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Spatial temporal variation of leptospirosis disease in Madurai city – Medico-geographical analysis

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Abstract
Leptospirosis is a zoonotic disease caused by bacteria of the genus *Leptospira*. The bacteria are typically found in animals, including rodents, farm animals, and dogs. Humans become infected when water or soil contaminated with the bacteria come into contact with their eyes, mouth, nose, or open cuts on the skin. It is also possible to be infected through rodent bites and drinking contaminated water. Leptospirosis it continues to remain as an important public health problem in Madurai city. The study area, Madurai is the oldest and second largest city in Tamil Nadu situated on the banks of river Vaigai in south central part of Tamil Nadu, India. It is located on 9^0 30' and 10^0 30' longitudes and between 77^0 00'and 78^0 30 latitudes. The broader objective of this study is to analyse the spatio temporal variation noticed between different unit areas of study area. The collected data includes both primary and secondary source. Standard score (Z-score) technique, is used to synthese the relationship between the sets of variables and total conditions of selected urban environmental variables. It includes mapping of the disease using the GIS software of Arc GIS. The study's social aspect of leptospirosis with reference to selected socio-economic determinants and suggests suitable preventive measures.

Keywords: Leptospirosis – Spatio temporal variation- Z score techniques - Quantitative techniques- GIS

1. Introduction

Leptospirosis is a zoonotic disease caused by bacteria of the genus *Leptospira* [1] It is most commonly spread via water contaminated with urine from infected animals, but contaminated food or soil can also act as vehicles for the disease [2]. The main animal reservoirs are rodents, livestock and dogs. The patients suffer from fever, swelling of legs, and sever body pain. Some severe complications include kidney damage, liver failure, respiratory distress, meningitis and death [3].

Leptospirosis is most common in urban slum areas, where there is inadequate sewage disposal and water treatment [4]. It can also be an occupational hazard for those working outdoors or with animals and a recreational hazard for those participating in water related activities.[5] Epidemics are typically seen during flooding. Changing environmental trends, with extreme weather patterns, may perpetuate these epidemics [6].

Transmission of the disease in humans occurs by either direct or indirect contact with the urine, blood, or tissue of an infected animal. Animals known to spread leptospirosis to humans include cattle, pigs, dogs, reptiles and amphibians, rats and other rodents, which are the most important sources for human infection [7, 8].

The urine of infected animals or healthy carriers, which may contaminated soil, pasture, drinking water and food, is the main source of infection. In the case of leptospira abortion, infection can spread through the aborted fetus and uterine discharges [9].

Humans are accidental hosts and acquire infection due to several occupational and recreational hazards associated with leptospirosis. Butchers, veterinarians, farmers and rodent control workers are at increased risk [10]. Outbreaks associated with recreational exposure to water have been reported from several countries [11].

Leptospirosis has been recognized as a potential hazard of water sports, swimming in the river and other recreational activities that expose people to possible contaminated waters. Direct transmission between humans is not indicated. They are not proven to be important epidemiological source of transmission although the excretion of leptospirosis in human urine occurs for months after recovery has been recorded [12, 13].

Medical geography is a multidimensional body of knowledge and at the same time a multifaceted approach is geared towards understanding the spatial aspects of health problems [14, 15, 16, 17, 18]. Epidemiology is a branch of medical science that deals with the incidence, distribution, and control of disease in a population [19, 20, 21, 22]. It also deals with the sum of the factors controlling the presence or absence of a disease or pathogen [23, 24, 25, 26, 27].

All the studies in medical geography are concerned with the description of spatial and temporal variations of a particular disease and are attempted at the regional level but limited with respect to micro level [28, 29, 30]. Hence the present study has focused its importance at micro level to study the spatial distribution of Leptospirosis in Madurai city. The purpose of this study is to analyze the geographical distribution of vector borne disease in Madurai city especially Leptospirosis and its association with selected socio economic, environmental, behavioral and Medical aspects.

The present study will identify the existing morbidity condition of population and health status prevailing in Madurai City. This offers a wide scope to find out the environmental conditions for both health and disease and stress the need for better environmental planning [31, 32]. In addition, it helps to provide the most appropriate description for its present standard of diagnosis and remedy [33, 34].

2. Study Area
Madurai city is situated in south central part of Tamilnadu on $9^0$55"N Latitude and $78^0$07"E Longitude at a distance of nearly 500 km from Chennai. (Fig 1) It is bounded on north by districts namely Dindigul, Tiruchirappalli, and on the east by Sivagangai and on the west by Theni and south by Virudhunagar. The city has grown on both sides of river Vaigai and lies at a low altitude being only about 100 mts above the mean sea level. Madurai city has an area of 52sq.km with an urban area now extending over at much as 130 sq.km.

3. Aims and objectives
The aims and objectives of the present sutdy are as follows;
- To analyse the ward wise spatial distribution of leptospirosis in Madurai City.
- To analyse the spatio temporal variation noticed between different years of study area.
- To analyse the inter relationship between the prevalence rate of leptospirosis and selected environmental, socio economic and health care variables.
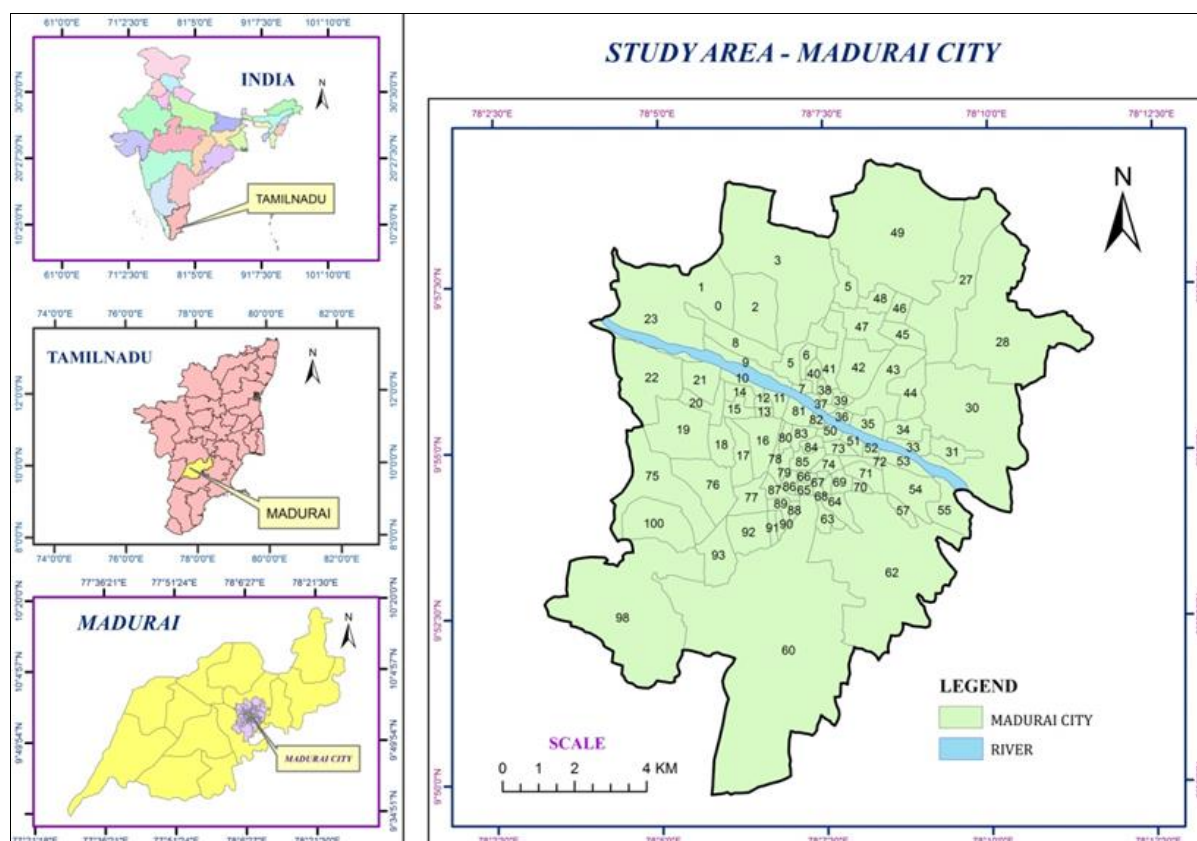

Fig 1: Location of Study area

4. Methodology
To fulfill the above objectives, the information was collected from both primary and secondary sources. The most important tool of analysis for geographers is cartographic interpretation and analysis of data with the help of maps.

4.1 Primary Data
The primary data is collected in the form of sample questionnaire survey in selected ward of the study area. The data collected were taken by using the method of stratified random sampling and a total of 300 samples were collected from the study is area with reference to different age groups and sex. The primary data in the present study based on direct personal interview which is selected as sampling units. Leptospirosis awareness of the public identified in Madurai city.

4.2 Secondary Data

The main sources of secondary data are available at health department (Viswanatha puram) and leptospirosis clinic (ECO) in West Zone. The data collected from the above institution are ward wise – vector borne disease and zoonotic disease 2014-2018. The rainfall and ward wise population data was collected from Assistant director of statistic in Madurai. The information about vectors was collected from respected health centers in Madurai. Census was collected from Madurai corporation office. Other socio-economic particulars were collected from the respective offices. The Study area maps and related information were obtained from the Town Planning office in Madurai Corporation.

4.3 Techniques Used

Two important techniques are used in the present study. They are statistical techniques and Cartographic interpretations. It includes mapping of the study area using the GIS software of Arc GIS 9.3. The primary survey is based on the method of stratified random sampling. Apart from this, the 'Z' score statistical techniques and used to find the major disease distribution and interrelationship between patients and health care centres.

'Z' Score Method

A 'Z' score is a statistical measurement of a score's relationship to the mean in group scores. A 'z' score can be positive or negative indicating whether it is above or below the mean and standard deviation [35]. 'z' score can also be explained as in addition of showing a score's relationship to the mean. 'z' scores also allow analyst to convert scores from different data sets into scores that can be accurately concerned to each other. In order to use a z-score, we need to know the mean μ (mu) and the population standard deviation σ. The z-score is calculated using the following formula by SPSS (Statistical package Social Sciences)

$$z = \frac{x - \mu}{\sigma}$$
Formula:

Where:
X= Raw score
μ= mean of the given population sample
σ = standard deviation of given population sample.

5. Results and Discussion
5.1 Gender Classification

Analysis of sex ratio is one of the important aspects of Leptospirosis study. In the sample population Females are more (73.3%) when compared to males (26.7%). In Madurai city Females are widely affected by Leptospirosis. Hence awareness about Leptospirosis is needed amongst them (Table 1)

Table 1: Gender Classification

Gender	Responses In%
Male	26.7
Female	73.3

5.2 Age Structure

In health care studies age group play a dominant role. Analyzing through various age group level in the

respondents it is found that 29% of the total population comes under the age group of 15-30, 43.3% of the respondents come under the age group of 45-60, 16.7% of the respondents come under 45-60, age group and only 10% of the total respondent is found above 60 years.

Table 2: Age Structure

Age Group	Responses In%
<15	02
15-30	29
30-45	43
45-60	16
>60	10

5.3 Spatial temporal variation of Leptospirosis In Madurai City

In 2014 people affected is very high (139). In 2016 affected 49 people. In 2017 it affected few people i.e 46. (Table 3) The number of in cases 2018 is only 21. The bacteria can get into a person's body through eating or drinking food or water with these bacteria, through a cut in the skin, or through mucous membranes (eyes, nose, mouth, or anus).

Table 3: Temporal Variation of Leptospirosis Occurrence

Year of Incidents	2014	2015	2016	2017	2018
Cases	139	82	49	46	21

5.4 Interpretation of Leptospirosis Z score value in Madurai City -2014

Low level (37.29%) affected areas are Madurai Baskaradas nagar, Vilangudi, Kochadai, Arasaradi, Othakkadai S.S.colony, TVS nagar, Thennaharam, Keeraithurai, Thallakulam, Reserve line, Azharagadi and Ponnaharam. Main reasons for Leptospirosis disease are granite quarries, water storage etc. Women and child are mostly affected. (Table 3) Moderate level (23.73%) affected areas are Anuppanadi, Pazhanganatham, Sundarrajapuram, Railway Colony, Perumal Teppakulam, and Kamarajar street. The main reason for the spreading of disease is drainage, animals and contaminated ponds. (Fig 2)

The area of major concentration (38.98%) is found in West and West Central part of the city. Highly affected areas are Ponmeni, Ellisnagar and Swami Sanathi Street. Spreading of this disease in this area is caused by animals, solid waste and drainages. This diseases mostly affected women and solid waste workers.

In the present investigation the secondary sources of information have been appropriately tapped to obtain the current trend of Leptospirosis. As per the Z score variable, it is found that the wards of Ponmeni, Ellis Nagar and Swamisannidhi record highest occurrence of Leptospirosis, i.e., 0.74-2.86%. We can observe the increasing trend of Leptospirosis in other three wards like Railway Colony, Sundarrajapuram and Kajimar Street with the positive value of 0.26-0.74%. Water is highly contaminated in these regions. So water borne diseases are also high. The mean value 2.7761 and standard deviation value 3.04270 was reported during the year 2014.

Any exposure to sewage increases the possibility of getting Leptospirosis. Highest degree of occurrence of Leptospirosis cases are found in this area, i.e z score value Ponmani 1.92, Ellisnagar 2.86, Swamy sannidhi 1.68, Veerakali ammon kovil 3.34. because of the favorable

conditions of host factors. Ponmeni has larger number of cows, pigs, and dogs and the major occupations of the people is farming. Continuous exposure to the risk factors result in high number of Leptospirosis.

Table 3: Spatial distribution of leptospirosis in Madurai city-2014

| Ward No	Ward Name	Leptospirosis in Percentage	Leptospirosis 'Z'Score Value	Ward No	Ward Name	Leptospirosis in Percentage	Leptospirosis 'Z'Score Value
8	Vilaivgudi	1.44	-0.439	47	Reserve Line	2.15	-0.203
11	Ponnaharm	1.44	-0.439	50	Swami Sannidhi	7.91	1.687
12	Chokkikulam	0.72	-0.676	57	Anuppanadi	3.59	0.269
13	Azhagaradi	1.44	-0.439	64	Keeraithurai	2.87	0.032
14	Viswasapuri	0.72	-0.676	65	Sappani Kovil	0.72	-0.676
16	Railway colony	5.04	0.742	70	Kamaraj Puram	0.72	-0.676
17	Ellisnager	11.51	2.869	76	Pazhhagaanathm	3.59	0.269
18	S.S. Colony	2.15	-0.203	77	Sundaraja Puram	5.03	0.742
19	Ponmeni	8.63	1.924	78	MaduraiBaskaradass Nagar	1.44	-0.439
20	Arasaradi Othakadai	2.15	-0.203	79	Perumal Theppakulam	3.59	0.269
21	Bethaniya Puram	0.72	-0.676	80	Krishnaraya Theppakulam	0.72	-0.676
22	Kochadai	2.87	0.032	81	Tamil Sangam	0.72	-0.676
34	Arigar Anna Nager	0.72	-0.676	86	Kaajimar Street	4.32	0.505
36	Aazhwar Puram	0.72	-0.676	88	Solai Azhagupuram	0.72	-0.676
39	Goripalayam	2.15	-0.203	90	Veerakali Amman Kovil	12.95	3.342
42	Chokki Kulam	0.72	-0.676	91	Thennaharam	1.44	-0.439
43	Thallakulam	1.44	-0.439	93	T.V.S. Nagar	1.44	-0.439
45	K.Pudur	0.72	-0.676	100	Muthramalinga Puram	0.72	-0.676

Mean Value 2.7761 Std.Deviation:3.04270
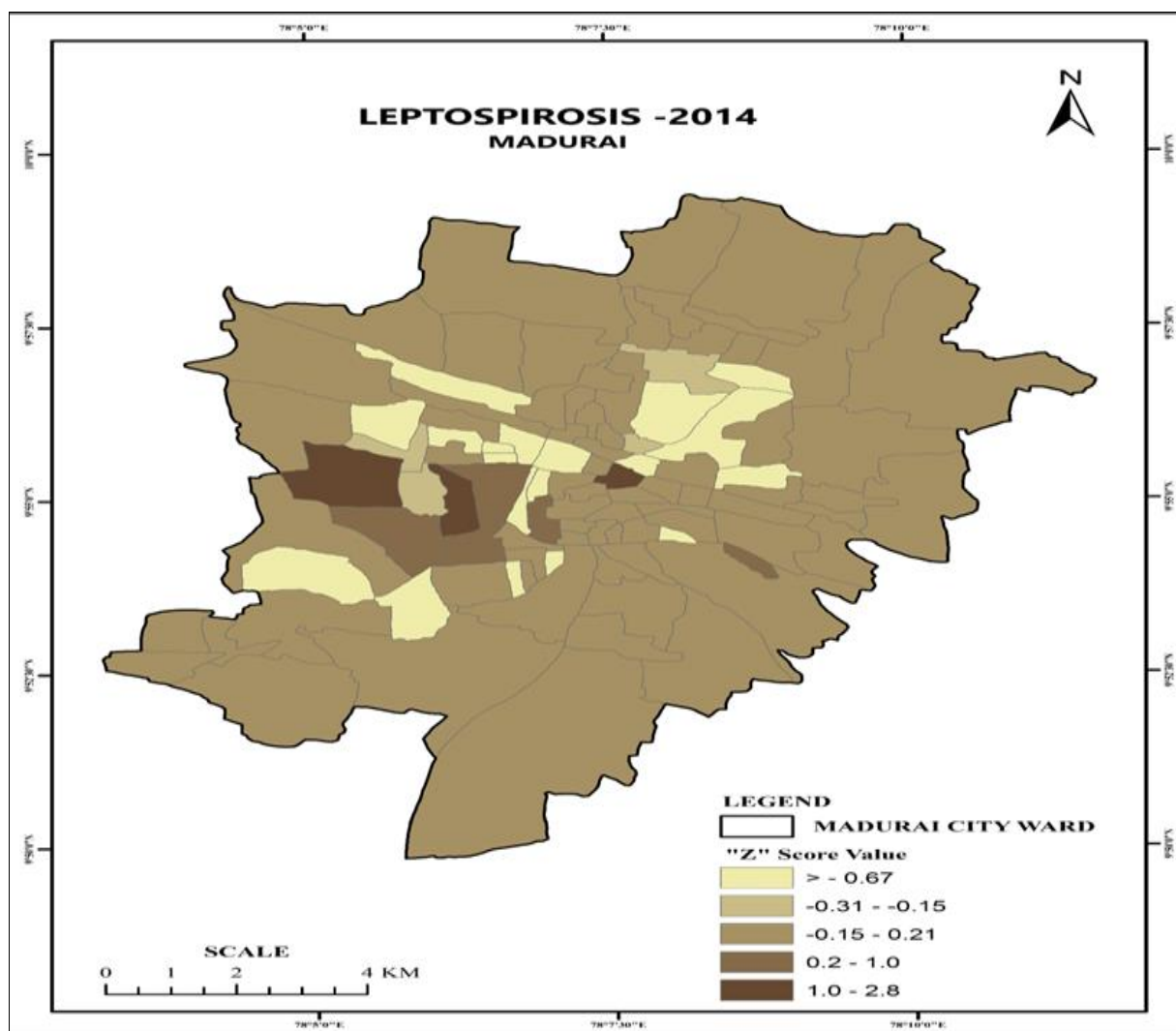
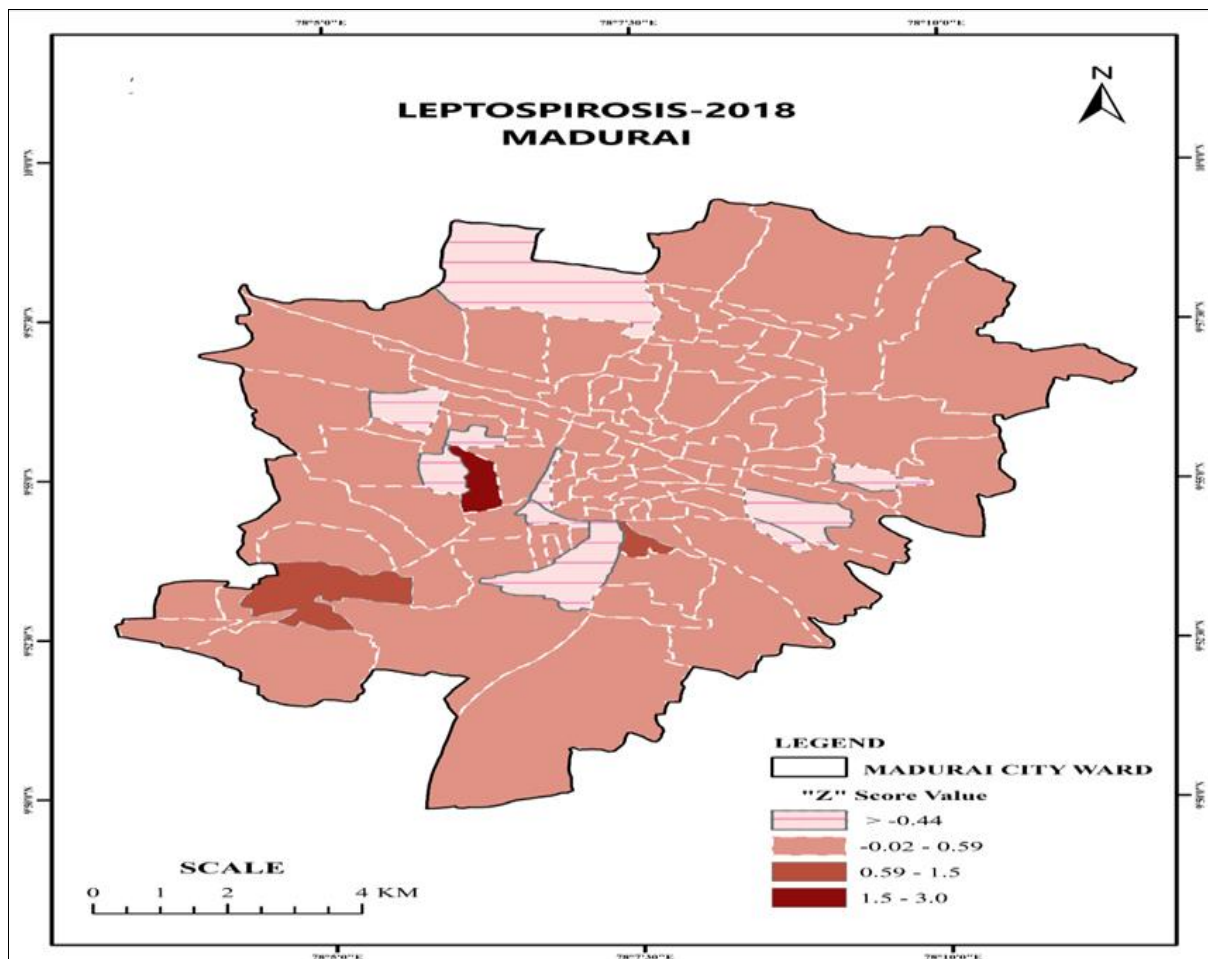**Fig 2:** Z score value of incidence of Leptospirosis case in Madurai city in 2014

Fig 3: Z score value of incidence of Leptospirosis case in Madurai city in 2018

Comparatively lowest degree of disease occurrence is found in wards like Vilangudi, Ponnaharam, Aazhwarpuram, Chokkikulam, Thallakulam, Kamarjapuram, Madurai Baskaradass Nagar, Krishnarayar Teppakulam, Tamilsangam, Solai Azakarpuram, Thenahuram, T.V.S. Nagar, and Muthuramalinga Puram. It may be due to the availability of quality health care facilities, and proper sewage management. Remaining parts of Madurai city recorded moderate occurrence of Leptospirosis.

5.5 Interpretation of Leptospirosis Z score value in Madurai City -2018: In 2018, 13 wards were affected in the city. Ellisnagar was heavily affected by leptospirosis. Other affected areas were Anaiyur, Bethaniyapuram, Viswapuri, S.Scolony, Madurai Baskaradass nagar, Subramaniapuram, Villapuram Pudhunagar, Anuppanadi, Mariamman Teppakkulam and Tahsildhar nagar.(Table 4)

In 2018 the number of occurrence of leptospirosis in Madurai city tends to decline when compared to 2014. Ellis nagar recorded highest rate of occurrence of leptospirosis. Lack of proper sewage management, highest concentration of animals like pigs, dogs, and cows creates un hygienic environment and it accelerates the waterborne disease incidences. (Fig 3)

Table 4: spatial Distribution of Leptospirosis in Madurai City-2018

Ward No	Ward Name	Leptospirosis in%	Leptospirosis 'Z'Score Value	Ward No	Ward Name	Leptospirosis in%	Leptospirosis 'Z'Score Value
3	Anaiyur	5.56	-.414	57	Anuppanadi	5.56	-.414
15	Melapponnaharm	5.56	-.414	61	Vellapurm,Pudhu Nagar	5.56	-.414
17	Eillnager	22.22	3.03	63	Villaapuram	11.11	.662
18	S.S Colony	5.56	-.4.14	78	MaduraiBaskaradass Nagar	5.56	-.414
21	Bethaniya Puram	5.56	-.4.14	87	Subramaniym Puram	5.56	-.144
31	Tahsildhar Nager	5.56	-4.14	95	T.V.S. Nagar	11.11	.662
54	Mariamman Theppakulam	5.56	-4.14	Mean Value::7.923 Std.Deviation:4.645			

At the same time the wards of Mannar College and Villapuram record moderate degree of occurrence of leptospirosis.The lowest number of occurrence of leptospirosis is found in S.S. Colony, Melaponnaharam, Bethaniyapuram, Anaiyur, Subramaniyapuram, Thepakulam, Tahsildar Nagar (0.43%-0%).The mean value

7.92 and Standard deviation value 4.64 are reported during the year 2018.

Overall incidence of leptospirosis is low compared to 2014. Improved health care, awareness about waterborne diseases, precaution against disease transmission are the causes for decrease in leptospirosis in the study area.

5.6 Significant variation of Leptospirosis in Madurai City 2014-2018

Madurai city was highly affected by leptospirosis in 2014 when compared to 2018. The major reasons are polluted water, solid waste management, and socio economic background of people.People can also get this disease through direct or indirect contact with the infected urine of people or animals. The bacteria can get into a person's body through eating or drinking food or water with these bacteria, through a cut in the skin, or through mucous membranes (eyes, nose, mouth, or anus).The most people affected in leptospirosis the government hospital. The mazimum affected areas are Anuppanadi, Ellisnagar.

6. Conclusions

Spatial distribution of this disease observed to be high in the Western part of Madurai City. The prevalence rate was very high in south western part of the city. This area has a slum, poor water supply, poor and low socio- economic status of people and personal hygienic etc,. Moderate prevalence rate is noticed in southern part. Low prevalence rate is found Leptospirosis in Northern area the city. The disease mostly affected women and children.

The present study will identify the existing morbidity condition of population and health status prevailing in Madurai City. This offers a wide scope to find out the environmental conditions to both health and disease and stress the need for better environmental planning. In addition, it helps to provide the most appropriate description for its present standard of diagnosis and remedy. The work also helps to plan for minimum essential health facilities needed for the people of Madurai city. The study has its own value if this subjective impression revealed from the maps, could be reinforced by objective. Hence the present study has made an attempt to throw light on specific environment and geographical pathology particularly with physical health with reference to selected environmental indicators of Madurai city. The study highlights that incidence rate of Leptospirosis has gradually reduced due to proper planning and management system of the study area.

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