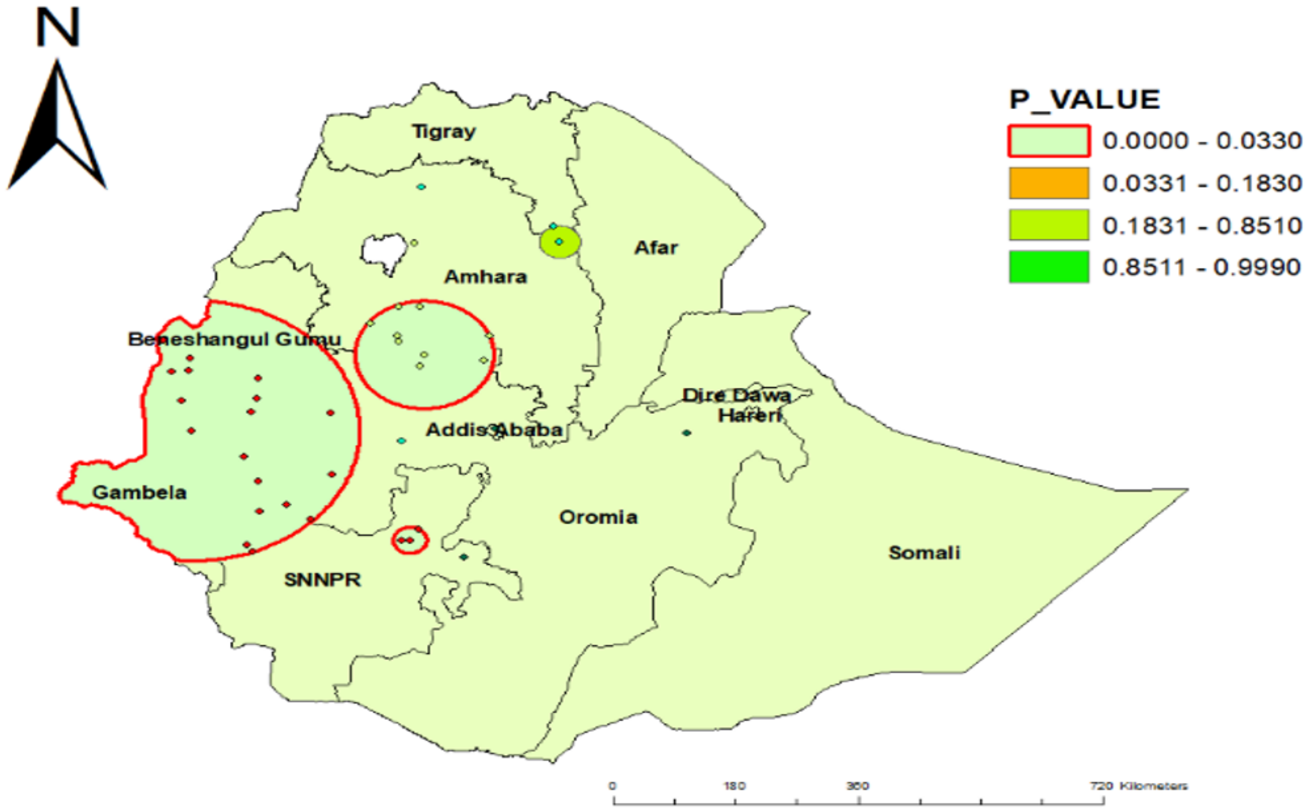

Figure 5

SaTScan result of Childhood diarrheal disease among under-five children in Ethiopia, EDHS 2016