Spatio-Temporal Risk-Analysis of Cancer Endemicity in Sulthan Bathery Taluk of Wayanad District of Kerala-A Geo-Informatics Approach

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Abstract

Context: Asian countries have to confront with the global burden of cancer and various environmental factors predisposing the incidence. Geoinformatics can assist in spatial autocorrelation and statistical analysis in determining environmental and demographic correspondence to endemicity. What is of prime importance is the availability of the spatial datasets of cancer cases. **Aims:** The aim of this study was to reveal the distribution pattern of cancer and its magnitude in the eight panchayats of Sulthan Bathery Taluk of Wayanad district. The present study also attempted to develop and implement a data frame facilitating better data collection. **Settings and Design:** This was a taluk-level cross-sectional retrospective analysis and interventional study. **Subjects and Methods:** A retrospective survey created a geodatabase with 547 cancer cases registered along the timeline of 2015–2016. Input datasets were geocoded using Google Earth Pro software. **Statistical Analysis Used:** The analysis was performed using ArcMap-10.2 version. **Results:** Registration revealed the high breast cancer incidences and temporal increment mainly in town areas. The incidence depicted male predominance and prevalence along the age group of 30–69 years. The pattern showed cancer incidence at a proximity to state borders and forest regions (Noolpuzha) which are high population density regions, instantiated relation of geographic variables, and cancer incidences. The implementation of data frame ensured structured data collection. **Conclusions:** This study concluded the spatial association of cancer incidence demonstrating the high-risk regions with male predominance and role spatial risk analysis in cancer database management.

Keywords: ArcMap, cancer, geographical information system, geoprocessing, spatial risk analysis

Introduction

In current scenario, the technology is progressing with an accelerated pace where, precise and rapid data disseminations are quite indispensable in delivering quality healthcare. One of such translation referred as "geographical information system" (GIS) or Geospatial Intelligence, dated back to early 18th century, and well known through an epidemiologist Dr. John Snow.[1] Environment is an inextricable and imperceptible aspect governing health, often a prime predisposing factor for certain debilitating illness.

The number of people living beyond a cancer diagnosis is expected to rise to 19 million by 2024 with 5-year survival rate of 67%.[2] Cancer morphometry substantiates the relation of the genetic factors with physical, biological, and chemical mutagens. Lack of speculation on the carcinogen is a hindrance to therapy reducing the life expectancy of cancer patients. More than 60% of the world's new cancer cases occur in Africa, Asia, and Central and South America. As per the IARC GLOBOCAN reports, 14.5 lakh new cases are diagnosed in 2016 and proposed to increase by 17.3 lakh new cases in 2020.[3,4]

In India, the National Cancer Registry Program (NCRP) coverage is erratic with noninteroperable platforms pausing

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threats on strategic planning and disease management. Cancer priority control needs understanding the occurrence, risk of exposure, consequences, and variations predisposing disease risk among the population, further strategize primordial prevention and targeted intervention. Spatial analytic methods provide such solution to understand the pattern, trends, and variation in the geographic features.[5-8]

Medical geography has emerged its applicability in clinical decision support system and geosurveillance programs. Health-care professionals and analyst need improvised tools for examining health-related information. The competitive capability of spatial visualization technique presumes and predicts various association of geographic components and endemicity, apparently not possible with other traditional statistical analysis packages.[9-11] This calls for a spatial dataset that facilitates geospatial risk analysis to exemplify the environment risk on health.

Subjects And Methods

Study aspects

A cross-sectional and interventional study by retrospective survey of cancer cases records was carried out along the timeline of 2015–2016. The entire study was in two phases (SP).

SP1: Development and implementation of data frame for data collection

Data frame was developed using the web development tool Dreamweaver CS6, facilitating the entry from the web page and store into MySQL database, which create the attribute table for the spatial analysis.

Data collection was at ten health centers of Sulthan Bathery taluk. Cancer cases segregated from the nominal register enumerated a total of 547 cases skimmed across the timeline. The data structure includes patient's gender, age, location, and cancer type. The location is geotagged using Google Earth Pro software. The implementation of the data frame enabled the health-care centers for complete accurate and reliable future data collection [Figure 1].

SP2: Development of thematic maps

Satellite imagery, cancer database, census data, and digitized administrative units form input datasets for ArcGIS analysis as shown in the workflow of thematic maps development [Figure 2].

Geographic extend

Sulthan Bathery Taluk, situated in the North Eastern part of the state of Kerala with geographic extent from 11°33'8.47"N to 11°51'49.47"N latitude and 76°4'16.67"E to 76°26'7.67"E longitude. Administrative units of Sulthan Bathery Taluk have eight panchayats [Figure 3]. As per the census of 2011, the district health book reported a total of 259,993 population in the study area with 130,052 males and 129,941 females.[12] The study area includes state borders of Karnataka and Tamil Nadu with major forest zones with a comparatively high density.

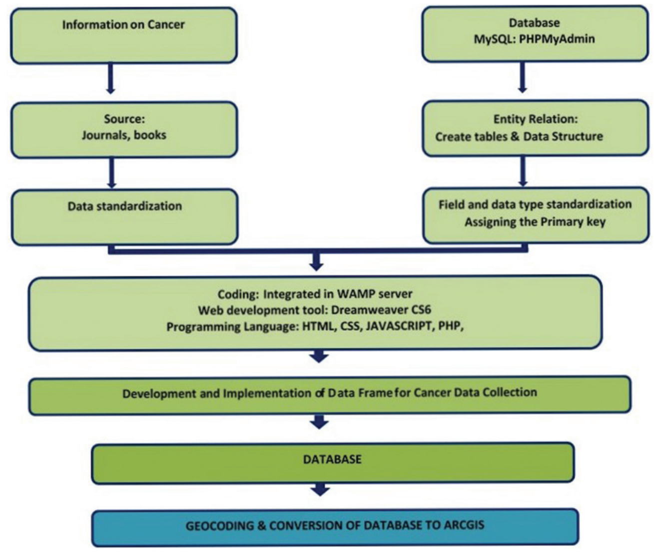

Figure 1: Process chart data frame development

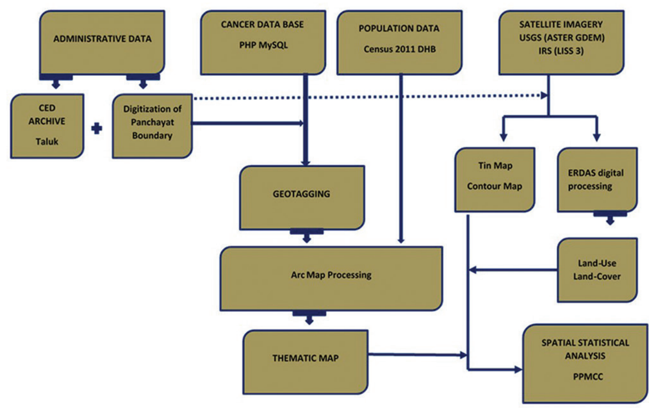

Figure 2: Thematic map development

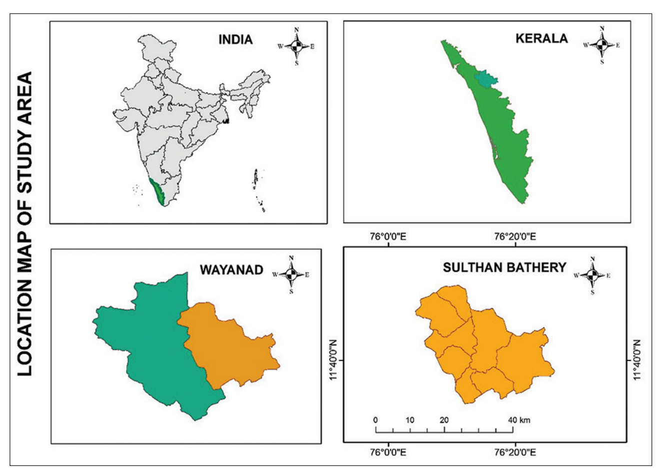

Figure 3: Location map

Ethical consideration

The statutory requirements from Directorate of Health Service, Kerala, were taken before the study. Secondary data collected was deidentified, and confidentiality is maintained.

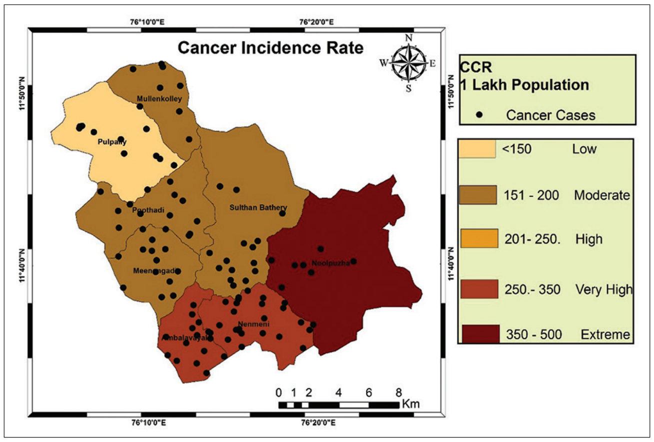

Figure 4: Incidence and prevalence mapping

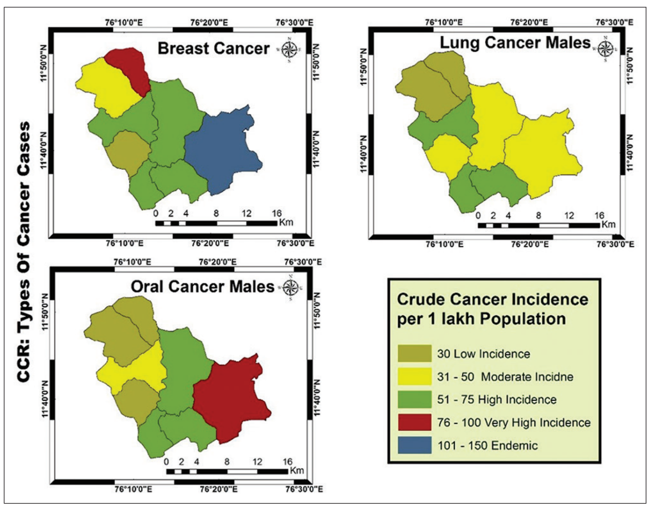

Figure 6: Distribution as per type of cancer cases

Analysis

The geoprocessing of polygon (Panchayat boundary) and point (Cancer database) geometry was done in ArcMap 10.2 version (Environmental Systems Research Institute, California) to create thematic maps and point density maps. The manual interval classification with graduating color symbology classified the incidence as low, moderate, high, very high, and endemic.

A cancer incidence rate is the number of new cancers occurring in a specified population over a year, usually expressed as the number of cancers per 100,000 people at risk.[2,3]

Crude cancer incidence rate (CCR) = (New Cancer Cases/Population) ×100,000

Results

The geoprocessing of the input dataset fetched results as the following:

Prevalence and incidence mapping

Distribution of the cancer in a geographical location draws light on endemicity to that segment. The point density

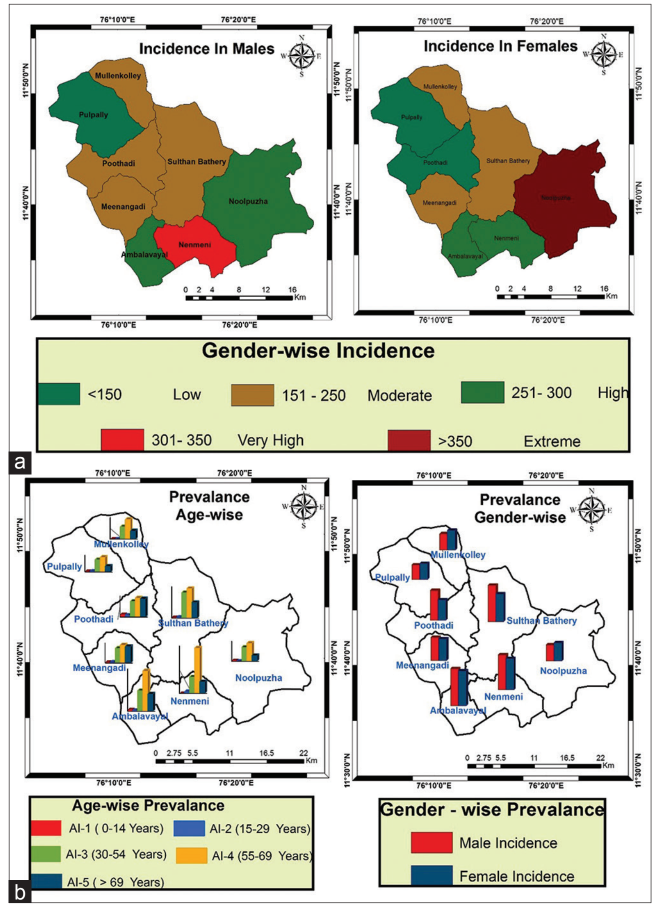

Figure 5: (a and b) Demographic distribution of cancer cases

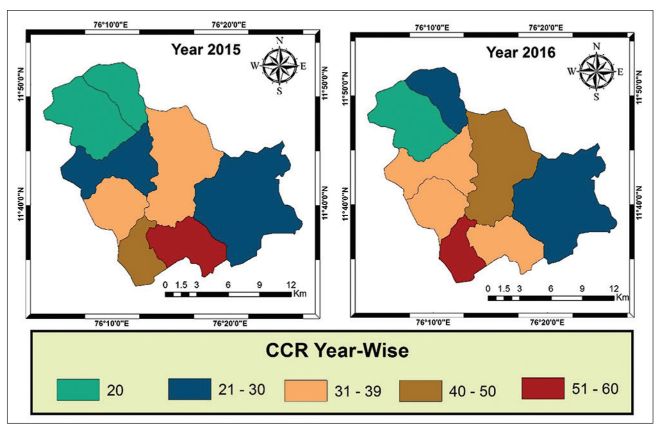

Figure 7: Temporal mapping

results depict the registration of cancer trends toward town agglomeration. Approximately 50.8% (278) of the new registration concentrates to Sulthan Bathery, Ambalavayal and Nenmeni panchayat quantify the burden at the health center. The Nenmeni, Ambalavayal, and Noolpuzha region collectively have higher density depicting higher incidence rate of >270 per 1 lakh population [Figure 4].

Demographic distribution of cancer cases

The graduated symbology illustrates that approximately

62.5%[5] of the administrative units have the male population at moderate risk, whereas 25%[2] of administrative units have the female population at low risk depicting the degree of male predominance of cancer incidence.

A total of 52% (286) registered are males, and 48% (261) registered are females. In the areas of Sulthan Bathery, Meenangadi, Ambalavayal, Poothadi, and Nenmeni shows high male incidence 62.5%[5] which are major town areas, whereas rest of the administrative units has very slight female dominance. In areas where elevation increases, proximity to hilly areas increased, the male prevalence has increased slightly but on the contrary to this proximity to forest regions such as Noolpuzha, Pulpally, and Mullenkolly depicted almost equal prevalence. The new diagnosis pattern shows late adulthood trends in all the administrative units irrespective of the spatial differentiation. Approximately 74.9% (410) of the total cases registered belong to the age group of 30–69 years, >50% (217) of the cancer cases registered in the age group of 30–69 years are from Sulthan Bathery, Ambalavayal, and Nenmeni region [Figure 5a and b].

Distribution as per the types of cancer cases

More than 70 different types of cancer are identified depending on the site of origin, of which major cancer types in both genders were chosen for analysis. The oral cancer and breast cancer incidences are very high, contributing 28% (158) of total cancer diagnosed.

The breast cancer incidences were found to be high in 75%[6] of the administrative units with CCR>50/1 lakh population, whereas the oral cancers were found to be high in 50% of administrative units with CCR of >50/1 lakh male population. The breast cancer cases contribute to 13.8% (78) of the total cancer cases, keeping 0.058% of the total female population at risk, whereas the risk associated to the oral cancer is 0.03% of total population. Tongue and buccal mucosa are the major site affected, which is 37.18% (28) of oral cancer diagnosed.

The lung cancer incidence is higher in males which is equal to the oral cancer incidence in males. The extend of spread is comparatively less as 37.5%,[3] administrative units have CCR >50/1 lakh male population, keeping 0.058% of the male population of that region at risk and the 0.04% of the total male population of Sulthan Bathery at risk of lung cancer [Figure 6].

Temporal mapping

The choropleth representation exemplifies that the cancer density across the administrative units are slightly increasing over the period. In 2016, the number of cancer registered at the 50% of administrative units has increased in Ambalavayal, Mullenkolly, Poothadi, and Sulthan Bathery on contrary, there is a reduction in cases at Nenmeni at a rate −43% [Figure 7].

Discussion

Advanced geoinformatics approach with its capabilities assist the health-care professionals with clinical decision support. Comprehensive e-atlas initiative by NCRP facilitates better location mapping but is exclusive of many regions of Kerala. Geosurveillance enabled faster result visualization and interpretation. The results provided a snapshot of incidence, prevalence, and temporal trends in Sulthan Bathery taluk. Thematic mapping and point density instantiated town agglomeration of cancer registration might be due to urban-rural shift and variation in approaching hospital. Similar results were interpreted in an article showed an urban agglomeration in Mysore regions of Karnataka.[9] The present study is affirmative to incidence at high-density regions with symmetric increase in high-elevation regions on the contrary to a study by George and Mathew[11] where there is an increment in breast cancer incidence in coastal regions with low elevation and high population density. The choropleth representation showed a male predominance near town areas, whereas equal predominance is featured at a proximity to the forest zones. The age-wise categorization quantifies the percentage of working population, dependency, and burden on the society. The study presented an increase in adulthood incidence similar to surveillance, epidemiology, and results report where the median age of diagnosis is 66.[2] Conversely, such analysis is not possible with other routine statistical analysis methods. The reports conceptualized that one in 28 women in India is likely to develop breast cancer.[4] The present study concluded a relative risk of 0.058% of breast cancer incidence is also conclusive in other constructive spatial analysis studies.[9-11]

Ostensibly, exponential increase in CCR intricate the probable risk advocates workforce and resource planning. A recent taluk-based study by Valarmathi *et al*. used temporal analysis to map breast cancer in Tamil Nadu over 5 years, expressed as the rate may vary over time as urbanization increases. Apparently, spatiotemporal analysis expedites precision in the decision regarding increment or decrement in the incidence and spatial correlation over time.

Spatial statistical capability can be categorized into analyzing pattern, mapping clusters, measuring geographic distribution, modeling spatial relation, rendering, and networking. A statistical analysis by Yomralioglu *et al*.[13] is suggestive of positive association of elevation and cancer types with a positive Pearson’s coefficient.

Geoinformatics integration to healthcare sector ameliorated analysis of service accessibility and understanding reasons for delay, modeling resource utilization and coverage of program, identification and eradication of vector transmission, and outbreak detection.[14-17]

The development and implementation of the web-based data frame fostered structured storage and management of cancer database extenuating a real-time source for information for further analysis.

Limitation

The present study was carried out in a small segment. Precision of location tends to delineate with the accuracy of the mobile GPS. Infrastructure was a limit for implementation of the data frame at the health center.

Conclusions

The present study instantiated applicability of geoinformatics in cancer database management and enhanced clinical decision support using spatial visualization techniques. Apparently, spatial–temporal analysis exemplified increment in new cancer case requiring preventive interventions and early identification strategy. Implementation of the data frame and software training can be a template for spatial data for further analysis. The present study articulates the need for geoinformatics approach in managing healthcare data to understand the endemicity of cancer cases and provide quality healthcare.

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Conflicts of interest

There are no conflicts of interest.

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