Mini Review

Methods used to Analyse Spatial, Temporal and Spatiotemporal Analysis of Diarrhea Among Under-Five Children in Coastal District of Karnataka

Dmello Mackwin K1, Badiger Sanjeev2*, Kumar Sudeep3

1Department of Public Health, K S Hegde Medical Academy, Nitte (Deemed to beUniversity), Mangalore, India
2Department of Community Medicine, A J Institute of Medical Science and Research Institute, Mangaluru, India
3Deputy Director, Community Health, Nitte (Deemed to be University), Mangalore, India

Corresponding author: Sanjeev Badiger, 2Department of Community Medicine, A J Institute of Medical Science and Research Institute, Mangaluru, India,E-mail: sbadiger.aj@gmail.com

Abstract

In the recent era, health science has bent towards spatially oriented research. Technology intervention in global health has shown positive results in reducing diarrhea, improving sanitation, and reducing diarrhoea.
Methodology: The article puts forward the methods used to analyse the spatiotemporal clusters of diarrhoea in Karkala taluk of Udupi District in India. The spatiotemporal models are developed by collecting the diarrheal data of under-five children across time and space at Karkala taluk. In this study, the spatial property was the location of the under-five child at the time of the diarrheal episode, and the temporal property was the time of the diarrheal attack. For the spatiotemporal analysis, both spatial and temporal correlation was taken into consideration. The geo-coordinates (location) were précised using a standard Cartesian coordinate system.
Results: To analyse solely spatial, temporal, and spatiotemporal clusters, the Kulldorff scan statistic (SaTScan v9.6.1) will be used. The SatScan software was used to detect the randomness of diarrhea distribution over space and time among under-five children. By considering the number of observed and expected cases inside the window, the software identifies and assesses the statistical significance of spatial or space-time clusters. The scanning window in SaTScan software considers time (interval), space (circle/ellipse) and space-time (a cylinder with an elliptical or circular base). A discrete Poisson-based model was used to analyse the monthly reported diarrheal cases following Poisson distribution.
Conclusion: The Spatiotemporal clusters results can be used to understand the risk analysis and decision making.

Keywords:

Spatial Epidemiology; Spatial Statistics; Childhood Diarrhea; Kulldorf StaTScan; QGIS

Introduction

In the recent era, health science has bent towards spatially oriented research.

Health Informatics intervention in global health at large has shown positive results in reducing diarrhea, improving sanitation and hygiene.

They differ from other health technologies, these are particularly designed to prevent disease, promote health, or cure illness from specific to more wide information.

The importance of utilizing Global Positioning System (GPS) and Geographic Information System (GIS) for spatial mapping has been increasing in recent years in epidemiological studies.
The GIS provides computerised capture, storage, and analysis of spatial data and gives insight into epidemiological linkages with potential risk factors.

The mapping of disease involves the capturing of image of more multifaceted geographical data, which will help in generating multiple hypotheses about aetiology and help in creating a platform for multi-disease surveillance

How to cite this article: Sanjeev B, et al.. Methods used to Analyse Spatial, Temporal and Spatiotemporal Analysis of Diarrhea Among Under-Five Children in Coastal District of Karnataka. AMHSR. 2021;11:1-4

activities. The Environmental factors of disease incident, data and statistics, different type of organisms in each area; high-risk region and zones that remove the source of infection can be analysed by GIS.

The prevalence of diarrhea is viewed as a serious problem significantly affecting the nation. Globally, India tops by contributing the highest number of diarrheal deaths among under-five children and has become a leading cause of childhood death in India, accounting for 13% of all deaths/year in children under five years. Rapid increase in population, urbanisation and poor environmental condition have disturbed the microbial world's equilibrium, leading to the rise of new emerging diseases. According to DLHS 3 report, India accounts for 12 % of children suffering from diarrhea, and in DLHS 4 Karnataka, the prevalence of diarrhea in the last two weeks preceding the survey is 5.5% which is equally distributed is among the urban and rural population.The burden of diarrheal disease among under-five in Udupi district in DLHS 4 more than doubled (4.2%) compared to that of DLHS 3 (1.9%).

The use of technology in global health is essential, but its assessment of contribution is not easy. Health technologies in high-income countries are beneficial, but the benefits are not well studied in low and middle-income countries. Even though satellite maps are made available, their uptake by the developing country was limited due to cost and infrastructure, particularly in public health. ArcGIS/QGIS and Kuldroff Scan are the software that public health professionals commonly use to generate geographical data and spatiotemporal information.

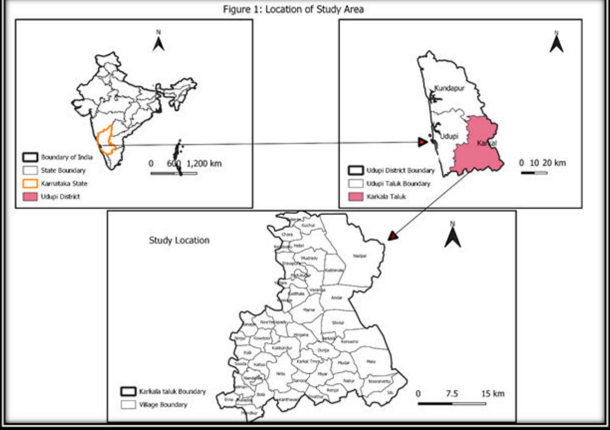
This study makes use of QGIS software and Kulldorff'sSaTScan software. The QGIS software is used for developing village shapefiles and for exporting graphical maps. QGIS software ropes both raster and vector layers where vector data is represented by point, line or polygon features and raster data by images. Kulldorff's scan statistics is used for analysing the geographical and temporal distribution of diarrhea cases among under-five children to identify purely spatial, purely temporal and spatiotemporal clusters [1].

Literature Review

Study Design and Study Site

A retrospective longitudinal study was conducted in the Karkala block/taluk of the Udupi district located in the southwest part of the country between 13011'60" North latitude and 74058'48" East longitude. This taluk has forty-nine villages and nineteen primary health centres. The shapefile of the Karkala taluk was created using QGIS software. Each child with the diarrheal episode was represented bygeographiclocation within the village site. Geo-coordinates were précised using a standard Cartesian coordinate system. The Karkalataluk has three seasons: summer, monsoon and winter. The warm season starts from March to May, monsoon from June to August and winter from September to February. In thestudy region, the average highest and lowest temperatures are 260C and 110C, respectively (Figure 1).

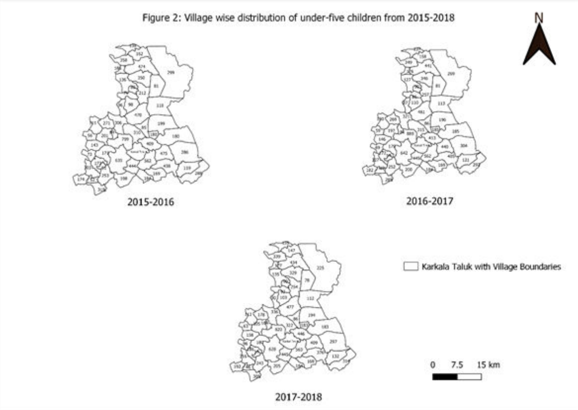
Figure 1: Location of Study Area



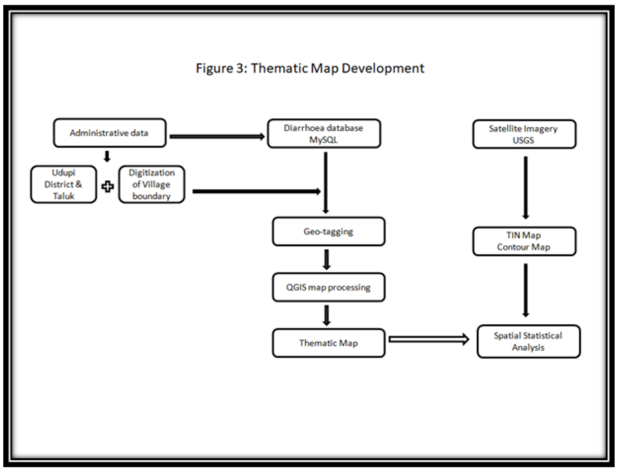
Data Collection

The under-five children with diarrheal episode were the unit of the study. This study recruited all under-five children of Karkala taluk who had a diarrheal episode in three years (2016-2019). The data on diarrhea among under-five children was retrieved from the District health authority with necessary permissions. This was validated at the village level; the researcher implemented a top to bottom approach, i.e. District level Taluk (block) level Primary health centre Sub centre. The collected data was collected using mobile specially developed for this project; it was then distributed based on the villages they reside. The demographic data of forty-nine villages were extracted from the subcenter and then validating it at each village panchayath by the trained health care professional (Figure 2).

Figure 2: Village wise distribution of under-five children from 2015-2018



Once the data was validated at the subcentre, the field data collection was completed with the help of a field investigator, who then visited the households with the ASHA worker. The consent to participate in the study was undertaken, followed by information related to the diarrheal episode to the child under five years. In addition to basic demographic information, the geo-coordinates of household, nearby water sources (river, lake, pond, tube -well), community water supply was obtained using a global position system (Etrex 10). The geo-coordinates was mapped on the map using Quantum Geographic Information System (QGIS) software. Thespatial and cluster analysis was done using SaTScan software (Figure 3).



Visualising Primary Health Centre at the village level:

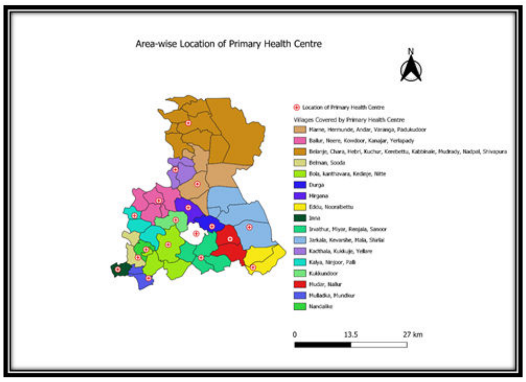
The locations of primary health centres were mapped using a GPS and were plotted using QGIS software to understand the distribution of public health services across villages. There was an unequal distribution of health centres across the villages, as seen in Figure 4. The mapping of the health centres will help in planning and resource allocation and preventive measures at the village level.

Data Analysis

Quantitative Statistical Analysis

Descriptive statistics and geographic analysis were performed to summarise the observed data. Two major approaches were performed for geographic analysis, i.e. geographical information system (GIS) and spatial statistics. The GIS gives statistical evidence for diarrheal pattern visualisation, diarrheal cases clustering and predictive modeling. At the same time, the spatial statistics will quantify the statistical significance of observed trends in location and spatial distribution.

Figure 4: Area-wise Location of Primary Health Centre



Discussion

Descriptive Statistics

The socio-demographic data were summarised using frequency, percentage, mean, standard deviation and range.

The annual under-five children diarrhea incidences per 1000 under-five population at risk in each village from April 2015 to March 2018 were calculated using excel.

The annual diarrheal incidence rate was calculated with a 95%confidence interval.

The excess hazard ratio (standard morbidity ratio > 1) for every village was estimated by dividing the observed cases by expected cases.

The expected number of cases in each village was estimated by E(c) =p*C/P, where c is the number of expected cases, and p is the population of the study village, C is the total number of observed cases. P is the total population in study taluk.

The Cluster

The cluster was identified based on a distinct aggregation of diarrheal cases in Karkala village relative to under-five children at risk.

The identified cluster will help to investigate the possible relation of diarrhea to underline factors so that the public health interventions could be focused on host spot areas.

It is imperative to note whether the observed clusters are due to chance; for this, Kulldorff has identified various tests to detect the disease clusters based on spatial randomness. The test takes space, time and space-time into consideration.

The space test will identify the clusters based on diarrheal disease concentration over the particular village, and the time test looks for temporal clustering.

At the same time, space-time detects diarrheal clusters in space, time and space-time.

The spatial analysis will also help us know whether the clustering of cases is global (over the entire village) or local (limited to small geographic areas of the study village) [2].

The spatial test takes the geographical area (i.e. the study village) and a centroid (i.e. geo-coordinates of the area) into consideration.

The geo-coordinates are given latitude and longitudes. The Poisson distribution model is used for cluster detection. It assumes the non-homogeneous Poisson process for generating diarrheal cases in the village under the null hypothesis. The expected cases are generated based on proportional population size.

Cluster Analysis

The Spatiotemporal and cluster analysis was conducted in 49 villages using the Kulldorff scan statistic (SaTScan v9.6.1). The SatScan software was used to detect the randomness of diarrhea distribution over space and time among under-five children. By considering the number of observed and expected cases inside the window, the software identifies and assesses the statistical significance of spatial or space-time clusters. The scanning window in SaTScan software considers time (interval), space (circle/ellipse) and space-time (a cylinder with an elliptical or circular base). A discrete Poisson-based model was used to analyse the monthly reported diarrhoeal cases following Poisson distribution.

Space-time cluster Analysis

Space-time scan statistic was used to detect clusters both in space and time. The space-time scan statistic uses a cylindrical window with a circular (or elliptic) geographic base and height related to time to determine spatiotemporal clusters. The purely spatial scan statistic is reflected by the geographic base of the cylindrical window, while the height of the cylindrical window reflects the period. The cylindrical window is moved in both space and time; it also visits each possible time interval. For each space-time window, the likelihood ratio is calculated to determine the rate of observed cases and expected cases. The Monte Carlo simulations (999) technique is used to estimate the p-value.

Ethical consideration

The study protocol was peer-reviewed by the experts before its submission to the review committee. The study was approved by the Central Ethics Committee [Ref: NU/CEC/2019/021]. The necessary permission from the District Health Authority and informed consent from participant and the guardians who participated in the study was undertaken [3].

Dis This study will give information onthe spatial cluster, temporal cluster, and spatial distribution of diarrheal cases among under-five children. The study's outcome shall support policymakers and planners for effective diarrheal management strategy within the village via primary health centre jurisdiction. The spatial analysis shall provide clues on environmental and social characteristics, disease aetiology, and population behaviour.

Though the spatial analysis techniques for multi-factorial investigations allow sound synthesis of information, the choice of test, the software and the methodology remain essential [4]. The data collection and the geo-coding of all houses, nearby water sources in the village was time-consuming. Additional training was required for data collectors to use the Garmin Etrex 10 (GPS) unit. The acquisition of village satellite images and the use of software programs such as QGIS and SaTScan required special skills. The training among the ASHA workers and the field investigators was effectively carried over with the help of a simple mobile application for the data collection, and the training was highly contextualized to the study setting. Some cautionary measures were taken to have accuracy in geo-coordinates; Etrex 10 GPS was used to collect log points manually [5].

The novel amalgamation of field data and spatial data in scan statistics will generate ideas to improve the health condition of the children in the most unreached areas of the village. The 'hotspot' and health care accessibility areas can serve as a guide for resource allocation.

Conclusion

Given the high mortality and morbidity rate among under-five children due to preventable disease like diarrhea, there is an urgent need to understand the epidemiological factors and measures to prevent thoroughly. The Spatiotemporal clusters results can be used to find the risk analysis and develop efficient policies by the decision-makers at the individual and community levels.

References

1. Njemanze PC, Anozie J, Ihenacho JO, Russell MJ, Uwaeziozi AB. Application of risk analysis and geographic information system technologies to the prevention of diarrheal diseases in Nigeria. Am J Trop Med Hyg. 1999;61(3):356–360.
2. Lakshminarayanan S, Jayalakshmy R. Diarrheal diseases among children in India: Current scenario and future perspectives. J Nat Sci Biol Med. 2015;6(1):24–8.
3. Kulldorf, M. An isotonic spatial scan statistic for geographical disease surveillance. J Nat Inst Pub Health,1999; 48: 94-101.
4. Kulldorff, M. Statistical methods for spatial epidemiology: tests for randomness. In GIS and Health London, 1998;49-62.
5. Sarkar R, Prabhakar AT, Manickam S, Selvapandian D, Raghava MV, Kang G, et al. Epidemiological investigation of an outbreak of acute diarrhoeal disease using geographic information systems. Trans R Soc Trop Med Hyg. 2007 ;101(6):587–93