

Research article

Geospatial analysis and hotspots of diarrheal cases among under-five children within a rural district of Karnataka, IndiaDmello M.K.¹, Badiger S.², Kumar S.³, Kumar N.⁴, D'Souza N.⁵, Purushotam J.¹¹Department of Public Health, ⁴Department of Community Medicine, ⁵Department of Biostatistics, K S Hegde Medical Academy, Nitte (Deemed to be University), Mangaluru, Karnataka, India²Department of Community Medicine, AJ Institute of Medical Sciences and Research Centre, Mangaluru, Karnataka, India³Senior State Child Consultant, United Nations Children's Fund (UNICEF), Karnataka, India

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Corresponding author: **Dr. Sanjeev Badiger**. Email: sbadiger.aj@gmail.com**ABSTRACT**

Introduction and Aim: Diarrhea is a significant public health problem, resulting in nearly 16% of child deaths below the age of five, globally. This study was undertaken to find the relation between geographical variance in diarrheal prevalence and spatial dependence among under-five children of Karkala taluk of Karnataka State, India, between 2015 to 2018.

Materials and Methods: Data on registered diarrheal cases among under-five children between April 2015 and March 2018 was obtained from the State Department of Health and Family Welfare. The thematic maps were prepared for the study area using data available at the village level. The GeoDa software was used to carry out spatial data analysis and spatial autocorrelation. Spatial dependence was analyzed through the Global Moran's Index and Local Indicators of Spatial Association (LISA).

Results: Three thousand eight hundred ninety-four under-five children were recorded with diarrhea in Karkala taluk with a mean annual rate of 123.6/1000 diarrheal cases. There was an increase in diarrheal incidence during the study period with peak trends being seasonal. Global and Local spatial correlation analysis detected several hot and cold spot clusters among villages in Karkala taluk.

Conclusion: Diarrheal incidence among under-five children is highly seasonal and spatially clustered. The spatial analysis helps decide preventive measures for identified clusters and determines the observed heterogeneity of diarrheal infection.

Keywords: Diarrhea; spatial correlation; hotspots; Moran's I; LISA; Q-GIS.

INTRODUCTION

Diarrhea is the second leading cause of mortality in children aged less than five years in the world (1). Globally, among the 1.7 billion under-five children affected by diarrhea every year, around 8% are known to succumb to the disease (1,2). In India, the number of diarrheal cases in this age group accounts to nearly 9% varying across regions (3,4) resulting in an estimated 0.30 million deaths annually (5). As per WHO definition diarrhea is defined as the passage of three or more loose or liquid stools per day (6), commonly caused by bacterial, viral or parasitic infections of the gastrointestinal tract arising due to the ingestion of contaminated food and water and poor hygiene (7).

As in every infectious disease, diarrheal infection also exhibits an epidemiological triad, i.e. agent, host and environment linkage manifesting spatial relationship (6). In India, although diarrhoea has been a major public health problem for several years, data on its spatial spread is limited. In order to identify areas and populations that are at high risk of diarrheal outbreaks, studies on spatial distribution patterns of

diarrhea within geographical areas and populations is essential. A better understanding of such spatial distribution patterns could aid in identifying high risk areas and help take preventive measures during the early stages of diarrhea outbreaks and spread (8). As per the National Family Health survey of India, the incidence of diarrhea among under five children in Karnataka showed an increasing trend between the years 2015-2018 (9). Hence, in this study we undertook to investigate the diarrheal incidence among under-five children in Karkala, a rural taluk of Karnataka and correlate its spatial dependence within this geographical area. Of the several analytical methods available to study spatial patterns of diseases, and find the significant occurrence of clustering in a given geographical area (9, 10-11), we used Moran's I spatial autocorrelation method as it detects spatial patterns by taking into consideration both incident locations and disease cases (12).

MATERIALS AND METHODS

The study was undertaken in Karkala, a rural taluk of Karnataka (13.2068657°N and 74.9991344°E), India for under-five children with diarrheal episodes for the

period 2015-2018. Karkala is divided into 49 villages (Fig.1), and as per the 2011 census, the population of under-five children numbered 12,245. The methodology used in this study is presented as a flowchart (Fig.2)

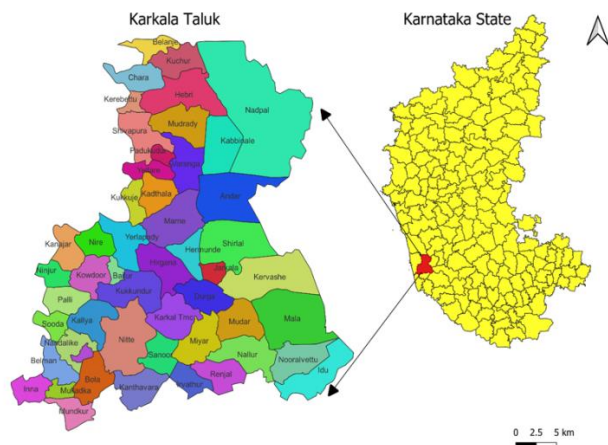


Fig. 1:Geographical map of Karkala Taluk, Karnataka

Data collection

The information regarding diarrheal episodes among children <5 years was collected from the concerned health and family welfare records department. It was validated further by an accredited community health activist, who interfaces between the public health centre and the village community. An episode of diarrhoea among under-five has been defined as the passage of three or more liquid stools per day (6). Based on the criteria, 3894 under-five children were included in this study. The spatial data in this study included the geographical location points of each village in the taluk, which was collected using the portable Garmin Etrex-10 GPS device.

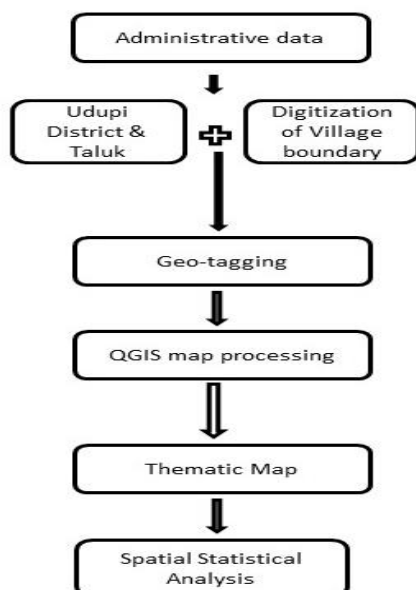


Fig. 2: Flowchart of method used

Diarrheal incidence rate

The diarrhea percent incidence for each of the 49 villages was calculated by dividing the number of diarrhea case by the population. Further, these villages were divided into three categories as low, moderate and high based on the percent diarrheal rate.

Geospatial pattern analysis

The standard Cartesian coordinate system was used in finding the geographic coordinates. The World Geodetic System (WGS84) was used as a spatial reference coordinate system. The geospatial data obtained was analyzed for its completeness and uniformity using the geographic information system Q-GIS (version 3.20). GeoDa software was used in spatial data analysis, spatial autocorrelation and modeling (13). To ascertain geographical clustering over the taluk (block) and local clustering across the villages, the program Global Moran's I and local Moran's I (LISA) was used, respectively. Local indicator of spatial association (LISA) provides statistics for each location, assessing for significance and establishing a relative relationship between the sum of the local statistics and a corresponding global statistic. The local Moran's I scatter plot provides information on spatial association at four categories, i.e. High-High, Low-Low, Low-High and High-Low. A Moran's I value of near -1 was considered as widely dispersed, +1 as closely clustered, and '0' as randomly distributed. Spatial autocorrelation of Moran's I values was considered significantly associated at p-value <0.05.

Hotspot analysis

The Getis-OrdGi* statistic was calculated using a hotspot analysis tool for each characteristic in the data set. The Z-score and the p-value (<0.05) computed was used in determining the spatial clustering of high and low values for each feature. High Gi* value signifies 'hotspot' while low Gi* signifies 'cold-spot'(12). A hotspot was considered statistically significant if the attribute had a high value with a p-value <0.05. Statistical significant Z-score results were also estimated.

RESULTS

The incidence of under-five diarrheal percentage in Karkala Taluk was 8.6%, 9.7% and 13.6% for the years 2015-2016, 2016-2017 and 2017-2018, respectively, with a mean of 123.6 per 1000 population. The average yearly rate of diarrhea among boys and girls were 123.2/1000 and 125.0/1000, respectively. The annual percentage diarrheal rate for the years 2015-2018 in all of the 49 villages is shown as parallel Boxplots.

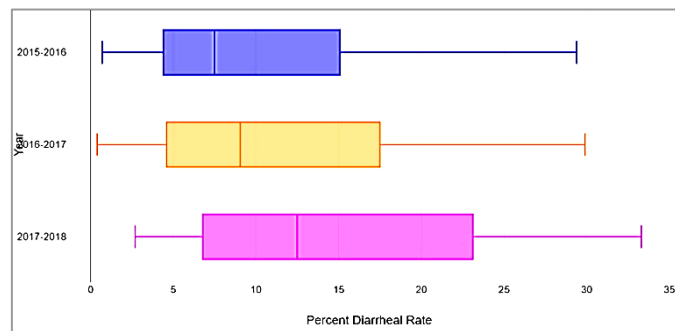


Fig. 3: Boxplot of diarrheal cases (2015-2018) in under five children of Karkala taluk

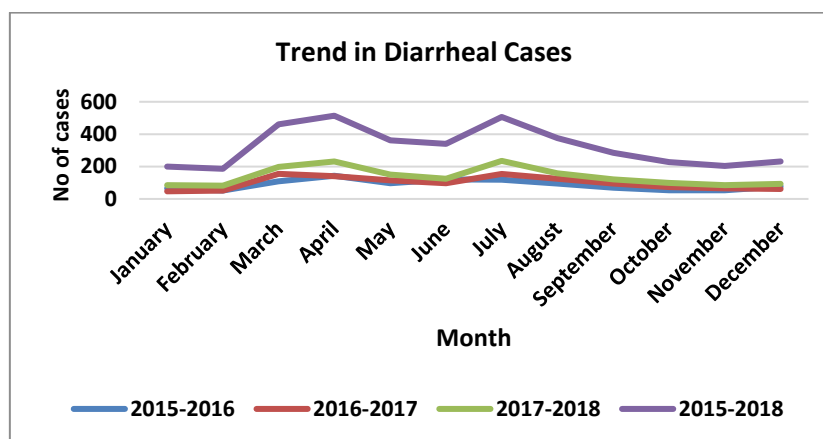


Fig.4: Trend in diarrheal cases among children aged <5years at Karkala Taluk for the period 2015-2018

The rate distribution for the years 2015-2017 shows smaller variability in comparison to 2017-2018. The median rate observed was 7.5, 9.0 and 12.5 for 2015-16, 2016-17, 2017-2018 respectively indicating an increasing trend of diarrhea in children under five (Fig 3).

A bimodal distribution of diarrheal incidence showed the lowest incidence to occur in January and February and the highest between March to May and June to August (Fig 4). Village-wise a consistently high incidence of diarrhea was seen to occur in five northern villages (Chara, Kabbinala, Kerebettu, Nadpal and Shivapura) and five in southern villages (Idu, Kedinje, Nandalike, Nooralettu and Mulladka). Similarly, consistently low incidence was observed in villages Durga, Jarkala, Kervashe, Miyar and Sanoor of Karkala taluk for the years 2015-2018.

Spatial patterns of diarrhea

Diarrhoea among under-five children was distributed non-randomly across all villages during the study period. Table 2 shows the Global Moran's spatial autocorrelation values for annualized infected diarrheal cases of villages in Karkala taluk from 2015-2018. The occurrence of diarrhea was observed to follow a cluster pattern every year being statistical significant for the years 2015-16 and 2016-2018 in this study (Table 2, Fig. 5).

Table 2: Moran's I spatial autocorrelation analysis of diarrhea among under-five children in Karkala taluk

Year	Observed Moran's I	Expected Moran's I	P-value
2015-2016	0.3497	-0.0232	0.001*
2016-2017	0.1639	-0.0204	0.035*
2017-2018	0.0122	-0.0202	0.338

*p-value significant

Hot-spot and cold-spot clusters of diarrhea

The local spatial autocorrelation analyses provided the incidence of diarrhea based on spatial association. A LISA cluster map representing the diarrheal locations by type is provided in Fig.6. The spatial clusters of diarrheal incidence are indicated as High (dark red regions); low (dark blue regions) and moderate (light red and light blue regions). Spatial clusters were observed to be specific covering similar areas for the years 2015-16 and 2016-2017 in comparison to the year 2017-18. The clustered villages with high diarrheal incidence (hotspots) were seen to cover across the northern and southern villages of the taluk. The hotspot villages identified in the northern part of the taluk were Chara, Hebri, Kerebettu and Mudrady (Fig.7). Similarly, Kervashe, Irvathur, Miyar, Nire and Kowdoor were identified as cold spot villages located in the southern part of the taluk (Fig.7).

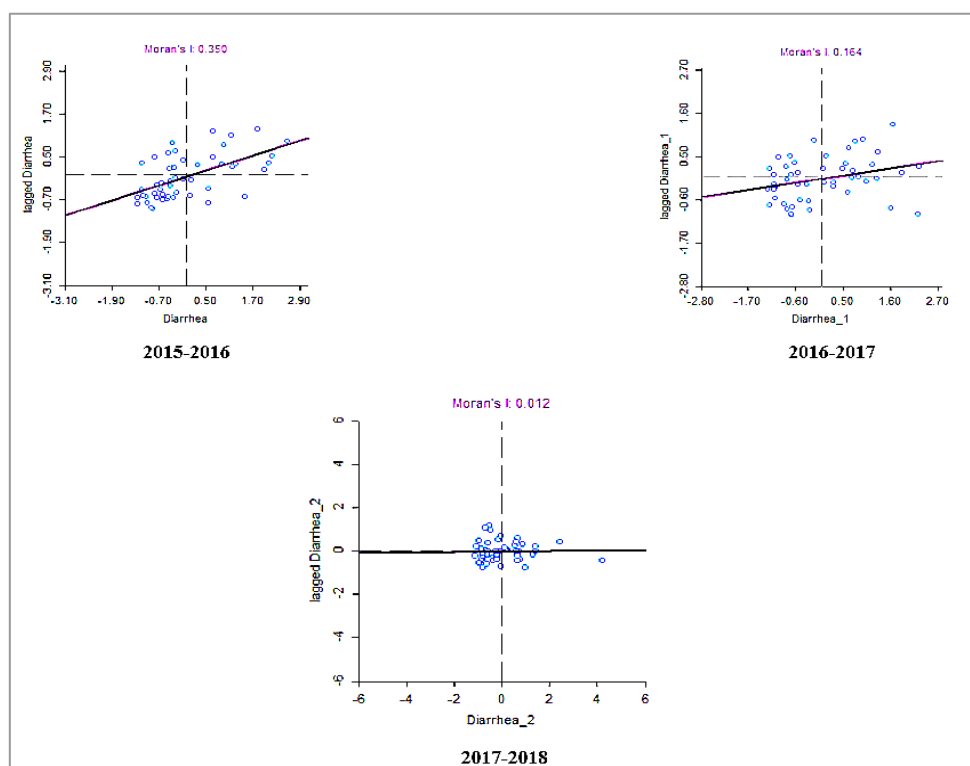


Fig.5: Global Moran I values for the years 2015-2016, 2016-2017, 2017-2018

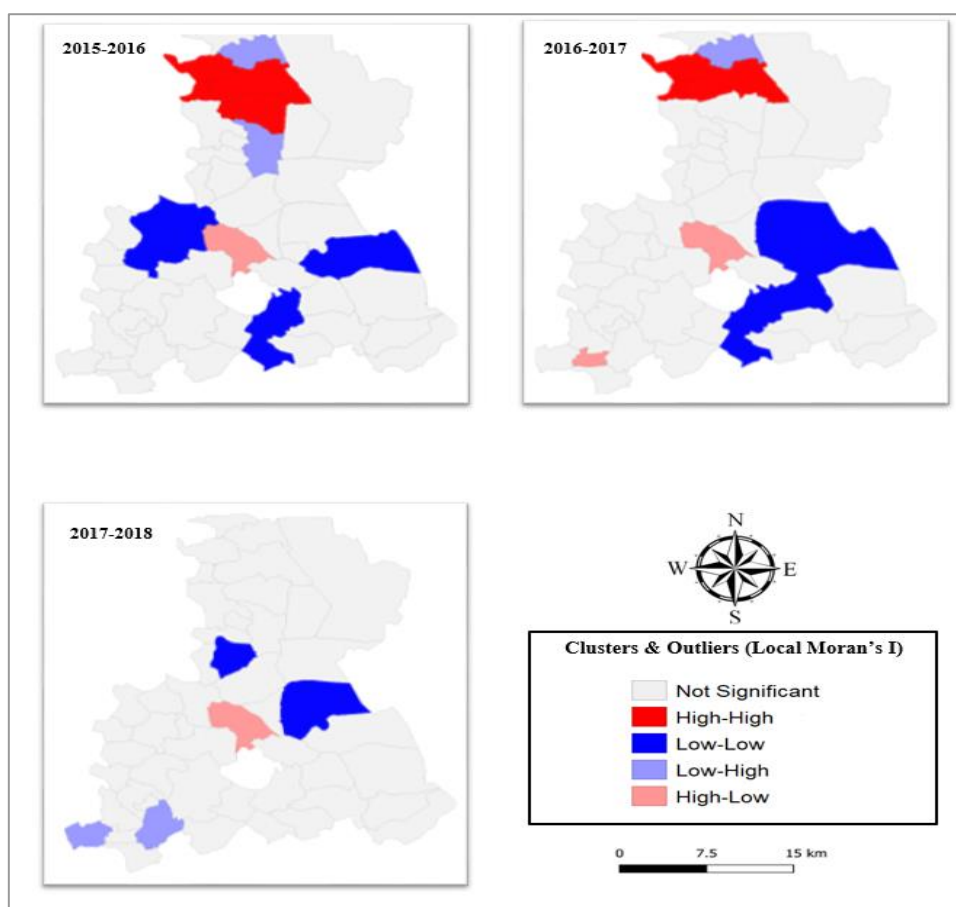


Fig.6: Local Moran's I cluster map for childhood diarrhea in villages of Karkala taluk in the year 2015-2016, 2016-2017 and 2017-2018

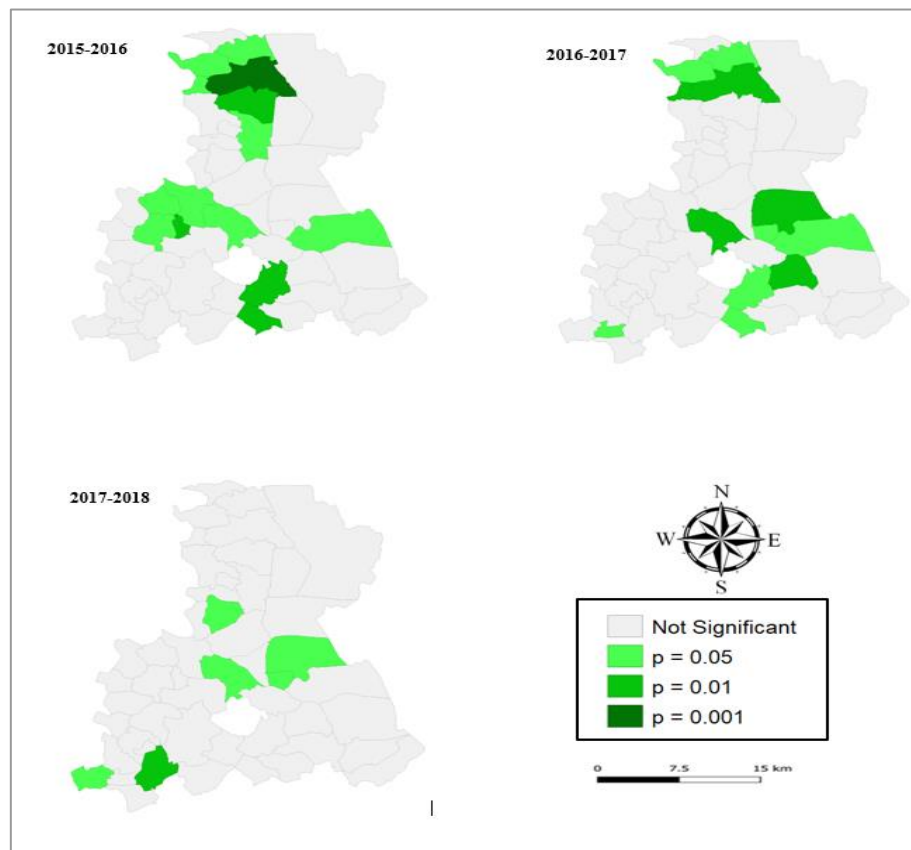


Fig.7: Local spatial association significance map for the prevalence of Childhood diarrhea in villages of Karkala taluk

DISCUSSION

India has introduced several programs, from the child survival and safe motherhood program in 1992 to National Health Mission in 2013, to reduce diarrheal disease's burden (14-16). Globally, diarrhea among under-five is considered serious; hence targets are being given to the countries to reduce the under-five mortality rate through Millennium Development Goals (MDG) in 2000 to be achieved by 2015 with sustainable Development Goals be implemented thereafter.

The present study showed increased incidence of diarrhea in under five children in Karkala taluk during the study period. According to data, diarrhea incidence was seen to peak annually during the summer and monsoon season. Several earlier studies have reported diarrheal outbreaks to these seasons, commonly caused due to water contamination (17, 18). Risk factors for diarrhea development among young children during these seasons are child malnutrition, inadequate breastfeeding, poor sanitation and hygiene practices among mothers (19).

This study also showed significant spatial distribution patterns of diarrheal incidence among under-five children across villages of Karkala taluk. The hotspot clustering patterns confirmed across the study period illustrated that few of the villages within the taluk could be grouped as diarrheal locations with higher risk. In a similar study, 1 primary cluster and 7

secondary clusters of diarrheal cases were identified covering 18 villages. Purely temporal cluster were also identified during summer season (20). Since such spatial distributions have been correlated to factors such as socio-demographic factors, environmental factors climate change (21), a further in-depth study investigating such under-lying factors could be useful in associating to hotspots identified in this study. This study also pointed out to strong spatial dependency and diarrheal occurrence among under-five children within the villages of the taluk, which could be useful to program planners for taking steps and prioritize interventions needed.

CONCLUSION

Despite taking several steps to reduce the burden, diarrhea management remains critical. Identifying spatial clusters and hotspots through spatial analysis tools could help plan resource allocation and in implementing strategies to specific geographic regions in health-risk reduction programs. In addition, such awareness programs, customized intervention, and available schemes to the hotspot area would bring down the burden of diarrheal incidence and improve child health.

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CONFLICT OF INTEREST

Authors declare no conflict of interest.

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