Epidemiological perspectives of ophthalmology in the four central districts of Kerala: A GIS approach

Praseetha Rajan, Devavratam. S, Sekhar L.K., P.I.Mohan MS
Good Shepherd School, Ooty. Freelance Geographer, Ernakulam.
Enter Technologies Pvt Ltd, Trivandrum. St Joseph’s Eye Hospital, Kottayam.

Abstract
The study is an attempt to utilize the possibilities of Geographical Information System (GIS) for understanding the prevailing ophthalmic health situation of four selected districts of Kerala, namely Alappuzha, Ernakulam, Idukki and Kottayam with a view on the physiographic and socio-economic aspects of the study area. The study was based on the data collected from four different hospitals, one from each district, on diseases such as cataract, refractive errors, viral keratitis, retinal diseases and glaucoma. This study is the first ever attempt to try and comprehend the geographic spread of ophthalmic diseases as a spatial phenomenon and view them in conjunction with the physiography and socio-economic aspects that have influenced in the existing patterns of disease distribution.

Key words: Geographic Information Systems, Medical geography, Health Care Delivery, Epidemiology, Maps, Cartography, Spatial Dynamics, Physiography, Correlation, Attribute Data.

Introduction
Medical Geography

Medical Geography

Geography, a subject much misunderstood as the study of 'countries and capitals, mountains and rivers' is emerging as a major tool in the field of health and related science. As the geographic methods, description, explanation, prediction and prescription were implemented in the field of medical sciences it saw the rise of a new field in geography 'Medical Geography'. The term Medical Geography was first introduced by 18th and 19th century physicians who attempted to understand the relationship between the occurrence of disease and environmental conditions (www.grids.ca, 2002). Medical Geography is that branch of Geography, which deals with the geographic aspects of health (status) and health care (systems). It is an interdisciplinary domain, which is having two streams, they being: 1) An Ecological stream (health) and 2) A Medical Care stream (systems). Studies in medical geography involve a number of quantitative analyses that can extract rational and scientific explanations out of the medico-sociological data in possession.

The Role of GIS

Geographic Information Systems (GIS) is simply defined as 'a computer system that integrates the acquisition, storage, analysis and display of spatial (geographic) data and its associated attribute data'. Advent of GIS not only enabled and eased the preparation of maps of concerned areas but also integrated analysis and cross correlation of associated data (attribute data) sets that emerge from various sources, thus supporting health care planners in optimizing their decisions on health care delivery mechanism.

GIS, in simple terms, can be considered as a map making software package, the components being the various tools used to enter, manipulate, analyze and output data. To be a little more critical in approach components of a GIS include: computer system, the software, and spatial data (Data that have same form of spatial or geographical reference that enables them to be located in two- or three-dimensional space), data management and analysis procedures and the people to operate the GIS.
GIS is a useful tool for health researchers and planners because: “Health and ill-health are affected by a variety of lifestyle and environmental factors, including where people live. Characteristics of these locations (including socio-demographic and environmental exposure) offer a valuable source for epidemiological research studies on health and the environment. Health and ill health always have a spatial dimension therefore. More than a century ago, epidemiologists and other medical scientists began to explore the potential of maps for understanding the spatial dynamics of disease.” (Scholten and Lepper, 1991)

GIS and mapping systems provide a common platform across disciplines. GIS can play a vital role in the detection, management and response to health problems. Effective surveillance systems are critical for program implementation and represent the first line of defense against infectious diseases. Public health officers and administrators in developed countries are now being assisted with GIS to the extent that their routine decision-making incorporates consistent surveillance and health information data from sophisticated computer systems. All the quantitative techniques used in medico-geographic research can be done with ease in GIS. Surface generations and interpolations are easy to create in GIS.

Present Study

The study focuses on five common eye related problems based on the number of incidences and commonness. These diseases are cataract, refractive errors, viral keratitis, glaucoma and retinal diseases (retinal detachment, diabetic retinopathy, macular degeneration and vascular diseases combined). An assessment of the distribution of ophthalmologists with reference to the disease patterns and various geographic and socio-economic parameters are also attempted.

The Need

An observation reveals that ophthalmologists of Kerala are more concentrated towards the major urban centers. It also seems that their distribution is largely dependent to the physiographic and socio-economic aspects of the region. There has been no study done in the state (to our knowledge), where the geographic patterns have been given importance to help decision makers in optimizing health care delivery measures. The study thus is a pilot work and can act as a catalyst for further research in the ophthalmic health care situation in Kerala.

Aim and Objectives

Aim

Aim of the study is to reveal the prevailing ophthalmic health and health care situation in the four districts of Kerala.

Objectives

1. To prepare a distribution map of the identified diseases.
2. To identify the spatial relationship between the patient distribution and physiography.
3. To identify the spatial relationship between patient distribution and doctor distribution.
4. To bring out the relationship between the distribution of patients, doctors and socio-economic conditions.
5. To prepare a flow map to show the flow of patients to the hospitals.
6. To create buffer zones to delineate the control zones that is most affected by the ophthalmic diseases.

Data

The study fully depends on the secondary data collected from one hospital each in each of the districts identified for the study. Data collected pertain to:

1. Eye patients: a) Number of patients affected by each disease, b) Sex, c) Place of individual patients and c) Age
2. Data related to the number of doctors
3. Data related to the socio-economic aspects.

Data Source

Data for the months of April, May and June 2002 relating to ophthalmic patients was collected from four major eye hospitals namely, Giridhar Eye Institute Cochin, K.V.M. Hospital Cherthala, St. Joseph’s Eye Hospital Kanjirappally and St. John’s Hospital, Kattappana for Ernakulam, Alappuzha, Kottayam and Idukki districts respectively. Data pertaining to the doctors was extracted from the KSSD Directory of Ophthalmologists, 2001. Disease incidence data was collected for the three months as because they are the peak patient inflow months of every year.

Base Maps

1. Administrative map in block level with a scale of 1:25000.
2. Map with the post office locations from State Survey Office.
3. Physiography map with a scale of 1:00,000 from State Landuse Board.
Methodology

Data pertaining to each of the disease was categorized based on the place of origin of patients using corresponding PIN codes. A block (an administrative subdivision) wise database was created for the same in MapInfo Professional. A physiography map was prepared. Isochrone maps (color coded maps of varying disease intensity patterns) were prepared to show the distribution trend of each disease, which were further overlaid by the doctor distribution maps in order to comprehend the relative availability of ophthalmic health care facilities for each of the disease. Choropleths (color coded maps based on differing disease intensity of administrative divisions) showing the total number of ophthalmic patients was overlaid with the dot map representing the distribution of doctors in order to bring out the prevailing situation of ophthalmic health care availability in various administrative divisions. Patient occurrence map was overlaid on the physiography map of the study area thereby trying to represent the relationship between them. A flow map is prepared to show the flow of patients from the blocks to the respective hospitals. Buffer zone of 5 km distance, up to 15 km pertaining to each hospital was created to assess the most optimal area entered. MapInfo Professional 5.0 was used for mapping. Microsoft word was used for creating tables and supportive documentation.

Study Area

Four central districts of Kerala namely, Idukki, Kottayam, Ernakulam and Alappuzha were chosen as the study area (map 1) based on the physiography divisions and the availability of secondary data. Idukki with an areal extent of 5019 km² lies between 9°15'N to 10°21'N and 76°7'E to 77°25'E, is a highland region marked by steep sloping hills and valleys. The height of the peaks varies from 20 m above sea level to 2800 meters above sea level. Anaimudi that is at a height of 2817 meter is one of the highest peaks in south India is situated in Idukki. Kottayam with an areal extent of 2195.5 km² lies between 9°15'N to 10°21'N and 76°22'E to 77°25'E. Kottayam district is well known for its rubber plantations. Ernakulam with an areal extent of 2407 km² lies between 9°42'N to 10°18'N and 76°12'E to 76°46'E. Ernakulam district is known as the industrial capital of Kerala. Alappuzha with an areal extent of 1414 km² is a coastal district which lies between 9°5' to 9°52'N and 76°17' to 76°48'E. Alappuzha is known as the “Venice of the East”. Alappuzha has got the longest coastline. About 80% of the land is situated between the sea level and 7 m above sea level. The general widely accepted physiographic subdivision of the state was adopted for the study too, thereby dividing the study area into the low land, mid land and high land.

Demographic and Socio Economic Profile

Idukki district has 8 blocks and 64 panchayats. The district has a population of 10.79 lakhs. The district has a population density of 215 persons / km². The literacy rate is 87%. The average gross domestic product is 28030 and the average Per-Capita income is 17407.

Kottayam district has 11 blocks and 73 panchayats with a population of 182871. The district has a population density of 890 persons / km². Kottayam has the highest literacy rate in the state with 96%. It has an average GDP of 36975 and an average Per-Capita of 20398.

Alappuzha has 12 blocks and 71 panchayats. The district has the highest population density of 1415 persons / km². It has an average GDP of 53692 and an average Per-Capita of 17388.

Emakulam district has 15 blocks and 87 panchayats. The district has a population of 1444059 with a population density as high as 1171 persons / km². The average literacy rate is 92.35%. It has an average GDP of 44105 and an average Per-Capita of 21435.

Health Care Delivery Infrastructure

Emakulam district has around 673 allopathic hospitals, 550 ayurvedic hospitals and 600 homeo dispensaries. Alappuzha district has comparatively less number of hospitals with 99 government hospitals, which include 41 Homeo dispensaries, 47 ayurvedic dispensaries and 68 public health centers. Kottayam has about 22 government hospitals, 187 private hospitals 54 primary health centers, 32 community health centers and 219 dispensaries. In Idukki there is only 1 government hospital, 2 taluk hospitals, 4 block public health centers and 51 mini allopathic primary health centers, 32 homeopathy dispensaries and 30 ayurvedic dispensaries. Interpreting the OP records for identifying the disease diagnosed for each patient was also very difficult task.

Discussions and Analysis

Limitations of the Study

Even though data pertaining to disease incidence was collected from the popular eye hospitals in each district there is an obvious locational bias because of the fact that patients prefer nearby hospitals and tend to ignore ailments unless its seriousness is understood to them. Moreover data on outpatients for the peak season was only collected and patients from outside the district were ignored in the case...
of all the hospitals. Another major limitation of the study was the non-availability of PIN codes or even place names in the outpatient records of hospitals, at least in few cases.

**Distribution of Ophthalmic Doctors**

There are about 600 practicing listed ophthalmologists (KSC&VS Directory of Ophthalmologists, 2001) in Kerala out of which 173 doctors fall in the study area. Distribution map (map 2) shows that ophthalmologists are concentrated more towards Cochin City, accounting for about 56 of them in Edappally block alone. In Alappuzha ophthalmologists are available in 7 out of the 12 blocks exhibiting a fairly well distributed pattern with Mavelikara block having 6 doctors. Ophthalmologists of Kottayam seem to be concentrated towards south west of the district especially in the Poonamala and Madappally block which together account for 28 doctors. Kottayam is the best served district out of the 4 districts in terms of availability of doctors, with only 3 blocks out 7, not with an ophthalmologist. Scenario is worst in the case of Idukki district with as low as 9 doctors in the whole district, which is the largest in the state and with a sizeable population. Seven (7) of the 9 doctors serve in Thodupuzha block and Devikulam and Adimaly blocks have one (1) doctor each exhibiting a wide distribution pattern and thereby feebly represented in the map. Doctor distribution map overlaid on the physiographic map of the study area indicates that around 50% of the ophthalmic doctors of the study area practice mid land regions, approximately 30% in the low land and the rest in the high land region.

**Disease Pattern**

Diseases selected for present study are the most common blinding diseases. Among these five diseases refractive errors and viral keratitis form the major proportion of the patients when compared to the other diseases. Glaucoma is the least in number. Disease incidence map shows that as distance increases from hospitals number of patients seems to reduce. Situation is critical, as one understands that the hospitals considered for the study as specialists hospitals and some of the most reputed ones in their respective districts. Issue aggravates when it is further known that there are no hospitals and doctors in some areas where the disease incidence map shows concentration of certain diseases.

Patients with refractive errors account for the highest number among the selected diseases, with a wide distribution all along the study area (map 3). A very high concentration is seen in the eastern and southern blocks of Idukki. A disease belt is seen along this region. A disease center is also seen in Kottayam district. The concentration decreases as one move towards the northern and central regions of the study area. Lowest distribution is seen in the northwest part of the region.

A high concentration of cataract patients is seen in Idukki district and almost equal number towards Cochin City. The distribution in Idukki is very high with two disease centers (map 4). Highest concentrations are seen along the eastern and central blocks of the district. Concentration seems to decrease towards the west and away from both the disease centers. Three relatively lesser concentrations of cataract patients are seen, two in Alappuzha and one in Kottayam. Cataract patients are less along the central blocks of the study area, exhibiting a corridor like area somewhat devoid of cataract patients.

Glaucoma seems to be considerably less in the study area (map 5). Highest concentrations are seen towards the north-western region, which includes Cochin City, Cherthala town and south central region with Kanjirapally town. Relatively lesser concentration of glaucoma patients is seen towards eastern regions of Idukki district also.

Distribution of Viral Keratitis patients provide a dramatic picture as it is seen all along Idukki district in varying concentration, with the highest towards the extreme east and south east. Even though less in incidence, wide distribution of this disease can be seen along the coastline (map 6).

The highest concentration of retinal disease cases is seen in the northwestern part of the study area, which includes Cochin City. The concentration shows a decline as it moves downward along the coastal regions. Central part of the study is almost devoid of the disease as seen from the map. Concentration, even though in lesser amount is seen towards the east and extreme southern blocks of the study area (map 7).

Disease incidence map overlaid on the physiographic map of the study area indicates that majority of the patients are spread in the coastal region of the study area. Disease incidence is also seen concentrated towards the east and east central parts of the high land. Together, the low land and highland accounts for about 90% of the disease incidence.

**Disease Patterns and Relative Distribution of Ophthalmic Doctors**

There is a significant lack of doctors towards areas registering high concentration of ophthalmic diseases. Almost all the diseases exhibit similar incidence patterns except in...
the case of glaucoma. From the maps prepared it can be inferred that doctor distribution of the study area is unsuitable for catering to the requirements of prevailing ophthalmic health scenario of the area. Choropleths map of total number of patients from each block overlaid with doctor distribution dot map clearly exhibits the prevailing situation, thereby reinforcing the fact of lack of ophthalmic care in high disease incidence areas (map 8).

Flow Maps

Flow maps show the movement of people from a particular location to the point of interest. The data in a flow map is represented quantitatively. Vectors or lines are graphic resources that aid in the analysis of disease diffusion and patient to health care facilities flow. In their simplest form, lines indicate presence of flow or contagion between two sub regions, which may or may not be contiguous. Arrows with width proportional or different colours proportional to the volume of flow between areas are important tools to evaluate the health care needs of different locations.

Map 9 shows the flow of ophthalmic patients from various blocks to the hospitals in each district. The blue denotes a flow of less than 100 patients, green 100 – 200, red 200 – 300, and black above 300. The flow map thus depicts the flow of patients from the blocks to the hospitals for the time period of three months.

Buffer Zones

Buffer zoning is one of the techniques that could provide meaningful information in health research planning. Buffer zones as the name suggest is a specified zone around a point or line that delineates a control zone that is most affected by the phenomena under consideration.

The buffer zones with a radius of 5 km up to 15 km and thus 3 zones around each hospital were delineated (map 10). Except in the case of St John’s Hospital Katappana, about 70% of the patients registered in each hospital fall within the 15 km radius from every hospital. The central 5 km zone accounts for the maximum concentration of patients followed by the second and the third zones. Thus it can be inferred that the optimal health care distance for a hospital in the case of ophthalmic diseases is approximately 10 to 15 km and the most effective distance 5 to 10 km.

Results

- Doctor distribution of the study area is influenced by physiography and level of urbanization.
- Ophthalmologists seem to prefer urban centers with relatively better socio-economic conditions.
- Ophthalmologists do not prefer practice in the highland regions of the study area.
- Eye disease incidence is more towards the low land and high land regions of the study area but ophthalmologists are concentrated in the mid land and low land regions of the area.
- Most optimal ophthalmic health care distance from a hospital is 15 km and the most effective distance is 5 km.
- Ophthalmic health care situation in the area is bleak and demands immediate intervention from concerned institutions and authorities especially along the high lands.

Suggestions

- Implementation and utilization of Geographic Information Systems for accessing the ophthalmic health scenario and health care scenario of the state.
- A data updatable online (Internet based) map based disease incidence database accessible for all ophthalmologists in the state.
- A regularly updated online map based doctor distribution information and practice location advice system for budding and newly registered ophthalmologists.
- Design and implementation of a state wide coding system for OP records, which invariably has the following data: Panchayat or place of patient, PIN code, Age and Sex.
- Free eye camps in areas lacking ophthalmic health care facilities.
- Public awareness camps and methods to attract patients to hospitals are to be implemented focusing on specific areas lacking ophthalmic health care facility.
- Development of an adequate health care delivery system.

Conclusion

Vision of Medical Geographers

Modeling capabilities of GIS helps health care planners and practitioners to understand the spatial variation of disease incidence, its correlation with environmental factors and the health care system. As suggested by Loslier L; 1986 (www.idrc.ca/books.../loslier1.html), GIS can play key roles in three levels of health sector they being Health Research, Health Education and Health Planning.
The dream of Medical Geographers may be 'a near real-time' array of data on the global status of all deadly diseases on a virtual world constructed from earth observing satellite sensors. This dream may not be far off as now a days availability of computers and access to information superhighways have made this world into a global village, wherein data transfer over great distances is a matter of seconds. It is ultimately the doctors who have to extend their hands to the social scientists, so as to make this dream come true, at the earliest. This study is even less than a step towards this goal.

Reference

Books


Thesis Work


Project Work


World Wide Web


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