APPLICATIONS OF GEOSPATIAL TECHNOLOGIES FOR DISEASE MAPPING

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Abstract:

Background: Geographical Information Systems (GIS) provides a holistic approach to deal public health scenarios that promotes the wellbeing of human populations through organizing data about who we are, where we live, and how we live within a geographic framework.. GIS incorporates data that describes population characteristics, socioeconomic conditions, and the landscape, and analyses the spatial relationship of these factors. The availability of powerful desktop GIS and spatially-enabled data has expanded the use of GIS beyond research institutes and state agencies to hospitals and medical centers. In addition to using GIS for organizing, linking, and presenting data sets, modeling local data can provide insights that lead to the development of programs that better serve the community.

Objectives: The present study aims to showcase the mapping of cancer data that was collected from medical records and also project the use of maps in targeting cancer control programs in the vulnerable regions for further research.

Methodology and Results:

1. The collected cancer cases were geocoded and prepared into a geo-database with necessary attributes and associated risk factors
2. Thematic maps were prepared using the ArcGIS Desktop software in order to assess the cancer burden in the study region

Conclusion: These maps could be used as a framework for primary prevention and also help the public health professionals to come up with awareness programs in regions of high cancer burden. This will further help to delineate the relationship of influential causative factors in the high risk regions.

About the Author:

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Dr.Janani Selvaraj just completed her Ph.D in Environmental Management and working as a Senior Research and Analytics Consultant at Learning Center, Trichy. She is currently training students in Data Science and is an avid researcher in the field of spatial data science. She contributed as a Research Fellow for a GIS Project that used ArcGIS as an exclusive tool for cancer surveillance.

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Introduction

Cancer control researchers seek to reduce the burden of cancer by studying interventions, their impact in defined populations, and the means by which they can be better used (Greewald and Cullen, 1985; Kerner *et al.,* 1988). It is a multidisciplinary field, comprising epidemiologists, demographers, statisticians, behaviorists, risk communication experts, and other social scientists. The first step in cancer control is identifying where the cancer burden is elevated, which suggests locations where interventions are needed. It has long been recognized that cancer rates vary by region, but it has become apparent that local neighborhoods also can have an influence on cancer outcomes (Diez Roux, 2001), perhaps through shared environmental exposures and cultural and behavioral factors. Hence, Geographic information systems (GIS) and other spatial analytic methods provide innovative solutions and thus can play a major role in cancer control.

Objectives

With this background information, the present study comprises of the following objectives

(i) To assess the status of various cancers among male and female populations of the region.

(ii) To prepare cluster based maps to determine the risk of cancer in the study region

Study Area and Data Sources

The data for the present cross-sectional study was collected from the National Cancer Registry Program (NCRP) Reports, as well as recognized cancer hospitals from the western region of Tamil Nadu for a tenure of 13 years from 2001 to 2013. The collected data comprised of new registered cancer cases of both male and female patients in the study area. The western regions of Tamil Nadu include districts like Coimbatore, Tiruppur, Erode, Namakkal, Salem, and Nilgiris.

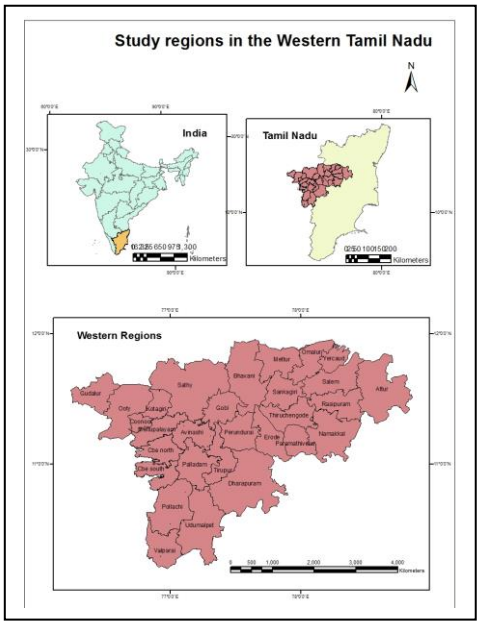

Fig: 1 – Study Area Location

The total individual cancer incidences from the 6 districts as mentioned above from the western region of Tamil Nadu were segregated with respect to the each district and were reported to be around total of 14,392 cases. The reported oncology case sheets from the hospital records were added with the necessary attributes and were recorded into a database. The attributes include demographic details, type of cancer, occupation, type of treatment, behavioral factors such as tobacco and alcohol consumption and reproductive factors.

Methodology and Results

The collected cancer cases from the hospital based cancer registries were segregated for each district. The cases were then divided into different age groups and also in accordance with International Statistical classification of Disease and Related Health Problems, 10th Revision (ICD-10) which is presented in Table 1. The major anatomical classes used throughout the study include blood, breast, gastro-intestinal, genito-urinary, gynecological, and respiratory cancers excluding certain cancer types that were highly negligible.

Table 1
ICD-10 coding for neoplasm based on anatomical sites

Cancer Group	ICD 10 codes	Cancer sites
Digestive System	C15,C16,C17,C18,C19-C20,C21,C22, C23-C24,C25	Oesophagus, Stomach, Small Intestine, Colon, Rectum, Anus, Anus Canal, Liver, Gall Bladder, Pancreas
Head and Neck	C00,C01-C02,C03-C06,C07-C08,C09,C10 , C11,C12-C13,C14,C30-31,C32	Lip, Tongue, Mouth, Salivary Gland, Tonsil, Oropharynx, Nasopharynx, Hypopharynx, Pharynx unspecified, Nose and Sinus, Larynx
Lymphoid and Haematopoietic System	C81,C82-85 and C96,C90,C91, C92-94,C95	HL,NHL,MM, Lymphoid, leukaemia, myeloid leukaemia, leukaemia unspecified
Breast and Gynaecological	C50,C51,C52,C53,C54,C55,C56,C57, C58	Breast, Vulva, Vagina, Cervix Uteri, Corpus Uteri, Uterus Unspecified, Ovary, Other female genital, Placenta
Respiratory	C33,C34	Trachea, bronchus and lung
Genitourinary	C60,C61,C62,C64,C65,C66,C67	Penis, Prostate, Testis, Kidney, Renal pelvis, Ureter, Bladder

The district wise incidences from the collected cancer cases are presented in Figure 2. It can be observed that maximum proportion of the cancer cases were recorded in Coimbatore district. Regions including Tiruppur and Erode districts contribute to moderate number of incidences and the lowest were recorded in the districts namely Salem, Namakkal and Nilgiris. The gender wise distribution varies disproportionately among men and women with the highest incidences being prevalent among the women population which could be attributed to the maximum contribution of gynecological and breast cancers (Figure 3).

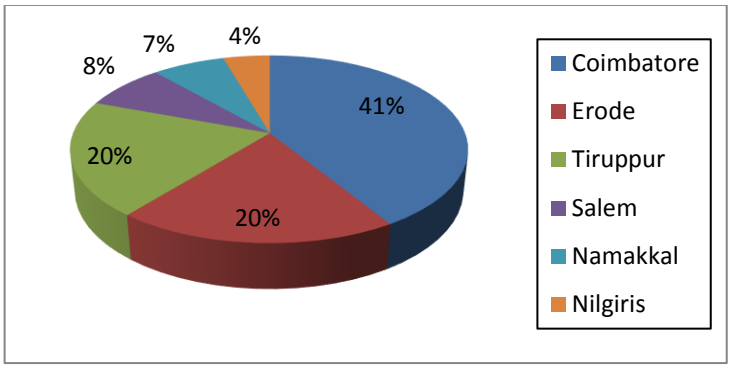

Fig: 2 – District-wise distribution of the collected cancer cases from 2001-2013

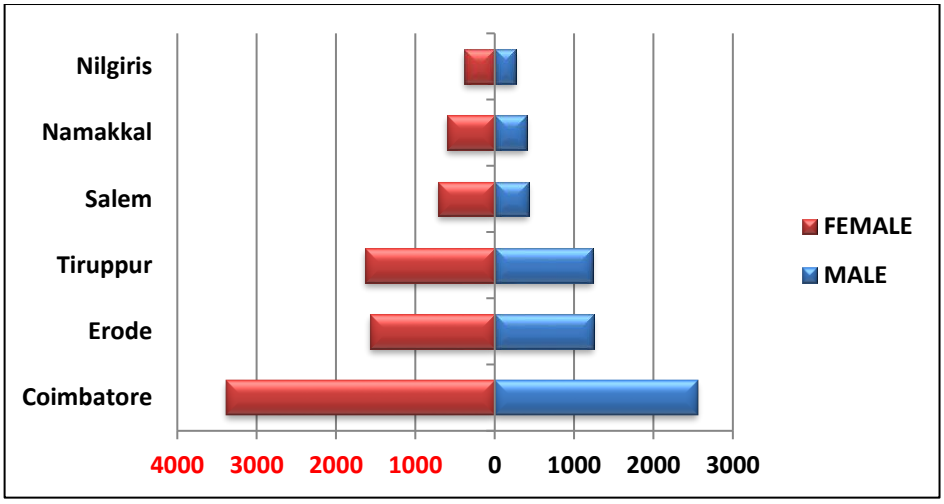

Fig: 3- Gender-wise distribution of recorded cancer cases from 2001 to 2013

The prevalent cancer types among men and women from the collected cancer cases are presented in Figure 4. It could be observed that among all cancer types, the head and neck cancer in the male population contributes to 30-40% of the total cancer cases in all districts. Gastro-intestinal cancers constitute the second highest cancer type prevalent among men among all districts. Less than 20% of the total cancer cases contribute to cancers of the blood, respiratory and genito-urinary system.

Oral cancer is a major problem in the Indian subcontinent as it ranks among the top three types of cancer in the country (Elango *et al.*, 2006). The main risk factors for these cancers are tobacco and alcohol. Tobacco was observed to be the most important identified cause of cancer in the study conducted by Jivaranjani *et al.*, (2015). Tobacco chewing has resulted in huge burden of oral cancers and oral pre-cancerous condition.

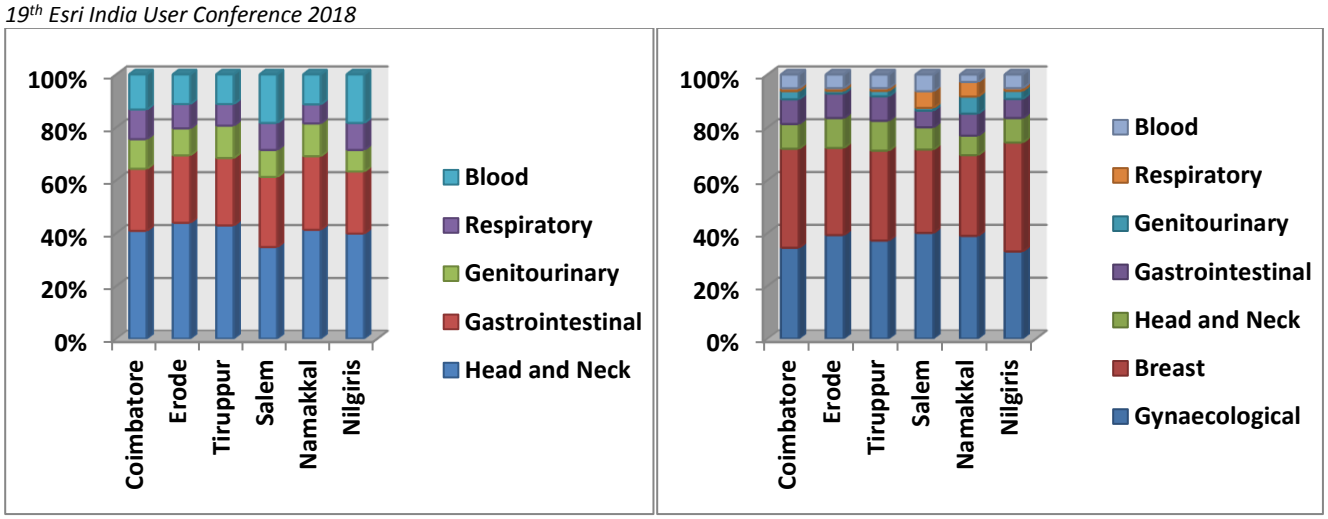

Fig: 4- Prominent cancer types among men and women from the collected data

It is also evident that among women the gynecological and the breast cancer are of the maximum proportion than the other cancer types (Figure 4). Cancers of the female breast and the gynecological related cancers have been projected to be the leading cancer sites among women in India (Ramnath *et al.*, 2010). Based on the NCRP data, gynecological cancers have increased in India and are estimated to be around 182,602 by the year 2020 constituting about 30% of the total cancer cases.

Geo-visualization of cancer incidences

The cases were segregated taluk-wise and geocoded using the address of the patients by a point map. The geocoded point map was then superimposed on the taluk map to realize the distribution and spread of the affected population in the study area. The point maps were prepared for all cancer types for both male and female population. The taluk wise aggregated data was, attributed into the polygon map. Natural breaks classification was used to classify the cancer incidences. Natural break method uses a computing algorithm to minimize the differences between classes. Custom classification method allows the user to choose the appropriate or meaningful class breaks. All the maps were prepared using ArcGIS 10.3.1 software. The taluk wise distribution of the aggregated cancer incidences for both the gender combined is presented in Figure 5.

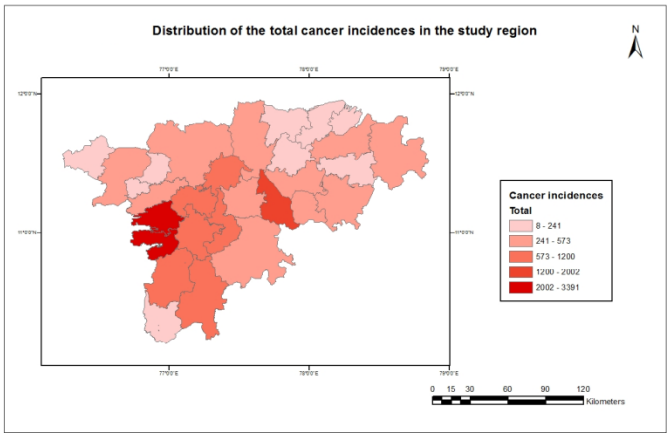

Fig: 5- Taluk wise aggregated cancer incidences

The taluk wise spatial distribution of the total aggregated cancer incidences and their corresponding crude incidence rates for the female and male population is presented in Figure 6. Among women (Figure

6(a)), very high cancer incidences could be observed in the Coimbatore North and South taluks followed by high cancer incidences in Pollachi, Tiruppur and Erode taluk with a similar pattern among the male population.

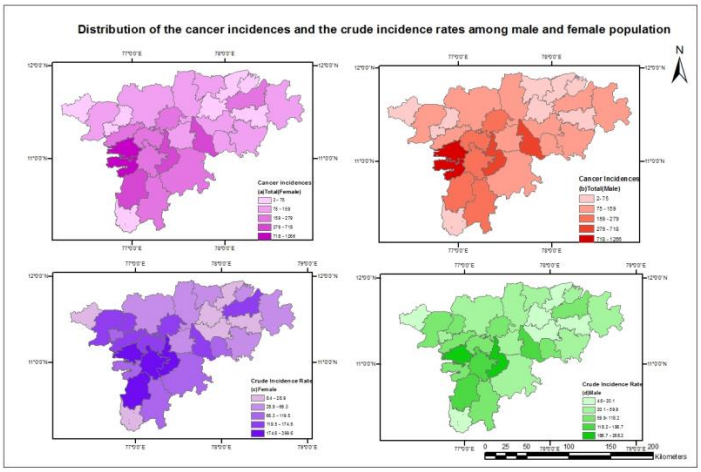

Fig: 6- Gender wise aggregated cancer incidences

In order to visualize the intensities of the cancer burden by type in the study region, the cancer incidences were geocoded in accordance with their postal addresses. The resultant point map depicting the geocoded individual coordinates of the cancer incidences shows high clustering of cancer cases in the intersection regions of the Coimbatore North and the South regions and also in the Erode taluk including major residential and commercial locations with high traffic intensities (Figure 7).

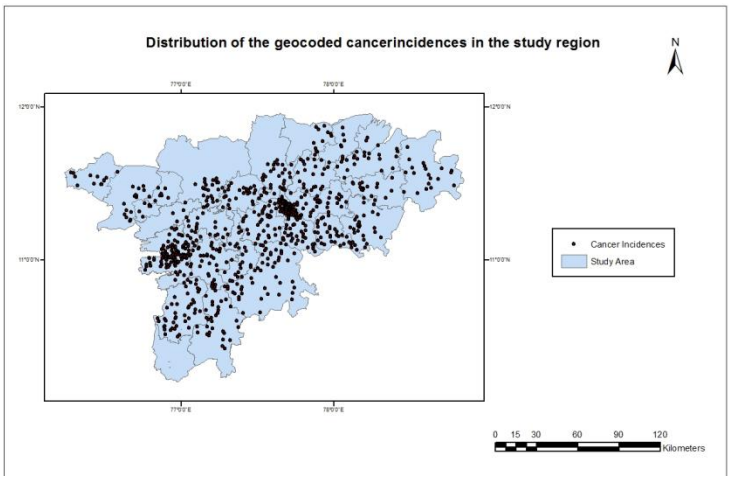

Fig: 7- Point map of the individual cancer incidences

The cancer incidences in accordance with anatomical sites have also been geocoded and the corresponding maps have been presented (Figure 8).The point maps of the specific anatomical sites among male and female population shows similar clustering of cases in the intersection regions of the Coimbatore North and South Taluks and parts of Erode Taluk.

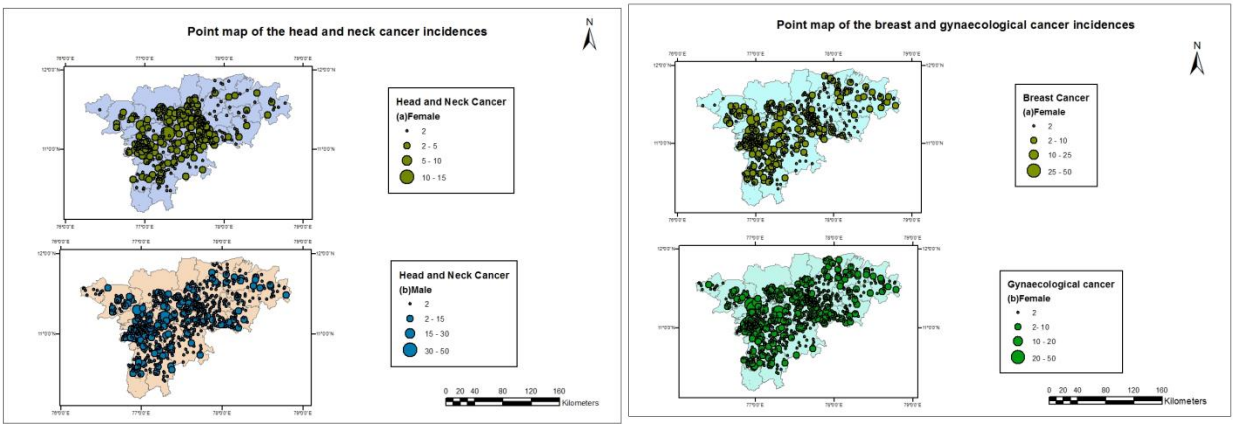

Fig: 8- Point map of the gender wise cancer incidences for specific anatomical sites

Conclusion

Cancer incidence maps are an effective tool to visualize and explore geographical differences and to seek for etiological differences of, e.g., subtypes of a cancer (Kris *et al.*, 2014). The results can be useful for primary prevention to increase awareness for the public, authorities and health care professionals in specific subpopulations. Geospatial methods enable the spatial analysis and mapping of cancer data to provide researchers with cartographic tools for developing epidemiological hypotheses, identifying opportunities for location-specific policy and targeting high-risk sub-populations. The results can be used to advocate for greater use of geospatial methods to supplement traditional epidemiological studies and communicate them to policymakers.

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