# APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM IN THE STUDY OF LEPTOSPIRAL UVEITIS

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# CERTIFICATE

This is to certify that this dissertation entitled "**APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM IN THE STUDY OF LEPTOSPIRAL UVEITIS"** submitted for MS (Branch III) Ophthalmology March 2008, The Tamil Nadu Dr. MGR Medical University, is a bonafide work done by **Dr. Fathima .A,** under our guidance and supervision in the Department of Uvea, Aravind Eye Care System and Postgraduate Institute of Ophthalmology, Madurai during her residency period from June 2005 to April 2008.

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# CONTENTS

# INTRODUCTION

Leptospirosis ,a zoonosis, caused by spirochete,that belongs to genus leptospira.Uveitis is an important late complication of systemic illness.It is a water - borne disease. It has a specific pattern for spread, can occur as epidemic or endemic.

Leptospirosis is worldwide distributed; more common in tropical rural countries. India is a tropical country and with majority of agricultural and rural population. Hence, leptospirosis is widely spread in India. Several major epidemic out breaks have been reported in India. The southern Indian city, Madurai and Its surrounding agricultural land is a known endemic place for Leptospirosis. To learn the epidemiological pattern of the Leptospiral uveitis in a hospital based population of this district, Geographic Information System is used as a tool in this study.

The application of geographic information system (GIS) methods in health and health care is a relatively new approach that started to gain importance a decade ago. GIS is a computer system designed for capturing, storing, integrating, analyzing and displaying data from a geographic perspective. A wide variety of cartographic methods become available for mapping and analysis of communicable disease data. The

application of GIS helps to examine a spatially related problem in different perspective. In addition to descriptive mapping function, GIS possess capabilities of data manipulation and geo statistical analysis.

In this study, we have applied GIS in mapping and analyzing the pattern of leptospiral uveitis in Madurai district in the period of 2001-2005.

# REVIEW OF LITERATURE

## 2.1.LEPTOSPIRAL UVEITIS

### 2.1.1 EPIDEMIOLOGY

### HISTORICAL PERSPECTIVE:

Leptospirosis was first described by Larry in 1812 of fièvre jaune among Napoleon's troops at the siege of Cairo. It initially was thought to be related to the plague but not as contagious. Throughout the remainder of the 19th century, the illness was known in Europe as "bilious typhoid."

A little over 100 years ago, Landouzy discovered it as a disease of sewer workers. In 1886, Adolph Weil published his historic paper describing the clinical entity of most severe form of infection that was later named as Weil’s disease.

In 1907, special staining techniques were used to confirm that a spirochete was responsible for this illness. A postmortem examination of the kidney of a person with Weil disease contained a spiral organism with hooked ends, which first was named Spirochaeta interrogans. Later in 1995, the causative organism was independently isolated by German and

Japanese investigators. During the later 1990s, leptospirosis was found to be reemerging infectious disease that affects human population on a global scale.

**FREQUENCY**:

**WORLD-WIDE**: Leptospirosis is noticed everywhere in the world but with higher incidence in tropical countries such as Latin America, India, and south eastern Asia but even in temperate areas as European Union or Japan, with a lesser extent. Mortality rate is around 10 percent of the patients but may reach 23.6 in some countries as Barbados, a Caribbean island.[2]

In Temperate climate: probable range is 0.1-1 /1, 00,000 per year

In humid tropics: probable range is 10 or more /1, 00,000 per year

In high risk groups and during outbreak: probable range is 100 or more /100,000 per year.[3]

**IN INDIA:** In the Indian subcontinent,leptospirosis was first reported in 1926.Since then major epidemic outbreaks have been reported in India[4,5]. Since 1980,increasing number of outbreaks have been reported

especially in Tamilnadu, Kerala and Karnataka [7] Surat district – Gujarat(1997,2004)and Mumbai(2000,2002).

**IN SOUTHERN INDIA** :The Southern Indian city Madurai and its surrounding agricultural land is a known endemic area for leptospirosis[3].In 1993,Madurai experienced one of the largest epidemic outbreaks following heavy rainfall[8] .In a hospital-based study of uveitis in Madurai,it was observed that 44.6% of uveitis was idiopathic, among the identified entities most common (9.7%)was leptospiral uveitis, and later comes tuberculous uveitis, herpetic uveitis [6]

**RISK FACTORS**

Leptospirosis is an **occupational** risk for rice growing, fishing, harvesting, during animal Breeding and slaughter. Leptospirosis is too a **home risk** by rodents and in a lesser extent by dog. Man could be more exposed to leptospiral transmission by modifying its one occupational and Leisure activities. Leptospirosis is a **leisure risk** for water activities as swimming, fishing, hunting, boating.It is an important health hazard to bathers, campers ,people involved in water sports and travelers [9,10,11] . The **epidemiological risky** conditions of leptospiral include excess of rain fall, hurricanes by increase and/ or changes in Rodents populations.[12]

### 2.1.2. MICROBIOLOGY

The leptospires are thin, coiled, gram-negative, aerobic organisms 6-20 µm in length, 0.1 µm thickness. They are motile, with hooked ends and paired axial flagella (one on each end), enabling them to burrow into tissue. Motion is marked by continual spinning on the long axis. They are unique among the spirochetes in that they can be isolated on artificial media. It can be seen under dark field Microscope, by the silver impregnation method and by immunohistochemical techniques.[1, 13]

Traditionally, the organisms are classified based on antigenic differences in the lipolysaccharide envelopes that surround the cell wall. Serologic detection of these differences, therefore, identifies serovars within each species.

Based on this system, 2 species exist within the genus Leptospira-

1)The pathogenic Leptospira interrogans, has at least 218 serovars which are grouped into 23 serogroup

2)The nonpathogenic, free-living, saprophytic Leptospira biflexa, which has at least 60 serovars.

Current studies that classify the organisms based on DNA relatedness identify at least 7 pathogenic species of leptospires. However, organisms

that are identical serologically may be different genetically, and organisms with the same genetic makeup may be different serologically. Therefore, some authors feel that the traditional serologic system is the most useful from a diagnostic and epidemiologic standpoint.[14]

Culture characteristics: They are obligate aerobes with the unique requirement of long chain fatty acids. They are grown routinely in EMJH medium; the medium is supplemented with 0.1%agar for primary maintenance of stock culture[15]

**PATHO-PHYSIOLOGY**

Leptospires enter the host through abrasions in healthy skin, through sodden and waterlogged skin, directly through intact mucus membranes or conjunctiva, through the nasal mucosa and cribriform plate, through the lungs (after inhalation of aerosolized body fluid), or through the placenta during pregnancy. Virulent organisms in a susceptible host gain rapid access to the bloodstream through the lymphatics, resulting in leptospiremia and spread to all organs. The incubation period usually is 5-14 days, but it has been described from 72 hours to a month or more[17].

If the host survives the acute infection, septicemia and multiplication of the organism persist until the development of opsonizing immunoglobulin in the plasma, followed by rapid immune clearance. However, after clearance from the blood, leptospires remain in immunologically privileged sites, including the renal tubules, brain, and anterior chamber of the eye, for weeks to months. In humans, leptospires in the renal tubules and resulting leptospiruria rarely persist longer than 60 days.

**2.1.3. CLINICAL FEATURES** :

Leptospirosis presents as a biphasic illness. The first phase is the acute or septicemia phase characterized by nonspecific features like fever, headache, myalgia and conjunctival congestion. The second phase is the immune phase characterized by increasing antibody titers and inflammatory infiltration of affected organ systems[16] .

**SYSTEMIC LEPTOSPIROSIS:**

Patients can present with symptoms that fall anywhere on the spectrum of a very mildly ill appearance to a toxic appearance. Anicteric

systemic illness occurs in 80-90% of cases. Others develop icteric, septicemic leptospirosis or Weil's syndrome. The characteristic feature of severe leptospirosis is the progressive impairment of hepatic and renal function.[17] Muscle tenderness can occur with the myositis in early infection.

Nervous system shows signs of meningitis. Occasionally, in severe disease, delirium may develop either as a consequence of or independently of shock. Late in disease and into convalescence, prolonged mental symptoms may persist, including depression, anxiety, irritability, psychosis, and even dementia.

Respiratory system can be normal in early or mild illness. In severe illness, signs of consolidation can be found as a result of alveolar hemorrhage. In patients with cardiac-related pulmonary edema, rales and wheezes can be heard.

In cardiovascular system, myocarditis, coronary arteritis can occur in severe disease.

Abdomen can show hepatomegaly and tenderness from hepatitis. Acalculous cholecystitis can occur which in particular is a finding of very severe systemic illness from leptospirosis[17,18] .

## OCULAR LEPTOSPIROSIS:

In acute phase, Ocular manifestation includes conjunctival suffusion which is a classic ocular finding that occurs irrespective of the severity of disease. It is characterized by redness of the conjunctiva that is similar to conjunctivitis but without inflammatory exudates. Also, subconjunctival hemorrhage, retinal hemorrhage and papillitis can occur, however uveitis does not manifest in the acute phase.

In immunological phase, uveitis is an important complication. It is commonly seen in young and middle aged patients .The presentation is usually acute, but occasionally chronic or recurrent presentations are seen[19]. The pattern may be anterior or diffuse. Both bilateral and unilateral presentations are equally common[20]. Non-granulomatous uveitis is the most common presentation, granulomatous reaction can be seen uncommonly[21]. In endemic areas, leptospiral uveitis is the commonest cause of hypopyon uveitis[20, 22,23]. Early onset and rapidly progression of cataract is a unique feature of this entity[22], dense vitritis with formation of veil like membranous opacities are common. Vitreous precipitates at posterior vitreous face can be seen. Snow ball opacities or snow banking can occur[24]. Disc edema and hyperemia can occur[25]. Cranial nerve paresis

such as third, fourth, sixth, seventh can occur. Retinal vasculitis with venous sheathing is commonly seen. However occlusion and neovascularisation are rare[19]. Other complications that are reported include iritis, iridocyclitis, hypopyon, vitreous reaction, papillitis and retinal vasculitis.

## DIFFERENTIAL DIAGNOSIS:

Although leptospiral uveitis is one of the common entities, it remains underdiagnosed mainly because of protean manifestations of both systemic as well as ocular presentations. Further the notorious ability of uveitic entities to mimic each other creates a diagnostic challenge. Other non-granulomatous uveitis entities that can mimic leptospiral uveitis are uveitis associated with ankylosing spondilitis and Behcets syndrome. Both of them may present with a non-granulomatous hypopyon uveitis, in young male patients, with or without arthralgia. However, the systemic history can help in differentiating these disorders; moreover the Behcet's syndrome has a chronic and insidious course while leptospiral uveitis is acute on its presentation. As far as the posterior segment is concerned, the disc oedema, vitreous reaction and vasculitis of leptospiral uveitis closely mimic the uveitis of sarcoidosis. Here again the sarcoidosis is a chronic

granulomatous uveitis and can be differentiated from acute non-granulomatous uveitis of leptospirosis. Endogenous endophthalmitis can rarely be mistaken for leptospiral uveitis and vice versa, specifically when the patient suffered from a febrile illness and was treated with intravenous fluids; both these histories are known risk factors for leptospirosis and endogenous endophthalmitis, respectively. The laboratory work including Microscopic Agglutination Test (MAT) for leptospirosis, blood and vitreous culture for other bacterial and fungal causes of endogenous endophthalmitis will help in the definitive diagnosis[19] .

**CAUSES OF DEFECTIVE VISION IN LEPTOSPIROSIS:**

In decreasing frequency active inflammation, Cataract, Vitreous hemorrhage, Optic atrophy, Cystoid Macular edema, Macular scar, Retinal detachment, Posterior capsular opacity, Keratitis and pthisis bulbi are the causes of defective vision[26] .

## 2.2. GEOGRAPHIC INFORMATION SYSTEM

### 2.2.1. BASICS OF GIS:

GIS is a computer system designed for capturing, storing, integrating, analyzing and displaying data from a geographic perspective

The term "Geographic Information Systems" (GIS) has been added to mesh in 2003, a step reflecting the importance and growing use of GIS in health and healthcare research and practices. GIS have much more to offer than the obvious digital cartography (map) functions. From a community health perspective, GIS could potentially act as powerful evidence-based practice tools for early problem detection and solving[27] .

“A new wave of technological innovation is allowing us to capture, store, process and display an unprecedented amount of information about our planet and a wide variety of environmental and cultural phenomena. Much of this information will be 'geo-referenced' – that is, it will refer to some specific place on the Earth's surface. The hard part of taking advantage of this flood of geospatial information will be making sense of it, turning raw data into understandable information. Former American Vice President Al Gore[27]

## FUNCTION OF GIS [27,28]

1. GIS handles input, output of geometric data and attribute data.
2. GIS stores the information in compatible formats usable in GIS operations.
3. GIS structures the information to ensure data access at maximum performance and maximal security for data holdings.
4. GIS edits the information to reflect changes in real world and updating the information.
5. GIS provides a tool for analyzing the stored data.
6. GIS provides the tool for visualizing the information in the database

## TECHNIQUES USED IN GIS[30,31,32]

The varied techniques used in GIS software are:

1. Relating information from different sources.
2. Data representation.
3. Data capture and
4. Data manipulation.

## 1. RELATING INFORMATION FROM DIFFERENT SOURCES[30,31,32]

The primary requirement for analysis of data consists of knowing the location for the variables. Location may be annotated by x, y and z coordinates of "longitude" as well as "latitude". Longitude denoted by Greek letterλ, describes the location of a place on earth as east or west of a north – south line called the prime meridian. Longitude is given as an angular measurement ranging from 0° at the prime meridian to +180° eastward and -180° westward. Unlike latitude which has the equator as a natural starting position, there is no natural starting position for longitude.

## 2.DATA REPRESENTATION[27,28,29]

**Data sets can represent the following information:**

- Raw measurements (such as satellite imagery)
- Compiled and interpreted information
- Data derived using geoprocessing operations for analysis and modeling

Many of the spatial relationships between layers can be easily derived through their common geographic location. GIS manages data

layers as specific objects and uses a wide collection of tools to work with the data layers to derive key relationships [30,31,32] .

GIS data represents real world objects [e.g. road, land use, elevation] with digital data. Real world objects can be divided into 2 abstractions:

a. Discrete object [e.g. Hours)

b. Continuous field (e.g. Rainfall, amount of elevation)

There are 2 broad methods used to store data in a GIS for both abstractions. They are:

a. Raster form and

b. Vector form.

❖ **Vector Form**[27,28,29]

Vector data is composed of discrete coordinates that can be used as points or connected to create lines and polygons.

➢ **Points:** Discrete location on the surface of the planet, represented by an x-y coordinates pair. Each point on the map is created by latitude and longitude coordinates, and is stored as an individual record in the shapefile. (Figure 1)

➢ **Lines:**

Formed by connecting two data points (See). The computer reads this line as straight, and renders the line as a vector connecting two x-y coordinates (X = longitude, Y = latitude). The more points used to create the line, the greater the detail. FPA requires that the line and polygon features include topology. For lines, this means that the system stores one end of the line as the starting point and the other as the end point, giving the line "direction". (Figure 2)

- **Polygons:**

An area fully encompassed by a series of connected lines. Because lines have direction, the system can determine the area that falls within the lines comprising the polygon. Polygons are often an irregular shape. Each polygon contains one type of data (e.g., vegetation, streets, and dispatch locations would be different polygons). All of the data points that form the perimeter of the polygon must connect to form an unbroken line. When preparing files for FPA, verify that the polygons are closed. (Figure 3)

❖ **Raster Form** [27,28,29]

Raster data represent features as a matrix of cells within rows and columns in continuous space. These cells are formed by pixels of a specific dimension size, and can be described as either "cell-based" or "image-based" data [30,31,32].

The raster data can be discrete [e.g. land use] or a continuous value [e.g. rain fall] or a null value [if no data is available]. While the raster cell usually stores a single value, it can be extended using “raster bands” to represent:

- RGB colors [Red, Green, Blue]
- Color maps [a mapping between a thematic code and RGB value]
- Or an extended attribute table with one row for each unique cell value. The resolution of the raster data is its cell width in ground units. For e.g., one cell of a raster image represents one meter on the ground. Usually cells represent square area of the ground; but other shapes can also be used.

- **Cell-based Data**:

Each raster data layer represents one attribute. Most analyses combine these layers to create new layers with new cell values, as either continuous or discrete data. Continuous data types have gradations, such as temperature or elevation (Figure 4). Discrete data types have clearly delineated boundaries, such as a city boundary or specific vegetation type.

The cell size used for a raster layer affects the results of the analysis and how the map looks. Using too large a cell size will cause some information to be lost. Using too small a cell size will significantly increase the storage space and processing time required, without adding precision to the map. To create an effective cell size, base the cells on map scale and on the minimum mapping unit of the other GIS data.

- **Image-based Data**:

Image data ranges from satellite images and aerial photographs, to scanned maps that have been converted from printed to digital format. (Figure 5)

- **Grid Data:**

The grid provides the simplest way of dealing with the data. Grids speed the calculation time required for the computer to determine the location of the data points within the polygon. For example, (Figure 6) elevation data are stored in this layer.

- **Attributes** [29,30]

Attribute (tabular data) is descriptive data that GIS links to map features. For example, attributes of a dispatch location, which is represented by a spatial point, might include an engine bay that accommodates a certain number of engines, crews, dozer pads, and so on. These attributes are stored in a database and relate to the feature using a primary key (unique identifier).

- **Database**[29,30,31]

The database forms the foundation of the GIS system. All the information about the GIS system is stored in the database. The first 5 fields of every GIS database always contain the same type of information, and provide a way to link each record with a unique identifier. All feature

classes in a feature data set must share the same spatial reference. Databases have the ability to implement sophisticated business logic that can build relationships between data types, validates data, and controls access (import, editing, & export).

❖ **Topology**[29,30,31]

Topology describes the spatial relationships between adjacent features, and uses x, y coordinates to identify the location of a particular point, line, or polygon. Using such data structures enforces planar relationships, and allows GIS specialists to discover GIS Shapefiles

A shapefile is a type of GIS data layer that is used to transfer vector data. Each shapefile can contain only one feature class. While less robust than coverages, shapefiles tend to be significantly smaller, which reduces processing time.

**3.DATA CAPTURE**[27,28,29]

Entering information into the GIS system is called “data capture”. There are several methods used to enter data in a GIS format. They are:-

1. Existing data printed on paper or mylar maps can be digitized or scanned to produce digital data.

2. Survey data can be directly entered into a GIS from digital data collection systems on survey instruments. Positions from a global positioning system (GPS), another survey tool can be directly entered into GIS.
3. Remotely sensed data are collected from sensors attached to a plat form. Sensors include cameras, digital scanners and RADAR; platforms include aircrafts and satellites.
4. Photo interpretation of aerial photographs soft copy workstations are used to digitize features directly from stereo pairs of digital photographs. These system allow data to be captured in 2 and 3 dimensions with elevation measured directly from a stereo pairs using principles of “Photogrammetry”.
5. Satellites remote sensing spatial data :-

Satellites use different sensor package to passively measure the reflectance from parts of the electromagnetic spectrum or radio waves that were sent out from an active sensor such as RADAR. Remote sensing collects raster data that can be further processed to identify objects and classes of interests such as land cover.

**Editing of GIS data**

1. For vector data it must be made "topologically correct" before it can be used for some advanced analysis. Eg. In a road network, lines must connect with nodes at an intersection.
2. Errors like undershoots and overshoots must be removed.
3. For scanned maps, blemishes on the source map may need to be removed from the resulting raster. For eg., a fleck of dirt might connect 2 lines that should not be connected.

## 5. DATA MANIPULATION[27,28,29]

Data restructuring can be performed by a GIS to convert data into different formats eg. A GIS may be used to convert a satellite image map to a vector structure by generating lines around all cells with the same classification, while determining the cell spatial relationships, such as adjacency or inclusion.

Since digital data are collected and stored in various ways, the 2 data sources may not be entirely compatible. So a GIS must be able to convert geographic data from one structure to another.

**POWER OF GIS**[27,28,29]

The analytical power of GIS comes from its ability to overlay and match different shapefiles for the same geographic area, which enables you to visualize the interactions among the different data.

## 2.2.2.APPLICATION OF GIS IN VARIOUS INFECTIOUS DISEASES:

**LEPTOSPIROSIS**

The places at risk of leptospirosis and associated environmental conditions in a flood-related outbreak in Rio de Janeiro were studied by Kolsky, Blumenthal, Narimen, Croner etal[34]. By using spatial analysis cases of leptospirosis were merged with socio-demographic data using GIS. After plotting risk areas, incidence rates were calculated for each areas. Higher rates were observed for census tracts inside the flood risk areas and in the vicinities of waste accumulation sites. This was in agreement with the expected risk of leptospirosis evidencing the role of environmental and collective factors in the determinate of the disease.

## TRACHOMA

Using geographic information system as a data base and a cartographic tool, Sarah polack, Simon brooker, Hannah kuper etal generated a global map of the prevalence of trachoma and trichiasis. The result of the study showed that trachoma remains highly endemic in many parts of Africa and continues to persist in a number of countries in the Middle –East, Asia and Latin America[35] .

## TUBERCULOSIS

Using GIS technology Patcrick K Moonan, Manuel Bayona, Teressa N Quitagua, Joseph Oppong identified areas of tuberculosis transmission and incidence[36]. They did a cross-sectional analysis of collected data on newly diagnosed culture positive tuberculosis clinical isolates, which was molecularly characterized using IS6110 – based RFLP analysis and spoligotyping methods [to identify patients infected with same strain]. Residental addresses at the time of diagnosis of tuberculosis were geocoded, mapped and generalized estimating equations (GEE) analysis models were used to identify risk factors involved in clustering. This showed distinct areas of geographical distribution of same strain disease.

This area can be targeted for screening and treatment programmes for aiming incidence redunct.

**SARS [SEVERE ACUTE RESPIRATORY SYNDROME]**

To understand the spatial clustering of Severe Acute Respiratory Syndrome (SARS) in Hong Kong, P.C.Lai, C.M. Wong, A.J.Hedley, S.V. Lo, P.Y.Leung, J.Kong, and G.M. Leung from the Department of Community Medicine, University of Hong Kong, , People's Republic of China used GIS as an operational tool[37]. They applied cartographic and geostatistical methods in analyzing the patterns of disease spread during the 2003 SARS outbreak in Hong Kong using GIS. Elementary mapping of disease occurrences in space and time simultaneously revealed the geographic extent of spread throughout the territory. Statistical surfaces created by the kernel method confirmed that SARS cases were highly clustered and identified distinct disease "hot spots". Contextual analysis of mean and standard deviation of different density classes indicated that the period from day 1(18 February) through day 16 (6 march) was the prodrome of the epidemic, whereas days 86 (15 May) to 106 (4 June) marked the declining phase of the outbreak. Origin – and – destination

plots showed the directional bias and radius of spread of superspreading events and also density data with their natural logarithm functions.

**TOXOPLASMOSIS**

Computer generated dot maps were used as an epidemiologic tool to investigate an outbreak of Toxoplasmosis by Steven B. Eng, Denise.H. Werker, Arlene S. King Stephen A. Marion, Alison Bell, Judith L. Renton, G. Stewart Irwin, and William R. Bowie. et al[38] .The group worked from Center for Disease Control and Prevention (CDC). They used computer generated dot maps to examine the spatial distribution of 94 Toxoplasma gondii infections associated with an outbreak in British Columbia, Canada. The incidence among patients served by one water distribution system was 3.52 times that of patients served by other sources. Also acute T. gondii infection among pregnant women was associated with the incriminated distribution system.

**HELMINTH INFECTION**

Remote sensing and geographic information system are used to assess the distribution of helminth infection among school children in Chad by Simon Brooker etal.They investigated environmental limits of helminth distribution[40] .

## CRYPTOSORIDIOSIS

**Using GIS the relationship between reported cryptosporidiosis and water supply was studied by Sara Hughes, Qutub Syed, Sarah Woodhouse, Iain Lake, Keith Osborn, Rachel M Chalmens, Paul R Hunter.et al[41]. They investigated the epidemiology of sporadic cryptosporidiosis in North West of England and Wales using GIS by plotting on maps of water supply and water quality area boundaries [provided by the two main water utilities]. It proved no correlation of drinking water source with any of five water supplies that serve the areas.**

## APPLICATION OF GIS IN AECS, MADURAI

**In ARAVIND EYE CARE SYSTEM ,MADURAI the concept of GIS is being used in sevseveral disciplines like planning of cataract screening camps, study of rubella eye infections, trematode induced uveitis.**

**GIS has emerged as an important component of many projects in public health and epidemiology[39,42]. GIS is particularly well suited for studying these associations because of its spatial analysis and display capabilities .Medical geography is relatively a new concept in India[43]. The sheer size of our country, varied life styles, climatic zones and environmental conditions makes it all the more important for India to have a health GIS[40]**

# AIM AND OBJECTIVE:

To study the epidemiological correlates of leptospiral uveitis in a hospital based population belonging to Madurai district

**Inclusion criteria**

Patients with leptospiral uveitis belonging to Madurai district who attended uvea dept, Aravind eye hospital, Madurai in the 5 yr period from January 2001 –December 2005

**Exclusion Criteria**

1) Patients with a history of recent migration outside Madurai district during the acquisition of leptospirosis.
2) Patients initially considered to have leptospirosis in differential diagnosis and later diagnosed to have some other specific disease based on the investigation and clinical behaviour of the disease.

# METHODOLOGY

This study was conducted in following steps

## 1.DEFINING THE STUDY GROUP AND DISEASE UNDER STUDY:

Retrospective collection of data regarding leptospiral uveitic patients belonging to Madurai district who attended Aravind eye hospital, Madurai in a period of January 2001-December 2005.

Selection of patients was done based on the following criteria

- History suggestive of leptospiral uveitis
- Clinical decision rule[26]
- Positive Micro-agglutination Test

The case sheets were analysed and refined ,those cases initially diagnosed to have leptospirosis and later changed to be different disease based on investigation were removed from the study.

## 2.COLLECTION OF DATA:

The following details were obtained from the case sheets

- Age
- Sex

- Occupation
- Date of first presentation
- Risk factors if any
- Serology

**3.REFINING THE DATA**

As many of the address given by patients were short and incomplete, the complete address of patients were found out with the help of GIS polygon chart ,Madurai.

**4.COMPARING THE DATA WITH KNOWN INDICES**

The following data regarding each taluk of Madurai district was collected from different sources

- Population data-Based on 2001 census
- Literacy percentage
- Number of Waterbodies-From statistical Hand Book, published by collectorate, Madurai
- Animal census from Animal Husbandry, Madurai.

- Rainfall data from metereology deparment, Air-port Madurai.

**5.DESCRIPTION OF STUDY BY PERSON, PLACE AND TIME.**

The patient data is analysed in the form of age, gender and occupation basis. The data was compared with other known indices like total population, urban rural ratio, Literacy rate, animal population and number of water bodies. In relation to time the disease frequency was correlated with rainfall data.

## 6. APPLICATION OF GIS

GIS was applied to describe variations in place distribution. The administrative boundaries based on Taluks were utilised to study the places in Madurai. Maps were generated in following steps

1. Data collection: The raster image of Madurai Taluk Map was downloaded from official website of national informatics centre. Georeferencing of the map was done with respect to geo corrected topo-sheet
2. Base map generation: new personal geo data has been created to store all the data.WGS84UTM zone 440 projection has been

assigned for the feature data set. New feature class been created for Madurai district.

3. Data generation: New vector data has been created for Madurai district from the geo referenced image using Arc view version GIS 9
4. Topology creation: Topology rules has been set for newly created Madurai feature class(*must be covered rules*)
5. Addition of attributes: Data collected has been added to each taluk.
6. Thematic map generation: Maps were created based on following themes
    a) Distribution of patient density among total population of each taluk.
    b) Distribution of Urban and Rural population in each taluk.
    c) Distribution of literacy rate in each taluk.
    d) Proportion of agricultural population to total working population
    e) Ratio of animal population to human population in each taluk.

**7.FORMULATION OF ETIOLOGICAL HYPOTHESIS** based on observation was done

# RESULTS

**Table 1. AGE-WISE DISTRIBUTION:**

*Highest number of patients in the age group of 11-20

Table 1 & Figure 7 shows that Out of 145 patients,62 patients(42.5%) belong to the age group of 21-30 years. 20.69% and 21.38% belong to 11-20 years and 31-40 years respectively . More than 80% belong to the age group of 11-40 years.

**Table 2.GENDER-WISE DISTRIBUTION**

| | MALE | FEMALE | TOTAL |
|---|---|---|---|
| NO OF PATIENTS | 93 | 52 | 145 |
| PERCENTAGE | 64.14 | 35.86 | |

Male: Female ratio=2:1

Out of 145 patients, 93 patients (64.14%) are male and 52 are female (35.86%). This could be due to under reporting of diseases among women who have primary domestic responsibility. (Table 2 and Figure 8)

**Table 3.OCCUPATION- WISE**

| | RISKY OCCUPATION* | NON-RISKY OCCUPATION |
|---|---|---|
| NO OF PERSONS | 50 | 40 |
| PERCENTAGE | 55.5% | 44.44% |

Risky occupation*-Farmer,sewer workers,veterinarians,Abattoir workers.

Out of 145 patients, the occupational data are available for 90 patients. Among them more than half of the patients belong to risky group, demonstrating the occupational risk involved in occurrence of leptospirosis (Table 3 & Figure 9)

**Table 4.RISKY OCCUPATION**

| | FARMER | NON-FARMER |
|---|---|---|
| NO OF PERSONS | 39 | 11 |
| PERCENTAGE | 78% | 22% |

Risky occupational group is divided into Farmer and Non-Farmer

Out of 90 patients, 50 patients belong to risky Occupational group, of which 39 patients (78%) are farmer by the occupation.Table 4 & Figure 10 clearly show that more proportion of patients are farmers.

**Table 5: Comparison of disease occurrence with rainfall data:**

| Year | Jun 01 to May 02 | Jun 02 to May 03 | Jun 03 to May 04 | Jun 04 to May 05 |
|---|---|---|---|---|
| Rainfall(in c.m) | 76.6 | 74.87 | 87.85 | 101.07 |
| no of patients | 39 | 36 | 22 | 12 |

In 2004-05-highest rainfall; but least number of patients

The above chart compares the number of patients in each year to the rainfall measurement in each year. Figure 11 shows that the frequency of occurrence of the disease doesn't correlate with the rainfall measurement.

## ANALYSIS USING GIS

Distribution of leptospiral uveitis patients in each taluk of Madurai district was analyzed using GIS.Out of 145 cases,135 cases are taken for GIS analysis,since the address of these 10 cases are incomplete and the exact location of taluk they belong to could not be made out. Madurai district is divided into following seven taluks. Madurai corporation is included in Madurai south taluk.The following are the name of the taluks(Map 1):

1. Madurai North
2. Madurai South
3. Melur
4. Vadipatti
5. Peraiyur
6. Thirumangalam
7. Usilampatti

**Table 6:Distribution of patients in each Taluk**

| Taluks | Number of patients |
|---|---|
| Madurai north | 33* |
| Madurai south | 29 |
| Melur | 19 |
| Vadipatti | 29 |
| Peraiyur | 7 |
| Thirumangalam | 7 |
| Usilampatti | 11 |

Madurai North-more number of patients;
Thirumangalam &Peraiyur-least number of patients

The number of leptospiral uveitis patients is peak in Madurai North and in more in Madurai South,Melur,Vadipatti.The number is least in Thirumangalam and Peraiyur.

**Table 7:Comparison of number of patients with population in each taluk**

| | Number of patients | Population | Patients per lakh |
|---|---|---|---|
| Madurai north | 33 | 346552 | 9.5** |
| Madurai south | 29 | 1196806 | 2.5* |
| Melur | 19 | 251103 | 7.5 |
| Vadipatti | 29 | 210023 | 13.8* |
| Peraiyur | 7 | 184353 | 3.7 |
| Thirumangalam | 7 | 195231 | 3.5 |
| Usilampatti | 11 | 178211 | 6.1 |

Patient density-peak in Vadipatti*;least in Madurai South**.

Table7 & Map 2 show population is highest in Madurai South.Madurai North stands the next. The other taluks have comparatively equal

population.When comparing the number of patients with Population , Vadipatti stands first in the density distrbution of patients.Madurai North and Melur remain next.Madurai south has remarkably lesser number of patients comparing to the highest population.(Figure 12) To evaluate such varied occurrence among different Taluks,the patient data is compared with the known indices like Urban population rate,literacy rate,Number of agriculturers,number of water canals.

**Table 8:Proportion of Urban and Rural population in each taluk**

| | **urban%** | **rural%** | **Patients per lakh** |
|---|---|---|---|
| Madurai north | 49.6 | 50.4 | 9.5 |
| Madurai south | 88** | 12 | 2.5* |
| Melur | 16.3 | 83.7 | 7.5 |
| Vadipatti | 29.9 | 70.1 | 13.8 |
| Peraiyur | 17.5 | 82.5 | 3.7 |
| Thirumangalam | 22.2 | 77.8 | 3.5 |
| Usilampatti | 16.6 | 83.4 | 6.1 |

In Madurai South-least patient density & highest proportion of urban population

Map 3 shows pie diagram representing the ratio between urban and rural population.Among all taluks Madurai South has the highest number of urban populaton.Madurai North has almost equal distribution of urban and rural population.Apart from these two taluks,in others the ratio is relatively equal with rural population constituting more than 70%.(Table 8)

**Table 9:Proportion of literacy percentage in each taluk.**

| | Literates% | others% | Patients per lakh |
|---|---|---|---|
| Madurai North | 79.7 | 20.3 | 9.5 |
| Madurai South | 86.0** | 14.0 | 2.5* |
| Melur | 69.9 | 30.1 | 7.5 |
| Vadipatti | 70.4 | 29.6 | 13.8 |
| Thirumangalam | 68.9 | 31.1 | 3.7 |
| Usilampatti | 64.1 | 35.9 | 3.5 |
| Peraiyur | 73.7 | 26.3 | 6.1 |

In Madurai South-least patient density* & highest proportion of urban population**

Map 4 shows pie chart representing literacy rate and others in each taluk.Madurai South has highest percentage(80%) literacy among all taluks.Madurai North has about 80% of literacy rate ranking next to Madurai South.Apart from these two taluks,others have comparitively equal literacy rate of around 70%.(Table 9)

**Table 10.Distribution of total working population in each taluk.**

Melur* & Vadipatti**-higher proportion of agricultural field workers;

Map 5 was generated after normalization of these data with total population as a common denominator. It evidently shows that Madurai South has least proportion of agricultural field worker among working population. Other than Madurai South, Madurai North has lesser proportion of agricultural field worker. All other remaining taluks, have

relatively equal proportion and definitively more than Madurai North and South(Table 10).

**Table 11. Distribution of animal and human population in each taluk**

| | Animal population | Human population | Animal:Human Population ratio | Patients per lakh |
|---|---|---|---|---|
| Madurai north | 198694 | 346552 | 1:2 | 9.5 |
| Madurai south | 83635 | 1196806 | 7:100* | 2.5** |
| Melur | 95394 | 251103 | 3:10 | 7.5 |
| Vadipatti | 69128 | 210023 | 3:10 | 13.3 |
| Peraiyur | 95105 | 184353 | 1:2 | 3.7 |
| Thirumangalam | 92059 | 195231 | 2:5 | 3.5 |
| Usilampatti | 64658 | 178211 | 2:5 | 6.1 |

In madurai south - least animal: human population* and least patient density**

The above mentioned table shows highest number of animal population in Madurai North, with Melur, Peraiyur, Thirumangalam, Vadipatti and Usilampatti in descending ranks. Map 6 shows combined bar chart comparing human and animal population. It shows significant difference among ratio between human and animal population in each taluk. Madurai South has lesser animal population comparing to highest human population. Madurai North has more animal and human population than other taluks, but the ratio between animal and human population is relatively similar to other taluks(Table 11)

**Table 12. Distribution of number of water canals in each taluk**

| | Patients per lakh | No of canals |
|---|---|---|
| Madurai north | 9.5 | 13 |
| Madurai south | 2.5 | 1 |
| Melur | 7.5 | 4 |
| Vadipatti | 13.8* | 30** |
| Peraiyur | 3.7 | 0 |
| Thirumangalam | 3.5 | 2 |
| Usilampatti | 6.1 | 1 |

In Vadipatti – Highest patient density * and number of water canals**

The Table 12 & Figure 13 show the actual number of water canals in each district, with highest number of water canals being in Vadipatti and least in Madurai South and Usilampatti. Peraiyur has no water canal and the source of water is wells and tanks as per data available in Madurai 2004- statistical hand book. The map (6) demonstrates number of water canals with increasing shades of colour in each polygon (chlorpleth map).The number of patients per lakh in each polygon is represented as dots over the polygon map. It strikingly shows the significant difference in the number of water canals and the number of patients per lakh among different taluks. Vadipatti has highest number of patient density and number of water canals as well. The number of water canals and the patient density are next higher in Madurai North. Madurai south has least number of water canals and patient density as well.

# DISCUSSION

Descriptive study is usually the first phase of an epidemiological investigation. This study is concerned with observing the distribution of the disease or disease related characteristics in human population and to identify any associated characteristics.

This study describes the disease of interest-Leptospiral uveitis in following headings:

- Person distribution –Age, Gender, literacy, Occupation, Socio-economic status.
- Place distribution-Taluk-wise, village wise distribution, Comparison with water bodies and animal distribution.
- Time distribution—comparison with year- wise rainfall distribution.

**Person distribution:**

1.This study shows occurrence of disease more in the **middle aged adult Males** (Fig 1,2&Table 1,2). This reflects the same pattern reported previously.[8]

This could be explained by following reasons.

- Young adults are exposed to occupational risk factors for leptospirosis.
- Young adult seek medical attention without difficulty.
- Under reporting of diseases among women who have primary domestic responsibility.

2. Available occupational data of patients show that more than half were in risky occupation, and among them **farmers** predominate (Fig 2,3 &Table 2,3 ) This data support the fact that farmers are having a propensity for leptospirosis, as they have more exposure to cattles, water bodies, and the habit of working in field with bare foot. This result is in consistent with published reports[1,3] .

**Time Distribution:**

On year wise comparison, the number of occurrence of the disease does not correlate with the rainfall average.(Figure 11 & Table 5).This could be explained by the following reason -Though rainfall and flooding is a risk factor for the occurrence of systemic leptospirosis, leptospiral uveitis occurs after a **latent interval** following systemic leptospirosis. This latent interval could vary between 2 days to 4 years and usually it

begins at 3-6 months[45] . Hence, direct relation between these two data could not be expected.

**Place distribution:**

Taluk wise distribution of cases was compared with data collected using Geographic information system. Based on the distribution of patient density, the order of taluks in decreasing range (Map 2 & Table 7) is:-

1. Vadipatti
2. Madurai North
3. Melur
4. Usilampatti
5. Peraiyur
6. Thirumangalam
7. Madurai South

In **Vadipatti Taluk** numbers of patients comparing to Total population is the highest.(Figure 5 & Table 6).The possible reasons could be due to the **predominance of rural population** (70%) (Map3& Table 8) and the relatively **low level of literacy percentage**(table 9 & Map 4). The predominance of rural population and low literacy level may correspond to the poor awareness among people regarding health and

sanitation, and increased occurrence of infectious diseases in general. Moreover, unlike in urban area the rural area has no proper service of waste collection

Considering the working population in this taluk, **majority** of them are related to **agriculture** (table 10 & map 6).As we already discussed, the occupation related to agriculture is a known risk factor.Another important reason could be the existence of remarkably **more number of water canals** (Figure13 & Map7). Though water in the canals are flowing water, it could be a risk factor because water source is often contaminated with animal excreta and solid waste where man has direct contact with the water by taking bath or using the water for household activities

**Madurai North** taluk ranks next to vadipatti in the density distribution of patients, inspite of high literacy rate and lesser proportion of farmers. The one possible reason could be due to the **close proximity of this hospital** to Madurai north and easy accessibility to the hospital. The other reasons could be due to the presence of more **animal and human population** than other taluks.(Map 6 & Table 11) and the existence of higher number of water canals than other taluks except Vadipatti. These facts could explain the possibility of disease

transmission due to crowding where humans are at risk of more contact with animals and common water source.

**Melur** stands next to Madurai north in the density distribution of patients. The reasons could be because the proportion of **rural population** in Melur **is highest** among taluks (Map 3& Table 8). Similar to Vadipatti, it has **low literacy** rate (70%). Considering the working population, though the total number of persons related to agriculture (i.e. cultivators and agricultural field workers) in Melur is equal to other taluks, **the proportion of agricultural field workers in particular is highest** in Melur.(Table 10). The numbers of field workers who are in direct contact with the field carry more significance because the group "cultivators" indicate the persons who cultivate with the help of field workers, and they may not necessarily have direct contact with the field.

**Usilampatti, Thirumangalam, Peraiyur** taluks in common, these have lesser number of patients, though the proportion of rural population and agriculturers in these taluks are more.The first possible explanation would be these taluks being **relatively far from hospital**,with Peraiyur and Usilampatti being nearer to Theni district.Thus Theni would be the primary cachment area for these taluks. The other reasons could be due to

**the lesser animal:human population and lesser number of water canals comparing to other taluks.**

**Madurai South taluk has the least number of patients comparing to highest population among all taluks. The possible reasons could be due to the Strikingly higher percentage of urban population (80%)(Map 3& Table 8) than other taluks. In this taluk predominated by urban population, the most households are served by regular waste collection and proper sewage drainage. Moreover, it has the highest percentage of literacy rate (88%) (Map 4 & Table 9).These facts would correspond to increased awareness among people regarding health and sanitation. The number of persons involved in risky occupations such as agriculture,sanitary work,butchery would be less,where the number of literates are more. In this taluk,there are considerably lesser numbers of persons being related to agriculture in comparison to total working population. (Map 5 & Table 10). This fact again supports for the lesser number of patients in this taluk.And it has remarkably lesser animal:human ratio than other taluks.This implies lesser contact of animals among people,thereby decreasing the disease risk.(Table 11 & Map 6).Considering the existence of number of water canals, it is least on comparing to other taluks,which could have markedly reduced the disease occurrence.(Table 12 & Map 7)**

# CONCLUSION

Though Madurai district as a whole is an endemic area for leptospirosis, variations in density distribution of patients among different taluks of Madurai have been observed in this study. It concludes that leptospiral uveitis occurs more common in rural and agricultural population and in places with more ratio of animal to human population. It occurs less frequently in places where Urban and literate population predominate. Map patterns using GIS being physically compact highlight these correlations and provide an added dimension to this study. GIS is a useful decision support tool for analyzing multiple themes simultaneously and in locating the places of need. Based on the results of this study, health education and preventive measures could be focused on the needy places. This study could be extended for analyzing the occurrence of systemic leptospirosis or similar other waterborne illness.

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# PROFORMA

**NAME :** _____

**M.R.NO :** _____

**Age :** _____**yrs**

**Gender :** Male-1 ☐ Female-2

**ADDRESS :** _____

**STREET :** _____

**VILLAGE/TOWN:** _____

**PANCHAYAT /MUNICIPALITY:** _____

_____

**TALUK:** _____

**BLOCK:** _____

**DISTRICT** _____

**Date of first presentation:** _____ _____

**Occupation:** ☐ _____

Risky(farmer)-1;Risky(Non farmer)-2;Non-Risky-3

**Laterality:** ☐

RE-1 ; LE-2

**Anatomical type of uveitis:** ☐

Anterior Uveitis-1

Intermediate Uveitis-2

Posterior Uveitis-3

Pan Uveitis-4

**Type of uveitis** ☐

Granulomatous-1 Non-Granulomatous-2

**Anterior Segment:**

Hypopyon: ☐ ☐

Complicated cataract: ☐ ☐

**Posterior segment:**

Vitreous membrane: ☐ ☐

Retinal vasculitis: ☐ ☐

Disc edema: ☐ ☐

**Micro-agglutination test:** ☐

Positive-1 Negative-2

☐