# **Original Research Article**

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# Distribution of leptospirosis patients in Sri Lanka: a retrospective study

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#### **ABSTRACT**

**Background:** Leptospirosis [LP] is zoonotic diseases and one of the main communicable diseases in Sri Lanka [SL]. SL is a tropical country in the Indian Ocean with favorable environmental and geographical conditions for dispersion of the LP infection. The aim of the study was to determine the pattern of distribution with possible environmental conditions/factors contributing to the LP in SL.

**Methods:** The study was carried out as retrospective study from 2009-14 throughout the all 25 administrative districts in SL.

**Results:** The multiple regression was performed to investigate any associations between the prevalence of LP and independent variable parameters namely, annual rainfall, average humidity, area of paddy lands and annual flood data. The results revealed that factors affecting prevalence of the LP in Sri Lanka can't be investigated in toto. Seasonal analysis is needed in the wet and dry zones corresponding to the main Yala and Maha agricultural seasons. Annual rainfall is mainly associated with the prevalence of LP in the wet zone while agricultural environment associated with the prevalence of LP in the dry zone (p<0.05). Furthermore, geographical distribution, high annual water discharge and low precipitation of the river water provides favorable environment for dispersion of LP in the wet zone whilst large reservoirs with highly functioning cascades correlated in the dry zone in SL.

**Conclusions:** It is concluded that pattern of distribution with possible environmental conditions/factors contributing to the LP in SL is vary in the wet and dry zones.

Keywords: Leptospirosis, Sri Lanka & Geographical distribution

### INTRODUCTION

SL is an island located in the Indian Ocean to the east of the southern tip of India separated by the Palk Strait. The total area of the country is 64,740 km² of land and 870 km² of water. The Island lies between the latitudes 5055'N and 9055'N and longitudes 79042'E and 81052'E. It is 440 km long from North (Point Peduru) to South (Point Dondra) (See Figure 1) and, 225 km wide at the broadest area from Colombo to point Sangamankanda.

According to the elevation, SL is divided into three main regions namely lowlands (<100 m), uplands (100-500 m) and highlands (>500 m). Further, SL is divided into 25 districts and 9 provinces for administrative purposes (Figure 2).<sup>2</sup>

Rainfall in Sri Lanka has multiple origins: Monsoonal, Convectional and Expressional rain. South- West monsoon prevailing from April to September and the North-East monsoon from October to March which

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accounts for a major share of the annual rainfall. On the basis of distribution of rainfall, the island is conventionally divided into three distinct areas: Wet, Dry and Intermediate Zones. The wet zone has 2000 mm average annual rainfall and the dry zone has an average annual rainfall of about 1450 mm while the intermediate zone has an average 1450-2000 mm annual rainfall (Figure 3).<sup>2</sup>



Figure 1: Location of Sri Lanka in the world map.



Figure 2: Provinces and Districts of Sri Lanka.



Figure 3: Areas of wet, dry and intermediate zone.

The average annual temperature of the country varies from 28 to 30 °C (82.4 to 86.0 °F). The day and the night temperatures may vary by 4 to 7 °C (7.2 to 12.6 °F). Furthermore, January is the coolest month whereas May is the hottest month of the year. Humidity varies from 77% to 86% and is typically higher in the South West and mountainous areas. It is depended on the monsoon patterns of rainfall.  $^{1,2}$ 

From ancient time SL has an agriculture based economy. One third of the total land (5.3 million hectares) of SL has been utilized for plantations and agricultural holdings. Depending on the pattern of the rainfall, agricultural practices of the country there are two agricultural seasons, named Maha and Yala seasons. <sup>1</sup>

The country is enriched with 103 distinct river basins and most of them have their origins in the central highlands. The rivers of SL are normally steep in their upper reaches, but flatten prematurely in their middle and lower reaches, forming flood plains. Some rivers create serious problems of flooding, as can be anticipated from their relatively flat long profiles in the lowlands. In addition to the rivers, network of manmade reservoirs and channels pave 5.3 million hectares of plantations and agricultural holding.<sup>2</sup>

Leptospirosis is zoonotic diseases and one of the main communicable diseases in SL. It is caused by pathogenic spirochetes of the genus Leptospira interrogans which is excreted in mainly rat urine and enters the host through a skin abrasion or intact mucous membranes.<sup>3,4</sup> Following 10 days of incubation period, the common signs and symptoms of LP is fever, headache, malaise and myalgia. However, small proportion goes on to develop hepatic and renal failure, haemalytic anaemia and circulatory collapse.<sup>4</sup> The disease is mainly distributed among the agricultural communities and the occurrence of the disease is associated with some environmental factors. Seven to 7.6 environment P<sub>H</sub> levels and high humidity identified as favorable conditions for spreading the disease and interestingly, the disease is endemic in humid, tropical, and subtropical areas of the world where the most of the developing countries are located.<sup>5</sup> Major outbreaks of LP were reported in Nicaragua, Brazil and India in 2008.<sup>6</sup> The risk for LP was significantly positively associated with shorter average distance to rivers or canals and also positively associated with the agricultural land extend cultivated by the farmers.<sup>7</sup>

LP is spreading among specific occupational groups such as farmers, miners, abattoir, sewer workers and among persons with recreational activities [8, 9]. According to the medical statistics in SL, a dramatic increase in the number of cases hospitalized for LP has been observed in the past 10 years. Deven thousand four hundred six (7406) clinically suspected cases and 204 deaths were reported to the Epidemiology Unit in 2008 and incidence rate was 35.7 per 100,000 populations. Subsequently, 4980 cases and 145 deaths were reported in 2009 and it was 4553 cases and 121 deaths in 2010. Death in 2008, the overall case incidence of LP was 22.5 per 100,000 populations in SL, and this is the second highest reported incidence of LP worldwide, the highest being reported from Seychelles (43.2 per 100,000 populations).

Reported cases of LP fluctuated with rainfall and farming cycles. However, the association with rainfall and farming cycles, nature of paddy farming activities, water retention in paddy fields, use of conventional and

sophisticated land preparation methods and river floods needs to be investigated in our settings. Moreover, researchers revealed that the disease is more common among agricultural communities hence the broad analysis of agricultural and the lifestyle activities is imperative to prevent next endemic of LP in SL. Though, LP was common in 9 districts in SL there is a paucity of data available to describe dispersion of diagnosed LP cases and relationship of associated factors in SL.<sup>14</sup> Thus, the main aim of this study was to identify the pattern of distribution with possible environmental conditions/ factors contributing to the LP in SL.

#### **METHODS**

Information on diagnosed LP patients from 2009 to 2014 was collected using weekly epidemiological reports published by the Epidemiology Unit, Ministry of Health, SL. The data was collected weekly on basis from 25 regional director of health services [RDHS] areas (Districts) and summarized into monthly, quarterly and annually in respective Districts and Provinces.

Humidity and rainfall data were obtained from meteorological department and census and statistics department, SL in all 25 administrative Districts (RDHS areas) during the period of 2009 to 2014. Flood details were collected from Department of Disaster Management, SL. Water discharge and deposition of each river, irrigation patterns, main reservoirs (schemes) and their water discharge and the average cultivated land area for each district were collected from the Irrigation department and census and statistics department, SL during the period of 2009 to 2014 associations between rainfall, humidity and flood with the prevalence of LP were analyzed using standard statistical software (SPSS - 17<sup>th</sup> Version). <sup>15-18</sup>

#### **RESULTS**

Prevalence of the diagnosed LP cases from 2009 to 2014 is depicted in Table 1.

As shown Kalutara, Ratnapura, Kegalle, Matara and Hambantota districts showed higher case prevalence than average island LP prevalence from year 2009 to 2014. The highest LP diagnosed prevalence was notified in Matale, Matara, Kurunegala, Matara, Kilinochchi and Ratnapura; 62.5, 47.3, 90.0, 21.3, 31.5 and 30.7 cases per  $1 \times 10^5$  populations respectively from year 2009 to 2014 respectively.

Furthermore, the lowest prevalence was reported in Mannar years 2009, 2013 and 2014 showing respectively 0, 0.6 and 0.8 cases per  $1 \times 10^5$  populations. In Jaffna (0.2 cases per  $1 \times 10^5$  population) was notified in years 2010 and 2011. Batticaloa had the lowest case prevalence in 2012 showing 1.2 cases per  $1 \times 10^5$  populations.

Colombo, Kalutara and Matale districts reported the highest prevalence rate as 48.5, 42.1 and 62.5 cases per

1x10<sup>5</sup> populations in 2009. In the year 2010, Matara and Kegalle districts respectively reported the highest prevalence rate of 47.3 and 39.3 cases per 1x10<sup>5</sup> populations. Furthermore, Kurunegala, Hambantota, Mullaitivu, Matara, Moneragala, Ratnapura and Kegalle showed the highest prevalence rate respectively as 90, 81.2, 41, 47.2, 36, 38.6 and 38.4 cases per  $1 \times 10^{5}$ populations in 2011. Interestingly, the highest prevalence rate and the second highest prevalence rate ware observed in year 2011 in Kurunegala and Hambantata during 2009 - 2014. The highest prevalence in 2012 was reported from Matara district as 21.3 cases per 1x10<sup>5</sup> populations. Polonnaruwa and Kegalle districts reported the highest prevalence rate of 39.1 and 33.6 cases per 1x10<sup>5</sup> populations respectively in 2013. Finally, Ratnapura, Kegalle and Kalutara districts were reported highest prevalence as 30.7, 30.2 and 28.7 cases per  $1 \times 10^5$ populations respectively in 2014.

Rainfalls data were recorded only in 18 districts out of the 25 districts in Sri Lanka during 2009 – 2013 period as shown in Table 2. According to the available rainfall data, second highest case prevalence and second highest rainfall (2134 mm) was reported in Colombo district in 2009. The highest rainfall in 2010 was reported in Ratnapura district and LP prevalence rate was 23.7 cases per 1x10<sup>5</sup> populations which was the 5<sup>th</sup> highest prevalence of the year. Kurunegala district showed highest cases prevalence of the year 2011 while reporting only 1958 mm rainfall throughout the year but had 634 mm rainfall in the month of March. Ratnapura district reported the highest rainfall (3430mm & 3380mm) in the years of 2012 and 2013 but the LP prevalence was 12.9 and 24.9 cases per 1x10<sup>5</sup> populations. However, in 2014 Ratnapura district reported the highest LP case prevalence while reporting the highest rainfall (3575 mm) in the year 2013.

# Matrix Scatterpolt of Explanatory Variables

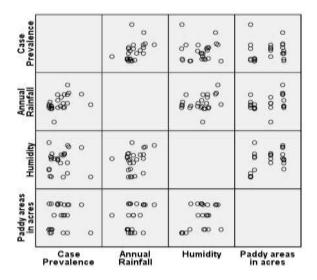


Figure 4: Matrix scatter plot of explanatory variables in wet zone.

Table 1: Prevalence of leptospirosis per 100000 populations from 2009 to 2014 in all districts of Sri Lanka.

Name of the Districts	Case Prevalence 2009	Case Prevalence 2010	Case Prevalence 2011	Case Prevalence 2012	Case Prevalence 2013	Case Prevalence 2014	District Average (2009- 2014)
Colombo	48.5	23.4	18.9	4.7	6.1	7.5	18.1
Gampaha	17.5	21.3	19.3	7.6	16.2	14.7	16.1
Kalutara	42.1	28.5	27.8	14.1	28.6	28.7	28.3
Kandy	16.0	13.1	13.1	3.8	6.0	6.0	9.7
Matale	62.5	26.0	31.6	6.3	11.9	8.6	24.5
Nuwara Eliya	6.5	5.4	6.8	3.6	3.6	3.6	4.9
Galle	23.4	16.8	18.8	9.1	20.3	16.5	17.5
Matara	29.0	47.3	47.2	21.3	22.1	17.1	30.7
Hambantota	18.6	14.6	81.2	10.4	26.8	15.4	27.8
Jaffna	0.6	0.2	0.2	2.8	1.8	2.8	1.4
Mannar	0.0	2	0.6	2	0.6	0.8	1.0
Vavuniya	0.0	5.3	8.6	12.5	7.3	3.3	6.2
Mullaitivu	9.0	2.5	41.0	16.3	28.6	3.2	16.8
Kilinochchi	6.3	6.3	4.0	3.1	31.5	12.6	10.6
Batticaloa	1.4	2.8	4.2	1.2	6.2	3.2	3.2
Ampara	2.5	2.6	5.2	2.4	4.5	2.5	3.3
Trincomalee	2.9	9.9	27.5	7.6	12.9	4.1	10.8
Kurunegala	10.5	22.8	90.0	6.9	21.4	9.1	26.8
Puttalam	11.9	10.0	11.9	3.8	6.0	8.3	8.6
Anuradhapur a	8.0	12.4	26.8	7.2	28.6	17.1	16.7
Polonnaruwa	15.0	23.0	20.5	13.0	39.1	9.7	20.0
Badulla	9.3	8.3	8.2	1.8	6.1	6.0	6.6
Moneragala	6.7	16.4	36.0	9.0	36.7	24.0	21.5
Ratnapura	20.1	23.7	38.6	12.9	24.9	30.7	25.1
Kegalle	28.7	39.3	38.4	14.1	33.6	30.2	30.7
Average Island Prevalence	15.88	15.56	25.04	7.88	17.24	11.48	

In an attempt to investigate any associations between the incidence of LP and independent variable parameters namely, annual rainfall, average humidity, area of paddy lands and annual flood data, linear regressions were performed. The results revealed no significant linear association (p>0.05). Accordingly, multiple regression was performed, but there wasn't significant association (p>0.05) were evident. Hence, multiple regressions were performed according to the geographical distribution, namely wet and dry zones. The results of the wet zone showed significant (p<0.05) positive association between incident of LP and annual rainfall whilst dry zone showed the positive association between incident of LP and area of paddy land which is related to agricultural environment in the dry zone as shown in Figures 4 and 5.

In the wet zone, reported cases of LP were significantly increased from September to December and from January to March in each year which is corresponds to the land preparation and harvesting periods of "Maha" agricultural season. Similar pattern was observed in Gampaha,

Kalutara, Matara, Kegalle and Ratnapura districts which also belong to the wet zone (Figure 6).

## Matrix Scatter plot of Explanatory Variables

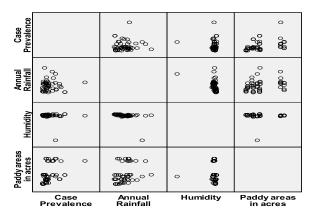


Figure 5: Matrix scatter plot of explanatory variables in dry zone.

Table 2: Annual rainfalls data from 2009 to 2014 in Sri Lanka.

Districts Name	2009 Rain Falls (mm)	2010 Rain Falls (mm)	2011 Rain Falls(mm)	2012 Rain Falls(mm)	2013 Rain Falls(mm)	Average (mm)
Colombo	2134	3370	1775	2464	1990	2346
Gamphaha	1691	2585	1446	1948	2057	1945
Kandy	1944	2665	1776	1990	1925	2060
Nuwara Elliya	1639	1639	1699	1771	2157	1781
Galle	2303	3049	2308	N/A	1799	2365
Hambantota	880	874	1015	1294	966	1005
Jaffna	869	1496	1470	943	1033	1162
Mannar	964	1074	1203	923	918	1016
Vavuniya	1369	1459	1869	1559	1304	1512
Batticaloa	2056	1760	3581	1786	1973	2231
Trincomali	1888	1419	2906	1810	1492	1903
Kurunegala	2050	2434	1958	N/A	1805	2061
Puttalam	957	1334	826	N/A	905	1005
Anuradhapura	1075	1664	1915	1878	1194	1545
Polonnaruwa	N/A	N/A	3159	1895	1414	2156
Badulla	1582	2176	2525	N/A	1865	2037
Monaragala	N/A	N/A	1797	1394	1559	1583
Ratnapura	3394	4561	3430	3380	3575	3668

N/A – No data available.

Table 3: Wet zone local flood details and diagnosed leptospirosis cases of Sri Lanka.

District	Division/Area	Time Duration	Leptospirosis Cases Reported (Approximately)
Colombo	Colombo, Kolonna and Maratuwa	September–November 2010	500
Gampaha	Wattala Biyagama and Wattala.	November 2009 March 2012	100 120
Kalutara	Panadura & Palindanuwara	September –November 2009	350
Ratnapura	Kuruwita, Kalawana & Ayagama Kuruwita, Eheliyagoda, Kalawana &	April 2009	65
•	Ayagama	November 2014	60
Kegalle	Ruwanwella, Dehiowita, Bulathkohupitiya & Warakapola	March 2011	50
	Ruwanwella & Rabbukkana	November 2014	65

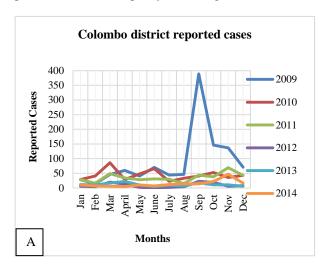
Table 4: Wet zone local flood details and diagnosed leptospirosis cases of Sri Lanka.

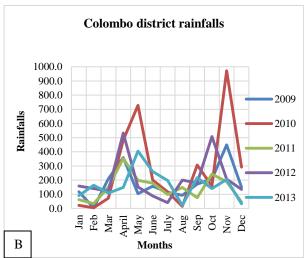
District	Division/Area	Time Duration	Leptospirosis Cases Reported (Approximately)
Anuradhapura	Horopothana, Palagala & Kalatagasdigiliya Nachchaduwa, Nochchiyagama, Kekirawa,	March 2011	80
	Horopothana Kalatagasdigiliya & Medawachchiya	November 2014	65
Hambantota	Ambantota & Hambantota	March 2011	120
Monaragala	Buttala & Monaragala Malimbada, Badalkubura & Bibile Kataragama, Buttala & Siyabalanduwa	April 2009 April 2011 December 2014	60 45 40

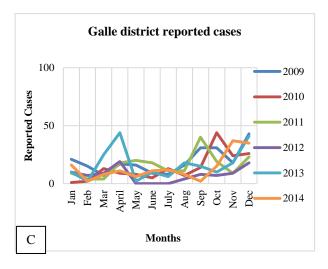
However, the distribution pattern of LP prevalence was different to Colombo and Galle districts, in the up country areas which also belong to wet zone and having comparatively high rainfalls throughout the year as shown in Figure 7. However, Matale district showed

comparatively higher prevalence rate of 62.5, 26 and 31.6 cases per  $1 \times 10^5$  populations in 2009, 2010 and 2011 respectively due to presence of many flatlands, which can hold stagnant water.

Furthermore, number of cases of LP reported in the dry zone during the same period was significantly lower than in the wet zone. Northern North – Central and North – East provinces are mainly belongs to dry zone. However, the distribution pattern in Kurunegala and Anuradhapura districts was basically similar to the wet zone due to the presence of extended paddy lands (Figure 8).







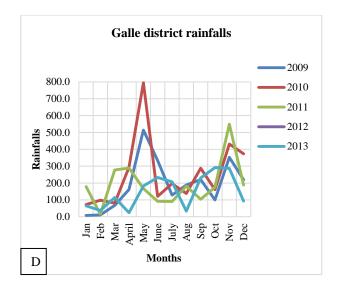
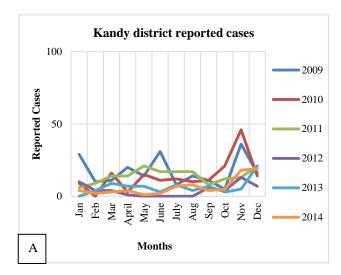


Figure 6 (A-D): Leptospirosis case prevalence and rainfalls of Colombo district & Galle district.



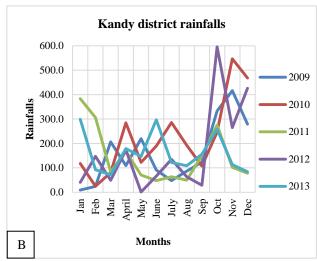
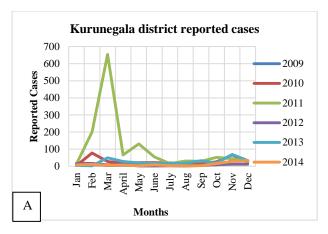
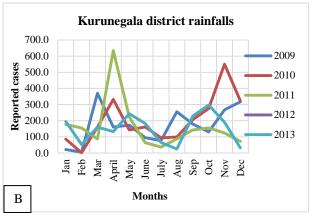
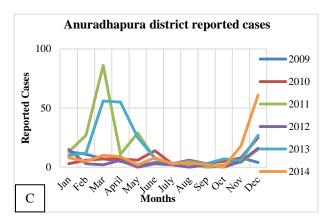


Figure 7(A,B): Leptospirosis case prevalence and rainfalls of Kandy District







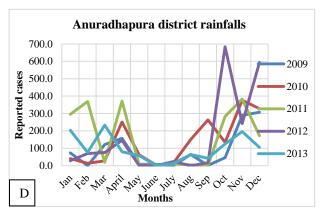


Figure 8(A-D): Leptospirosis case prevalence and rainfalls of Kurunegala district & Anradhapura district.

#### **DISCUSSION**

This retrospective study examined the prevalence of LP in SL from 2009-14 and investigated the correlations between prevalence of LP with annual rainfall, extend of paddy land, humidity and local flood. Recent studies have shown that the distribution of LP patients is mainly with rainy seasons and agricultural associated environment in a particular area.<sup>19</sup> However, as whole, in the current study, similar observations were not evident in SL. For example; annually Ratnapura district showed the highest rainfall during 2009-2014, although the highest LP prevalence was evident only in 2014. Batticaloa showed the lowest case prevalence in 2012 showing 1.2 cases per  $1 \times 10^5$  populations in spite of having considerably high rainfall (1796 mm) in the same year. Similarly, area wise, Anuradhapura, Kurunegala and Polonnaruwa districts have the highest agricultural lands (169173, 154810 and 153538 hectares respectively), but highest LP prevalence wasn't evident during 2009-14.15 This indicated that in SL, the prevalence of LP wasn't only depended on rainfall or agricultural environment. Therefore, seasonal analysis (Yala & Maha) was undertaken and regression analysis of the present study indicated that rainfall, agricultural pattern, operational cascades of rivers and reservoirs and incidence of local flooding in both wet and dry zones provided favorable conditions for spreading of LP. In this regard, it is interest to note that most LP incidence was found in the wet zone around stagnant waters such as ponds in Republic of Serbia.20

In SL, rainfall parallels the two monsoons, the South-West monsoon prevailing from April to September and the North-East monsoon from October to March. On the basis of distribution of rainfall, the island has been conventionally divided into two distinct zones as the Wet and the dry zones. Wet zone comprises of Western, Sabaragamuwa, central and part of the Southern provinces while dry zone comprises of Northern, Eastern, North – Central and North – Western provinces.

In the wet zone two peaks of prevalence of LP is clearly which correspondent to the ending and commencement of Yala and Maha seasons. Further, the wet zone has higher rainfall than the dry zone. Because of the considerable rainfall throughout the year, in the wet zone, cultivation takes place throughout the year and the prevalence of LP paralleled. In contrast, the dry zone has no significant peaks of the prevalence of LP as in the wet zone: total diagnosed LP cases per year were less than 100. Further, in agricultural districts of the dry zone such as Anuradhapura, Monaragala, Kurunegala and Puttalum have showed only one peak of LP cases, during March -April which is the harvesting period of "Maha" season. an example, Kurunegala district reported approximately 900 LP cases in March 2011 while having 653 mm rainfall, and no local floods. Interestingly, in Northern Thailand, high prevalence of LP has been seen during the months of high precipitation, from June to

December.<sup>21</sup> However, in Germany, majority of the diagnosed LP patients were reported during August – November in each year despite of rainy season.<sup>22</sup>

The major irrigation schemes in SL are located in the dry zone of the country due to low rainfall throughout the Anuradhapura, Ampara, Polonnaruwa and Trincomalee districts have 11, 08, 05 and 07 major irrigation systems respectively and one irrigation scheme usually supplies over 1000 hectares of paddies in the respective districts.<sup>23</sup> Further, in Sri Lankan majority of the rivers and its basins (total of 103 in Sri Lanka) such as Mahaweli, Malwatu, Kala oya, Deduru oya and Yan oya etc, and major water reservoirs are located in the dry zone.<sup>2</sup> However, annual discharge, as a percentage of precipitation of the river water, is considerably high in the wet zone compared to dry zone. For example, major rivers such as Kelani, Kalu, Gin, Nilwala, Bentara, Madu which are located in the wet zone and their discharge, as a percentage of precipitation, is 64%, 72%, 70%, 48%, 57% and 58% respectively while Mahaweli (30%), Maduru (27%), Yan oya (19%), Malwatu oya (12%) and Kala oya (21%) which are located in the dry zone have considerably low percentage of precipitation [2]. Consequently, stagnant water accumulates in small tanks that are located in the dry zone and a recent study conducted by us has shown that LP patients were mainly scattered around large scale reservoirs in the dry zone with highly operating cascades.<sup>24</sup> Thus, this study indicates that high flow rate of water may favorably contribute to the spreading of LP rather than small cascades with low flow rate of water. Similarly, the wet zone has highly operating water cascades and major river basins than in the dry zone which may account for high prevalence of LP in the wet zone. Furthermore, the study of Robertson, Nelson and Stephen revealed that high risk of LP was positively and significantly associated with shorter average distance to rivers or canals in 2011.<sup>7</sup>

Further, according to the geographical distribution wet zone of SL is classified as low lands, up lands and high lands obviously. The water drainage from high lands to low lands is grater due to the gravity. However, in the dry zone, majority of the lands belongs to low lands and water usually stagnant in the reservoirs. Ratnapura district is located in high and up lands and the highest rainfall has been observed during 2009-2014. However, LP prevalence in Ratnapura district wasn't compatible with the rainfall although the district has highly operating cascades which facilitates the dispersion of LP to the up and low lands such as Kalutara, Galle and Matara districts.

Additionally, there was peak LP cases, presented in both dry and wet zones in particular years, which are positively associated with the localized flood. In the wet zone, Gampaha, Kalutara and Ratnapura districts have reported local floods in year 2009 and approximately 100, 350 and 65 diagnosed LP cases were reported respectively. Colombo district has reported heavy local

flood in year 2010 and approximately 500 diagnosed LP cases were notified. Nearly 50 cases and 65 cases respectively were diagnosed in Kegalle district in year 2011 and 2014 and approximately 120 LP patients were reported in Gampaha district in 2012 due to local floods.

Similarly, in the year 2011, heavy floods in many areas of the dry zone mainly, in Anuradhapura, Hambantota and Monaragala districts were evident. Approximately 80, 100 and 45 diagnosed cases were reported in respective districts in the year 2011. Furthermore, Anuradhapura and Monaragala districts had another local flood in year 2014, notifying 65 and 40 LP cases. Additionally, approximately 60 cases were reported in Monaragala in year 2009 due to local flood. However, frequency of local floods was higher in wet zone due to highly operational water cascades of rivers.

Based on the results of this retrospective study, it is concluded that factors affecting prevalence of the LP in SL can't be investigated in toto. Seasonal analysis is needed in the wet and dry zones corresponding to the main Yala and Maha agricultural seasons. Annual rainfall is mainly associated with the prevalence of LP in the wet zone while agricultural environment associated with the prevalence of LP in the dry zone. Furthermore, geographical distribution, high annual water discharge and low precipitation of the river water provides favorable environment for dispersion of LP in the wet zone whilst large reservoirs with highly functioning cascades correlated in the dry zone in SL. However, irrespective of the zones locals flood increased the LP incidences. These are novel findings for SL which also has global relevance.

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