AMJ
ISSN: 0005-2523

ISSN: 0005-2523
Volume 62, Issue 01, March, 2022

Application of Spatial Analysis to Nutritional Epidemiology among Under - Five Children in Karnataka, India

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Keywords:
Malnutrition, Moran's Index, LISA, Spatial analysis

ABSTRACT

Malnutrition has become a significant public health challenge strongly associated with the substantial increase in the risk of mortality and morbidity in children. This study will be conducted to determine the geographical variation in nutritional status of under-five children and identify the spatial clusters based on demographic and household characteristics in Karkala taluk of Karnataka state, India, and replicate the same in other areas. The aggregated nutrition status data of children under five years are collected from the Udupi district health office for three years, validated at the village level. The anthropometry, topography, and socio-demographic data is collected by visiting the household. The retrospective discrete Poisson probability model will identify the clusters of underweight, stunting and wasting. Spatial autocorrelation statistics like Local Indicators of Spatial Association (LISA) statistics of nutritional status will be analysed. The logistic regression model will be used to analyse the causes of clustering. The geo-coordinates of the households were summarised using a Cartesian coordinate system. The SaTScan statistic software (SaTScan v10.0.2) will be used to identify the spatial, Spatio-temporal clusters of underweight, stunting and wasting among under-five children. This software will detect the randomness of nutritional status of under-five children over space and space-time. The spatial data analysis and spatial autocorrelation will be carried out using GeoDa software. Spatial dependence of nutritional status will be analysed through the Global Moran's Index and Local Indicators of Spatial Association (LISA). The observed and expected cases inside the window are considered for spatial and space-time cluster significance in SaTScan software. The LISA statistics will indicate the local pockets of non-randomness or hot spots. The LISA statistic is also used to assess the contribution of location on the magnitude of global figures. The Spatiotemporal and autocorrelation results can be used for risk analysis of malnutrition among under-five children by the policymaker for decision making.

1. Introduction

The coexistence of under-nutrition and over-nutrition has surfaced as a public health paradox in developing countries that undergo economic, epidemiologic and nutrition transitions. Malnutrition has become a significant public health challenge strongly associated with a substantial increase in the risk of mortality and morbidity in children [11]. Infants and school children are most vulnerable to the vicious cycle of malnutrition. In 1975, the Government of India launched Integrated Child Development Scheme Services (ICDS) for early childhood care and combat malnutrition. The introduction of the Anganwadi centre for 0 to 6-year children and Anganwadi workers was the highlight of the ICDS program. The Anganwadi centre provides essential health care services to the children like health education, supplementary nutrition, immunization services, informal education, etc [4].

Globally, more than 26% of children below five years are stunted, and 39% come from South Asia. India contributes 38% of under-five stunted children globally and is considered to have the highest prevalence of moderate to severe wasting. India accounts for 20, 43 and 48 percent of under-five children in wasting, underweight, and stunting [13]. India is ranked 2nd globally for the number of children suffering from malnutrition accounting for 47%, and top in the world in contributing underweight children. According to NFHS 4, Karnataka accounts for 36.2%, 26.1% and 35.2% of stunting, wasting and underweight under-five children, respectively [12]. DLHS 4 Karnataka report showed that 29.9% and 16.0% of under-five children were moderately and severely stunted, respectively [1]. Diarrhoea and lack of sanitation and hygienic practices are the primary culprits of malnutrition among under-five children [8].

Traditional descriptive epidemiological studies observing infant and child mortality determinants have focused on the proximate determinants of child survival. Still, they have ignored the importance of geographic space as an independent factor leading to the risks of infant and child deaths [14]. Analysis of spatial clustering usually is employed in combination with geographic information systems to understand whether the values of the variable follow the specific spatial pattern. The geospatial exploration will assist in determining whether the observation of interest is distributed randomly or exhibiting a particular spatial pattern [2].

Local Indicators of Spatial Association and spatial clustering is a new way to identify the role of place as a related factor for dietary behaviour and other associated problem. The study will also help the local policymakers plan for intervention for the targeted population. The study concentrates on the local block because the analyses conducted at the state level or the larger area may not provide results for planning the intervention at the local level [10].

SIGNIFICANCE OF STUDY:

Geographic distribution of malnutrition among under-five is fundamental to plan interventions that target high-risk areas. Although geospatial analysis has been used in identifying other infectious and chronic disease risk factors, its use in determining malnutrition is limited in developing countries. Many studies have identified risk factors at the child, maternal, and household levels. Still, they have failed or overlooked the potential effect of geographical and environmental factors in explaining child survival. The limited studies in this area are primarily due to insufficient use of health informatics at the field level.

ISSN: 0005-2523
Volume 62, Issue 01, March, 2022

2. Methodology

2.1 Study location

This study is conducted in Karkala, Karnataka, located (13011'60" North latitude and 74058'48" East longitude), and sited in the southern part of the country. The taluk has 228 anganwadis and 19 health centres. The shapefile of the study area was created using QGIS software. (Figure 1).

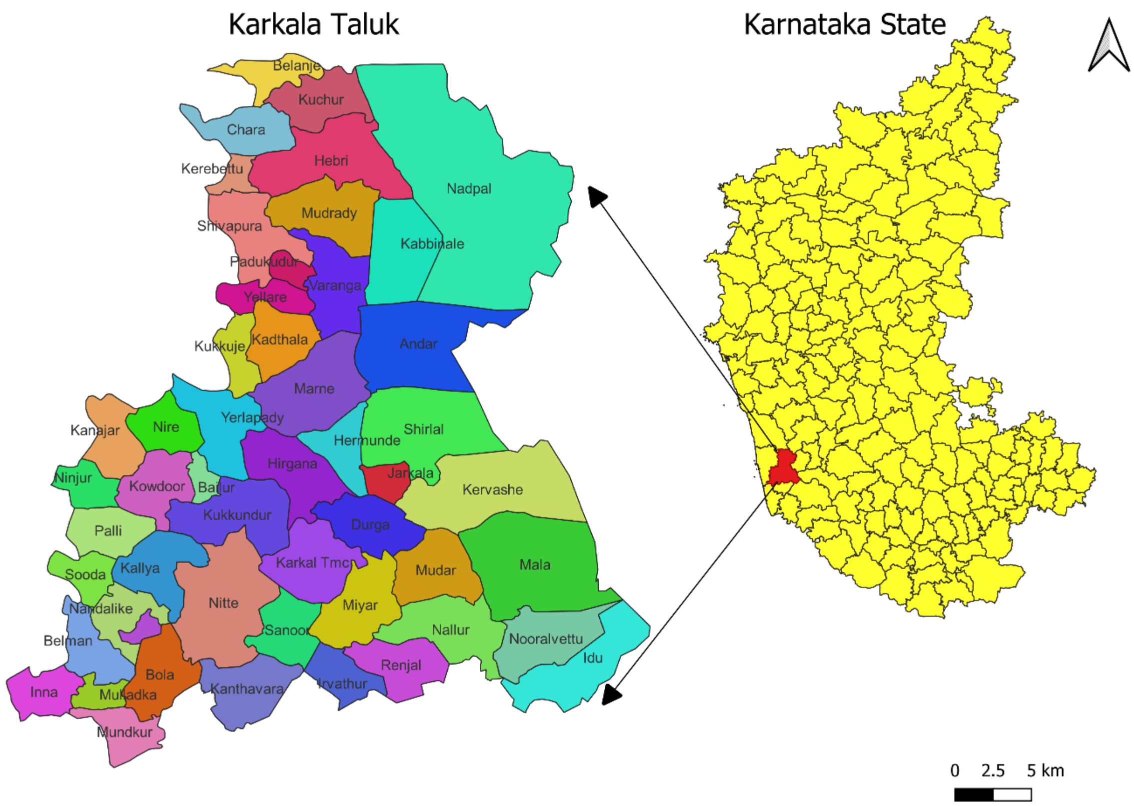
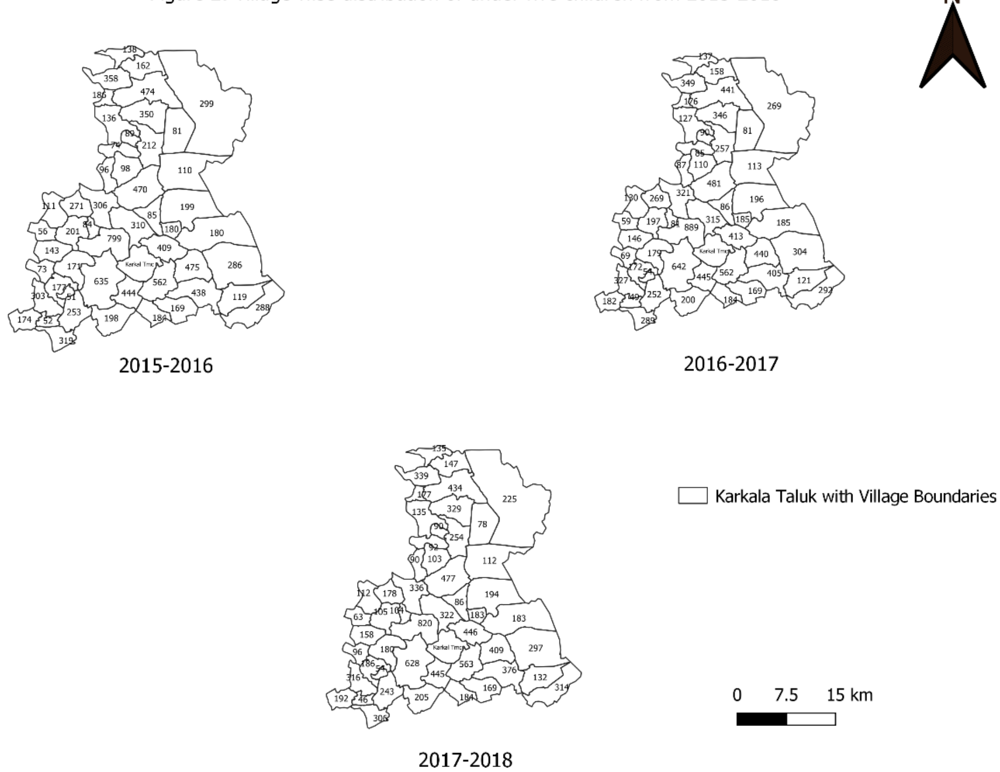


Figure 1: Study Location

2.2 Data Collection

The nutritional status of children was collected from the health department, Udupi. This study will recruit all under-five children of Karkala taluk for six years (2015 - 2021) and assess their nutrition status. The study duration for extracting the secondary data and analysis was two years (December 2019 – January 2022). With the necessary permissions, the nutritional status of under-five children was collected from the health department, Udupi. The data collected at the district health office was then validated at the Anganwadi level. The trained health professional extracted the demographic and dietary information from the Anganwadi (Figure 2).

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



The information will be authenticated at the Anganwadi centre, and the field investigator will collect field data with the help of ASHA and Anganwadi workers. The demographics, food habits, and geo-coordinates of home and water sources will be obtained using a GPS (Etrex 10). The mapping of geo-coordinates of households will be completed using QGIS software. The spatial and hot-spot analysis will be done using SaTScan and GeoDa software, respectively (Figure 3).

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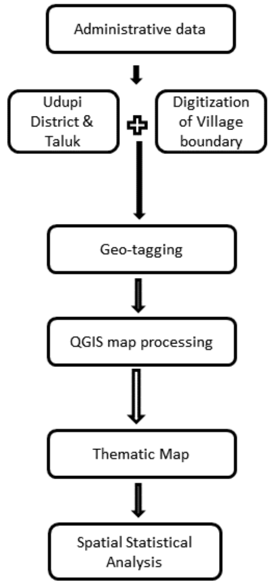
Figure 3: Development of Thematic Map



2.3 Visualising Anganwadi at the village level

The locations of Anganwadi centres were mapped using a GPS and were plotted using QGIS software to map the Integrated Child Development Scheme (ICDS) Services across villages. Figure 4.

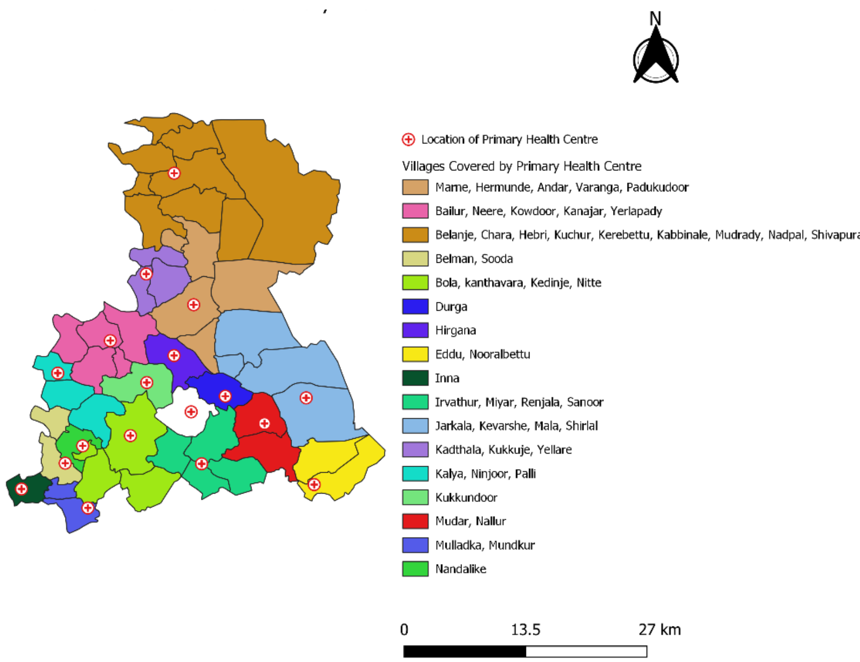


Figure 4: Location of Centres

2.4 Data Analysis

2.4.1 Descriptive and Quantitative Statistical Analysis

Data summarisation will be done using geographic and descriptive analysis. Spatial statistics and Geographic Information System (GIS) will be conducted for geographic analysis. The statistical evidence for malnutrition and its visualisation, clustering and predictive modelling is given by geographic information system. The quantification and statistical significance of observed trends in villages will be done by spatial statistics using SaTScan software.

The baseline data will be summarised using frequency, proportion, average and standard deviation. The prevalence of malnutrition among under-five children will be calculated with a 95% confidence interval. The risk ratio (standard morbidity ratio > 1) for each area will be assessed by dividing the observed cases by expected cases. The expected number of malnourished children in each location will be estimated by $E(c) = p*C / P$, where c is the number of expected cases, p is the study village's population, and C is the number of total observed instances. P is the total population in study taluk [5].

2.4.2 The Cluster

The cluster will be recognised based on the specific aggregation of wasting, underweight and stunting cases among children in the study area concerning children at risk. The cluster will assist in determining the potential connection between undernutrition and the underlying spatial factors to initiate intervention on hot-spot villages. The SaTScan software uses different tests to recognise a cluster of malnourished children in various village [7].

The software considers factors such as spatial, temporal and Spatio-temporal. The spatial check will recognise the clustering of malnutrition cases in the study area. Temporal clustering of cases will be identified by time test. The spatial investigation will help us distinguish whether the clustering of cases is over the entire place (global) or limited to small geographic areas of the study village (local).

2.4.3 Analysis of Spatial Clustering

To identify the spatial clustering of under-five children's malnutrition status, we will be using SaTScan software. Scan statistics will assess the randomness of case distribution over a geographic area. The significant spatial clusters will be recognised if the malnourished cases are non-random distributed. The Kulldorf spatial scan will use a circular window to identify substantial clusters of malnutrition over the study area. The size of the circular window will vary from zero to an upper limit; the upper boundary of the circular window size will be set at 50% to identify small and large clusters. A likelihood ratio will be calculated for each scanning window to determine the increased risk of malnutrition among under-five children compared with neighbour window distribution. A purely spatial Poisson probability model will be used to recognise the villages with high cluster rates and with a significant p-value.

Local indicators of Spatial Autocorrelation, the spatial analysis was applied to find out the Local Moran cluster map and significance map. LISA map will provide the statistic for each area with an assessment of significance. Also, it creates a relative association between the sum of statistics with corresponding global statistic [6].

2.5 Ethical Consideration

The professionals reviewed this protocol paper prior to its submission to the institutional review committee and were approved by the Institutional Ethics Committee.

3. DISCUSSION

The inequitable access to health care services and human resources constraints have made the health care

ISSN: 0005-2523
Volume 62, Issue 01, March, 2022

sector more challenging. The development of spatial research to understand the environmental and spatial role in disease incidence and build-up algorithms for addressing unmet needs is essential to achieve Universal Health Coverage.

Voluminous health-related data are generated, stored and validated. The value of the data is limited, especially in an Asian country like India [3]. Knowledge and evidence from multiple sectors by analysing standard data sets are necessary for planning any health promotional program. Data from multi-sectors is essential to develop decision support tools and early warning signs in public health [9]. The various data sets available in different formats require pre-processing to amalgamate them for spatial and temporal analysis.

This study comprises routine line list data of malnutrition (wasting, stunting and underweight) cases among under-five children from the Anganwadi centre. This study will give information on the spate, time, and space-time distribution of malnutrition cases in under-five years. The study's outcome will support public health representatives for effective nutritional management strategies.

The novel combination of field-level data with spatial data will generate strategies to develop the nutrition status of the children in the most remote or unreached areas of the community. The 'hot-spot clusters' locations can assist as a guide for resource sharing or allocation at the village level.

Limitations
Although this study explores demographic, climatic, space and time aspects of malnutrition cases among children, this study has certain limitations. The unavailability of the routine spatial data and poor mechanism of reporting system by the private sectors is a limitation in this study. In the future, for robust scientific support, developing data sets that include these parameters is necessary.

4. CONCLUSIONS

The spatiotemporal patterns of any health condition are an inherent characteristic of routine health data. Also, voluminous data on health are generated from multiple sectors, which can be used as indicators for risk profiling. The association of spatial and temporal patterns of malnutrition cases with forecaster variables derived from the routine information is necessary to develop data-driven public health decision making.

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