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Preparation of Acute Gastro Enteritis Distribution Maps and Estimation of Population at Risk in Coimbatore District of Tamilnadu, India

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Abstract

Factors such as booming population, environmental pollution, rapid urbanization, and global warming all influence the conditions for disease outbreaks. Disease studies have revealed strong spatial aspects, including disease case location and disease diffusion. Thus, mapping spatial aspects of diseases could help people understand some puzzles of disease outbreak. Geographical Information Systems (GIS) provide an effective way of managing, storing, analyzing, and mapping disease information. GIS has strong capabilities in mapping and analyzing not only spatial data, but also non-spatial data, and can integrate many kinds of data to greatly enhance disease surveillance. This paper deals with the preparation of Acute Gastroenteritis incidence distribution maps based on population density that would constitute a useful tool for disease control and for the health planners of Coimbatore district of Tamilnadu. The Acute gastroenteritis incidence data was collected from the Deputy Directorate of Health services, Coimbatore district for the period (2000-2009). The data was imported into ArcGIS 10.0. The mean Acute gastroenteritis incidences of Coimbatore district were used for the preparation of the thematic maps. For the present study, Natural breaks classification was used to classify the Acute gastroenteritis incidences data for thematic mapping. Mettupalayam predominantly remains a high incidence area from 2000 to 2009. From the year 2003 onwards and upto 2009, Avinashi and Coimbatore North taluks have consistently shown high incidences. Two village panchayats Irumbarai and Ikkaraiboluvampatti are at high risk which has an Acute Gastroenteritis incidence rate of more than 1; whereas the villages Maruthur and Coimbatore corporation have an incidence rate between 0.5 and 1 and the incidence rate below 0.5 is observed in ninety six villages. The risk map clearly visualizes the regions where efforts to control Acute Gastroenteritis have to be concentrated.

Keywords: Geographical information systems, incidence rate, thematic mapping, population density.

Introduction

Disease studies have revealed strong spatial aspects, including disease case location and disease diffusion. Mapping spatial aspects of diseases could help people understand some puzzles of disease outbreak. Booming population, environmental pollution, rapid urbanization, and global warming all influence the conditions for disease outbreaks[1].

Disease maps offer a visual means of identifying cause and effect relationships existing between humans and their environment. Disease maps can enable health practitioners and the general public to visually understand about disease distribution.

Geographical Information Systems provide an effective way of managing, storing, analyzing and mapping disease information. GIS has strong capabilities in mapping and analyzing not only spatial data, but also non-spatial data and can integrate many kinds of data to greatly enhance disease surveillance. It can render disease data along with other covariates like demography and environment, representing the differences with various cartographical styles.

Disease maps have been playing a key descriptive role in epidemiology. Disease distribution can be represented on maps like dot-density, proportional circles, spheres, grey scale (chloropleth maps), contours (isopleth maps), cartograms and 3-D surface plots[2].

Disease data are generally derived from the standard records maintained by Government or Non-governmental organizations or surveyed data collected to address specific queries[3]. The standardization of disease data is essential for making realistic comparison, particularly for individuals of different ethnic groups, socio-economic strata and other factors that may also be important. Hence, the aspects of data collection, management and recording are critical.

The most common types of disease maps are those based on standardized rates and those based on significant deviations from the area average. The rate maps can be generated from estimates of incidences or prevalence while significance maps are based on the use of statistical distributions such as normal or more usually Poisson, to map the significant differences between observed and expected occurrence of disease. Maps

based on probabilities have been extensively studied for brain tumours in Poland[4].

Time is an important factor in analyzing disease outbreak. Spatio-temporal characteristics are an important feature in health studies[5]. By comparing the thematic maps at different time intervals, the spatial-temporal change of the disease could be projected, including temporal cluster shift, vector transmission rates, and mobility of susceptible populations. The spatio-temporal patterns of viral meningitis was analysed to aid the identification of risk factors[6]. A desktop application with a time bar for exploring spatio-temporal patterns of colon cancer mortality rates was developed[7]. Significant temporal and time space clustering for rotavirus infections causing severe gastroenteritis was carried out in an urban slum area in Vellore[8]and in a Harijan colony in South India[9].

Linking GIS technology with molecular surveillance helped to identify geographical areas where on-going tuberculosis transmission was occurring[10]. Spatial implications of the tuberculosis DOT's strategy in rural South Africa for TB control, research and evaluation was put forward[11]. GIS and spatial scan statistics have been used to investigate statistically the significant hotspots of tuberculosis in Almora district of Uttaranchal[12].

The geographical distribution of enteric diseases in Vietnam and the potential environmental and human risk factors were analyzed for schistosomiasis in Brazil[13,14]. Applications of GIS were proposed for modelling of dengue risk based on socio cultural data[15]. Raster GIS is used to scale data by means of spatial filtering methods commonly used to enhance satellite imagery. Spatial filtering has been used to create smoothed maps of health data[16-18]. Diarrhoeal disease has been related to social networks and the geographic configuration of communities in rural Ecuador[19]. An integrated GIS approach on groundwater quality and its health effects were studied. Based on map query, water quality zones were demarcated as "Affected area" and "Not affected area" based on the quality of water and diseases[20]. Geographical distribution and risk factors associated with enteric diseases were similarly studied in Vietnam[21].

This paper deals with the preparation of Acute Gastroenteritis incidence distribution maps based on population density that would constitute a useful tool for disease control and for the health planners of Coimbatore district of Tamilnadu.

Methodology

The Acute gastroenteritis incidence data was collected from the Deputy Directorate of Health services, Coimbatore district for the nine Government hospitals situated in each taluk and from six major private hospitals of Coimbatore district for the period (2000-2009). The data was imported into ArcGIS 10.0. The digitized map of Coimbatore district was used for the present study. The attribute data table of the Coimbatore district layer consisted of the taluk name, disease incidence data, population size, geographical area, population density, socio-demographic variables, water quality data and the meteorological data of each taluk.

The population density of each taluk was calculated based on population / area in sq.kms. The value was used as a factor to prepare the risk map of the population prone to Acute Gastroenteritis. Using the above, a population at risk map was prepared thematically to identify risk areas based on population. Natural breaks classification was used to classify the population into three classes namely highly populated, moderately populated and lowly populated.

Results and Discussion

Preparation of thematic maps: Acute gastroenteritis distribution: Thematic mapping is the process of using geographical properties and values, such as size or colour, to represent data on a map. Thematic maps can be used to highlight individual features or illustrate a series of features. Thematic mapping involves data classification methods, which is known as the most common method for map manipulation. Generally, six data classification methods are available: equal interval, equal frequency, equal area, mean and standard deviation, natural breaks and user defined. Equal interval uses a constant interval in classification. Equal frequency, also called the quantile, divides the total number of data values by the number of classes and ensures that each class contains the same number of data values. Equal area divides the map area by the number of classes and ensures that each class contains an equal proportion of area. Mean and standard deviation sets the class breaks at the units of standard deviation above or below the mean. The method of Natural breaks uses a computing algorithm to minimize differences between data values in the same class and to maximize the differences between classes.

Mean Acute gastroenteritis incidences (2000 to 2009) of Coimbatore district were used for the preparation of the thematic maps. In the present study, the Natural breaks classification was used to classify the Acute gastroenteritis incidences data.

Map 1represents the mean incidence for the years 2000 to 2009. It is observed that out of the nine taluks of Coimbatore district, Coimbatore north, Coimbatore south and Mettupalayam are classified as high incidence areas. Avinashi, Palladam and Tiruppur are moderate incidence areas and Udumalpet, Pollachi and Valparai are low incidence areas.

The total area of Coimbatore district is 7805 sq.kms. The area under high disease infection covers 1833.47 sq.kms and the calculated percentage is 23.49%. The moderately infected area occupies 2232.82 sq.kms and the percentage is 28.61%. The total area with low infection covers 3738.50 sq.kms and the percentage is 47.90% (figure 1).

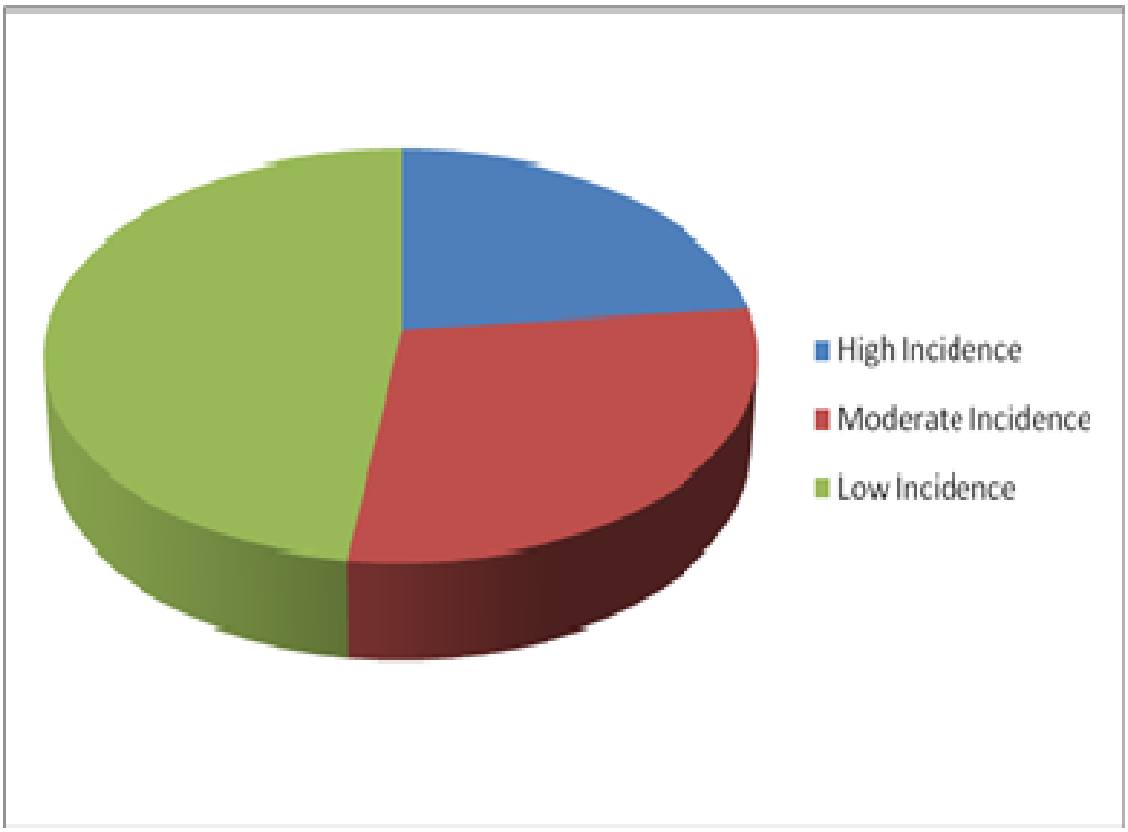

Figure-1
Percentage disease distribution in Coimbatore district

Temporal thematic map of Acute Gastroenteritis incidences: Table 1 shows the sum and mean data for ten consecutive years (2000 to 2009). A thematic map for each year was prepared and presented as Maps 2 to 11 respectively to understand the significance in temporal changes on Acute gastroenteritis in the nine taluks of Coimbatore district. The thematic maps were prepared using natural breaks classification.

In the year 2000, the high risk area was Mettupalayam and Valparaitaluks. The moderate risk area includes Coimbatore North, Avinashi, Palladam and Udumapet and the low risk area includes Coimbatore South, Pollachi and Tiruppur.

For the year 2001 and 2002 the trend remains the same. The high risk areas comprise Mettupalayam and Valparaitaluks, moderate risk areas are Avinashi, Coimbatore North and Palladamtaluks and the low risk areas include Coimbatore South, Pollachi, Tiruppur and Udumalpettaluks.

From the year 2003, the high risk area includes Avinashi, Coimbatore North and Mettupalayamtaluks consistently. The moderate risk areas include Palladam, Tiruppur, Udumalpet and Valparai for the years 2003 to 2007 and 2009. In the year 2008 only Palladam and Valparai are classified as moderate risk areas. For the year 2006 Coimbatore South comes under the moderate risk area along with Palladam, Tiruppur, Udumalpet and Valparaitaluks.

The low risk areas include Coimbatore South and Pollachi for the years 2003 to 2005 and 2007 to 2009. In 2006 only Pollachi is classified as a low risk area and in 2008, Tiruppur and Udumalpet is also classified as low risk areas along with Coimbatore South and Pollachitaluks.

The summary of the temporal changes of Acute Gastroenteritis in the different taluks of Coimbatore district is presented in table 2. It is observed that there is some consistency in the occurrence of Acute Gastroenteritis incidences: i. Mettupalayam predominantly remains a high incidence area from 2000 to 2009, ii. From the year 2003 onwards and upto 2009, Avinashi and Coimbatore Northtaluks have consistently shown high incidences. Valparaitaluk has remained a high risk area from 2000 to 2002. iii. Palladam, Tiruppur ,Udumalpet and Valparai have remained as moderate risk areas from 2003 to 2009. In the years 2000 to 2002 Coimbatore North and Avinashi come under moderate risk areas and in 2006 Coimbatore South is also included in the moderate risk area. iv. Pollachi and Coimbatore South consistently remain as low incidence areas from 2003 to 2009, except in 2006 where Coimbatore South comes under moderate risk area. In the years 2000 to 2002, Tiruppur and Udumalpe*t*also come under the low risk areas.

Table-1
Descriptive statistics of Acute gastroenteritis incidences in Coimbatore district of Tamilnadu (2000 to 2009)

Taluk	N	Mean	SE	Median	Mode	SD	Variance	Skewness	SE skewness	Kurtosis	SE Kurtosis	Range	Minimum	Maximum	Sum	% CV
Avinashi	10	435.20	78.12	503.00	102.00[a]	247.04	61029.29	-0.48	0.69	-1.33	1.33	657.00	102.00	759.00	4352.00	56.76
Coimbatore north	10	618.10	111.69	707.00	139.00[a]	353.20	124749.88	-0.49	0.69	-1.47	1.33	881.00	139.00	1020.00	6181.00	57.14
Coimbatore south	10	831.10	135.09	978.50	258.00[a]	427.18	182482.99	-0.43	0.69	-1.40	1.33	1134.00	258.00	1392.00	8311.00	51.40
Mettupalayam	10	621.70	116.59	686.50	140.00[a]	368.68	135927.57	-0.32	0.69	-1.37	1.33	941.00	140.00	1081.00	6217.00	59.30
Palladam	10	357.60	49.89	413.00	129.00[a]	157.76	24888.71	-0.42	0.69	-1.22	1.33	445.00	129.00	574.00	3576.00	44.12
Pollachi	10	257.60	37.74	289.00	90.00[a]	119.33	14239.82	-0.30	0.69	-1.19	1.33	325.00	90.00	415.00	2576.00	46.32
Tiruppur	10	532.80	87.12	625.00	625.00	275.51	75905.73	-0.34	0.69	-1.12	1.33	762.00	156.00	918.00	5328.00	51.71
Udumalpet	10	301.10	45.63	343.00	480.00	144.30	20821.43	-0.44	0.69	-1.16	1.33	384.00	96.00	480.00	3011.00	47.92
Valparai	10	97.40	11.13	108.00	47.00[a]	35.19	1238.49	-0.24	0.69	-1.44	1.33	98.00	47.00	145.00	974.00	36.13
	Mean	**450.29**														

Table-2
Temporal changes in the incident rate of Acute Gastroenteritis from 2000 to 2009

Taluks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Avinashi	**	**	**	***	***	***	***	***	***	***
Coimbatore North	**	**	**	***	***	***	***	***	***	***
Coimbatore South	*	*	*	*	*	*	**	*	*	*
Mettupalayam	***	***	***	***	***	***	***	***	***	***
Palladam	**	**	**	**	**	**	**	**	**	**
Pollachi	*	*	*	*	*	*	*	*	*	*
Tiruppur	*	*	*	**	**	**	**	**	*	**
Udumalpet	**	*	*	**	**	**	**	**	*	**
Valparai	***	***	***	**	**	**	**	**	**	**

Low	*	3	4	4	2	2	2	1	2	4	2
Moderate	**	4	3	3	4	4	4	5	4	2	4
High	***	2	2	2	3	3	3	3	3	3	3

Thematic map prepared using geographical area: The geographical area occupied by each was estimated in Arc GIS 10.0 and mapped to identify the taluk occupying the largest land area. From the result of Map 12it is observed that Udumalpet has a large geographical area of 1563.13sq.kms. Palladam, Pollachi and Valparai have a moderate geographical area of 882.53sq.kms, 1217.37sq.kms and 958sq.kms respectively. The rest of the five taluks have low geographical areas.

The population distribution of the study area was collected for each taluk and represented in Map 13. The map shows that Coimbatore south has the highest recorded population in Coimbatore district. Palladam, Pollachi, Tiruppur and Udumalpet have a moderate population distribution, while Mettupalayam, Coimbatore North, Avinashi and Valparai have low population distributions.

However, the increasing number of incidences depends on the density of the population rather than the area occupied. Therefore, a density based thematic map was prepared. Based on the population density of each taluk, a factor was introduced in Equation 1 to establish a relationship between population and disease incidence[22]. This factor was calculated based on

$$\text{Population Density} = \frac{\text{The total number of people}}{\text{Geographical area}} \times 100 \quad (1)$$

For each taluk, this factor was used to prepare a thematic map of Acute gastroenteritis incidence distribution in Coimbatore district of Tamilnadu. The Natural breaks classification was used to classify the taluks into high, moderate and low incidence zones.

The population density of each taluk was calculated based on the population by the total geographical area of the taluk and presented as Map 14. The highest population density was recorded in Coimbatore south, moderate population density in Avinashi, Coimbatore north, Mettupalayam, Palladam, Pollachi and Tiruppur. Udumalpet and Valparai have low population density.

An average of the Acute gastroenteritis incidences was calculated for ten years and using the obtained values, the Acute gastroenteritis incidence risk based on population density was calculated and used as a factor for preparing the population-at-risk map for Coimbatore district. From thematic Map 15 it is observed that the population at high risk are found in the talukMettupalayam, Coimbatore North, Avinashi and Udumalpet. The population at Moderate risk are found in Palladam and Valparaitaluks and population at low risk in Coimbatore South, Pollachi and Tiruppurtaluks.

Incidence rate of Acute Gastroenteritis: The Acute Gastro Enteritis incidence rate is calculated based on the incidence and population density using the formula.

$$\text{Incidence rate} = \frac{\text{Number of Cases}}{\text{Population}} \times 1,00,000 \qquad (2)$$

The calculated incidence rate for each village is plotted as a map and the same is presented as Map16.Map 16reveals that two village panchayatsIrumbarai and Ikkaraiboluvampatti are at high risk which has an Acute Gastroenteritis incidence rate of more than 1. Maruthur and Coimbatore Corporation have an incidence rate between 0.5 and 1 and the incidence rate lesser than 0.5 is observed in ninety six villages. The rest of the villages recorded no or very low incidences pertaining to observed population.

From the map, it is observed that high and moderate rates of incidence were observed in four villages. Low incidence rates are observed throughout the district, however, the distribution is observed to be sparse at the periphery and more concentrated or clustered towards the municipality. The reasons for such occurrences are dealt and estimated through statistical measures in the next sections.

Discussion: The resultant maps clearly indicate the major risk areas of Acute gastroenteritis in Coimbatore district of Tamilnadu. The risk map clearly visualizes the regions where efforts to control Acute Gastroenteritis have to be concentrated. Contaminated drinking water has found to be the source for most diarrhoeal outbreaks recorded in India[23]. In Tamilnadu, during the pre-monsoon, the groundwater is the only alternate source when surface water becomes scarce[20]. Concentrations of chemical and biological parameters greater than their permissible limits in drinking water have been linked to health problems. An in-depth study of these regions have been taken up by integrating water quality factors such as physical, chemical and biological to further identify the driving forces of the occurrence of Acute Gastroenteritis.

Sanitation facilities are of prime importance in diarrhoeal diseases. The relationship between diarrhoea and environmental sanitation has positive impacts but there is considerable variation in the magnitude of effects observed[24, 25].

Studies have shown that diarrhoea morbidity is influenced by weather and climate variability[26-28]. Temperature is said to affect pathogen survival[29]. Water supply contamination due to heavy rainfall has led to diarrhoea outbreaks[30]. Low temperature and low indoor relative humidity may be key factors in temperate zones that rotavirus infection tends to peak in mid-winter[31].

Conclusion

Work has been done to try to associate water quality parameters, meteorological factors and socio-demographic variables with incidences of Acute Gastroenteritis. The maps serve as a guide for Public Health Administrators / Managers / workers for identifying appropriate study environments for international trials and also for assistance in identifying the population potentially benefiting from the new interventions.

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