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Temporal analysis of leptospirosis incidence according to rainfall levels

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ABSTRACT

The aim of this study was to analyze the temporal trend of leptospirosis incidence according to rainfall levels in Santa Catarina State between 2005 and 2015. This is an ecological time-series study involving data on leptospirosis incidence and rainfall indexes in Santa Catarina State Health Regions. The distribution of leptospirosis, rainfall indexes, and cases/rainfall ratios, according to seasonality and stratified by Health Regions, were evaluated. There were 5,274 cases, with an average rate of 7.03 cases/100,000 inhabitants per year, varying from 24 to 1,458 cases (Serra Catarinense and Northeast regions, respectively) in Santa Catarina, revealing an increase in the rates of 0.70 cases/100,000 inhabitants in Serra Catarinense and 13.99 cases/100,000 inhabitants in the Northeast. Four regions (Foz do Rio Itajaí, Médio Vale do Itajaí, Grande Florianópolis and Northeast) were responsible for 71.8% of the cases, particularly in the Northeast region (38.5%). The five regions with the highest rates presented greater risk of leptospirosis (RR > 1), ranging from 10.9 to 19.9 more new cases of the disease. The average rainfall volume for Santa Catarina State was 158.69

mm, ranging from 136.44 mm in Laguna to 186.81 mm in the Northeast. The five regions contributed with 32.8% of the rainfall index accumulated in the period. In conclusion, leptospirosis occurred all around Santa Catarina State, differing its temporal trend according to the Health Regions.

Keywords: leptospirosis; zoonoses; incidence.

INTRODUCTION

Leptospirosis is a widespread and prevalent seasonal zoonotic disease caused by pathogenic spirochetes of the genus *Leptospira*. The incidence of the disease, according to the World Health Organization, is higher in countries with tropical climate[1]. It is among the most common diseases transmitted to humans by animals[2,3], especially by rodents, but also by cattle, swine, dogs, horses, sheep, and goats, being ubiquitous and poorly diagnosed. Once infected, the animals may release the organisms in their urine, contaminating the environment, in particular water. Human spread occurs due to exposure to contaminated animal urine, contaminated water or soil, or infected animal tissue through cuts or abraded skin, mucous membranes, or conjunctiva. It is recognized as an occupational illness (rice farmers, abattoir and sewer workers, pet traders, veterinarians, laboratory and military personnel) both in developed and developing countries, common in urban areas, and is often associated with a lack of local basic sanitary conditions[4-6].

In Brazil, leptospirosis is an endemic disease, becoming epidemic in rainy periods or major climatic events (flooding), affecting particularly low-income populations living in rodent-infested, flood-prone slums, which occur mainly in capital cities and metropolitan areas. The magnitude of the risk depends on the local prevalence of leptospirosis and the degree and frequency of exposure[4-8].

The leptospirosis incidence is seasonal, usually with a peak in the summer and fall in temperate climate countries, and during the rainy seasons in tropical areas[9]. It is considered an emerging infectious disease, since its burden is expected to worsen, in both developed and developing countries, as global climate changes cause more extreme weather events, such as floods, promoting leptospirosis outbreaks[9,10].

Leptospirosis can be related to the process of disordered occupation, with construction of houses in floodplain areas and lack of basic infrastructure. The transformation of the environment, with the clear degradation of space, may take the place to an unhealthy scenario, risk area for various ailments, including leptospirosis[4,7,11].

There were 20,810 confirmed cases in Brazil from 2010 to 2014, representing an annual average of 4,160 cases. The largest number of cases was observed in the Southeast (7,457) and South (6,030) Brazilian regions, and the states with the highest percentage of confirmed cases were São Paulo (20.9%), Santa Catarina (10.7%), Rio Grande do Sul (10.6%), and Acre (10.5%). In the same period, the country recorded an average incidence of 2.1/100,000 inhabitants of cases of leptospirosis[4,5].

Therefore, conducting studies of temporal trend is appropriate in order to analyze the association of leptospirosis with the rainfall indexes in Santa Catarina State and its Health Regions, considering that there are few studies about leptospirosis and its relationship with the rainfall levels, and the potential contribution of epidemiological surveillance to risk assessment and management. Such studies increase the ability to respond to natural disasters in Santa Catarina and contribute to measures for the prevention and control of leptospirosis to be more effective.

The aim of this study was to analyze the leptospirosis occurrence in accordance with the rainfall and the disease temporal evolution in Santa Catarina State and in the State's Health Regions, according to seasonality, in the period from 2005 to 2015.

METHODS

An ecological study of time-series analysis was carried out, based on data from health authorities' notifications of patients with leptospirosis in Santa Catarina, in the period from 2005 to 2015.

Santa Catarina's territory is characterized by a humid subtropical climate with either hot or mild summers. Hot summers occur on the coastal lowlands and in parts of the lower altitude plateau, in the far west and in the Uruguay river valley. In these areas, the average temperature is 20ºC, with rainfall reaching 1,500 mm along the year. Mild summers occur in the rest of the plateau, with an average annual temperature of around 15ºC, quite pronounced differences between winter and summer temperatures, and rains that resemble those in the regions initially mentioned, parts of which in the form of frosts and snow[12-14]. Thus, there is a variation in the monthly rainfall in Santa Catarina, the highest values occurring in the north coastal region, between the months of October and March. The lowest rain precipitation is seen on the south coast.

The new managerial and administrative organization of the Health Policy of Santa Catarina was structured in 16 Health Regions, according to Resolution No. 348 of August 30th, 2012, as depicted on a representative map (Figure 1), with the following composition[14]:

1. Far West;
2. West;
3. Xanxerê;
4. Alto Vale do Itajaí;
5. Foz do Rio Itajaí;
6. Médio Vale do Itajaí;
7. Grande Florianópolis;
8. Midwest;
9. Alto Vale do Rio do Peixe;
10. Alto Uruguai Catarinense;
11. Northeast;
12. Planalto Norte;
13. Serra Catarinense;
14. Santa Catarina Far South;
15. Carbonífera;
16. Laguna.

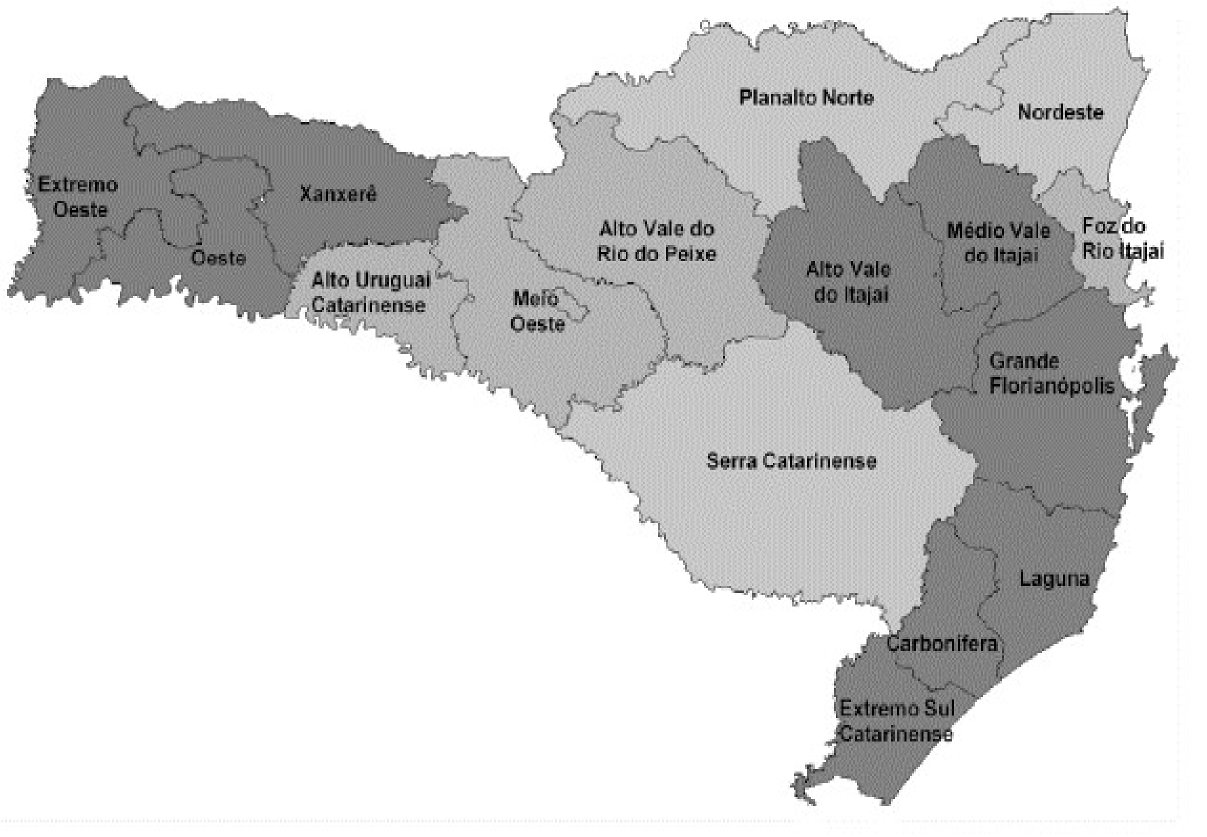

Figure 1. Representative map of the 16 Health Regions of Santa Catarina.
Source: Pandolfo et al.[14].

The information collected consists of data on leptospirosis and rainfall rates for Santa Catarina State, from 2005 to 2015. The sample, based on a series of 11 years, ensures data representativeness. The information survey on confirmed cases of leptospirosis was acquired from the restricted access database of the Board of Epidemiological Surveillance (Diretoria de Vigilância Epidemiológica — DIVE) of Santa Catarina. The rainfall data, or the precipitation in millimeters, of each of the municipalities that comprise each of the Health Regions of Santa Catarina were obtained from the National Water Agency (Agência Nacional de Águas — ANA) and the Company of Agricultural Research and Rural Extension of Santa Catarina (Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina/Centro de Informações de Recursos Ambientais e de Hidrometereologia de Santa Catarina — EPAGRI/CIRAM). Recorded daily precipitation data were obtained from 155 rainfall stations, distributed throughout Santa Catarina, from 2005 to 2015. From these data, the average monthly precipitation by municipality, by Health Regions, and for Santa Catarina were calculated. Data regarding the current population of Santa Catarina and the respective Health Regions were obtained from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística — IBGE) website.

The outcome variable is represented by the number of monthly cases of leptospirosis. The monthly rates of incidence as a whole were calculated in the period for each group of months. Adjustment for potential variations in the age structure and gender, upon comparing different periods, used the method of direct rates standardization, taking the population of Santa Catarina in 2010 as a reference. The number of cases of leptospirosis, its monthly average and the rate of the disease in the period studied are displayed. It was chosen to present the non-standardized rates, whenever a significant correlation ($r > 0.90$) was found when comparing the raw and standardized rates, thus retaining the original value of the rates, understood as more representative and interpretable.

The distribution of cases of leptospirosis and the rainfall indexes were first obtained in accordance with each one of the Health Regions. For each of the 16 regions, the following data are presented: the number of leptospirosis cases, the average rates of the disease and their rainfall indexes, the proportional contribution of cases and their rainfall indexes, and the ratios of cases per unit of rainfall. In order to estimate the relative excess in the incidence of diagnosis, upon comparing the 16 regions, ratios of monthly leptospirosis rates were calculated, taking as a reference the month with the lowest rate in the period (Serrana). The probability of leptospirosis occurrence when comparing each of the regions with that of reference is represented by the relative risk (RR).

Exploratory analysis of monthly trends over the period detected the existence of a pattern with two distinct seasonal periods, the first (from April to September) with low rainfall levels and the second (from October to March) with higher rainfall levels. Thus, the investigation of temporal associations between exposure (rain) and outcome (leptospirosis) in the present analysis, in addition to the monthly evolution in the period as a whole, focused on the existence of two distinct seasonal periods.

Linear regression analysis of the association between leptospirosis cases and variations in rainfall levels was carried out for the period and the population as a whole, according to the Health Region. In the investigation of the temporal evolution in the monthly occurrence of leptospirosis, the monthly incidence rates of the disease represent the dependent variable, i.e., the outcome (y); and, the months in the studied period, the independent variable (x). Thus, in the proposed model, monthly variations in leptospirosis cases are supplied by the angular coefficient (beta), from the adjustment of linear regression, having the months in the calendar year as dependent variable. The trend analysis applied the method of Prais-Winsten generalized linear regression, according to Gaynor and Kirkpatrick[15], in which the regression parameters are corrected for first-order autocorrelation.

For each Region, in addition to leptospirosis rates, the magnitude of the associations among months of occurrence and leptospirosis rate are presented, represented by the coefficient of correlation (r) and the proportion of variation in disease occurrence, which can be explained by the independent variable (R^2). In interpreting trends, in addition to calculating the beta coefficient (b), it was also chosen to estimate the Monthly Percentage Variation (MPV), which adjusts the points of temporal series through the logarithmic transformation of the values of Y, with additional benefits by reducing the heterogeneity of variance of residues from regression, obtained by the formula: MPV = $[-1+10^{b1}]*100\%$. The trends of increase, decrease or stability, and their p-value are presented.

Finally, associations were graphically explored among the variations in the rates of leptospirosis according to the seasonal period, stratifying according to the eight regions that showed the highest and lowest rates of leptospirosis and the lowest and highest ratios of cases by rainfall, in search for a potential cumulative influence of rain on the incidence of the disease.

This study was based on the ethical principles of Resolution 466/12 of the National Health Council, having been approved by the Research Ethics Committee under CAAE No. 60174117.0.0000.5369.

RESULTS

In the period from 2005 to 2015, there were 5,274 cases of leptospirosis in Santa Catarina, with an annual average of 479 cases, ranging from 341 cases in 2013 to 982 cases in 2008.

The average monthly variation of cases stratified according to seasonal periods can be identified in Figure 2. An average increase was detected in leptospirosis cases from October to March, followed by a decline, from April on, initiating a period of decline until the beginning of August.

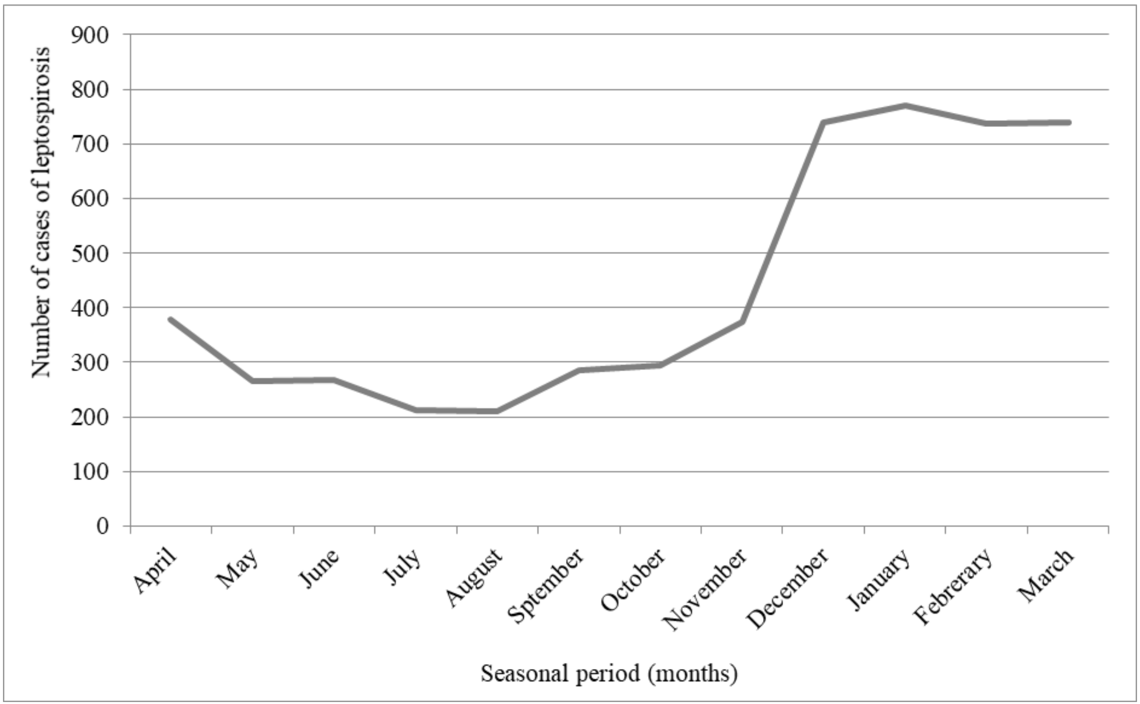

Figure 2. Average monthly variation of leptospirosis according to the seasonal period. Santa Catarina, Brazil, 2005–2015.

Table 1 shows the seasonal variation of cases and rainfall indexes in Santa Catarina (2005–2015), according to the 16 Health Regions. An average number of 329 cases of leptospirosis by Health Region in the period showed minimal variability of 24 cases (Serra Catarinense) and a maximum of 1,458 cases (Northeast). Four regions (Foz do Rio Itajaí, Médio Vale do Itajaí, Grande Florianópolis, and Northeast) were responsible for 3,789 (71.8%) cases of leptospirosis; 1,458 (38.5%) occurred in the Northeast region. When considering the size of the population in each of the regions, the variation in rates was 0.70 cases/100,000 inhabitants in Serra Catarinense, 13.99 cases per 100,000 inhabitants in the Northeast. However, the Far West, with the second highest rate (11.18 cases of leptospirosis/100,000 inhabitants), together with the four regions previously mentioned (Foz do Rio Itajaí, Médio Vale do Itajaí, Grande Florianópolis, and the Northeast region), are responsible for the higher incidence of leptospirosis. These five regions, with the highest rates, presented a risk of higher incidence of leptospirosis (RR > 1), ranging from approximately 11 to 20 times more new cases of leptospirosis (RR = 10.9–19.9), when compared to the region with the lowest rate in the period (Serra Catarinense). The average rainfall rate for Santa Catarina was 158.69 mm, with extremes of 136.44 mm in the region of Laguna to 186.81 mm in the Northeast region. The five regions, described above, with the highest rates of leptospirosis, contributed with 32.8% of the rainfall accumulated in the period, two of which, Far West and Northeast, presented both the highest leptospirosis and average rainfall rates.

Table 1. Seasonal distribution of leptospirosis and rainfall indexes according to Health Regions. Santa Catarina, Brazil, 2005–2015.

Health Regions	Cases of leptospirosis			Rainfall indexes		
	n (%)	Mean rate	RR	Mean (mm)	%	C/PI
(1) Far West	300 (5.7)	11.18	15.97	179.55	7.07	1.67
(2) West	200 (3.8)	5.15	7.36	165.71	6.53	1.21
(3) Xanxerê	28 (0.5)	1.23	1.76	166.32	6.55	0.17
(4) Alto Vale do Itajaí	156 (3.0)	4.83	6.90	142.16	5.60	1.10
(5) Foz do Rio Itajaí	510 (9.7)	7.65	10.93	160.75	6.33	3.17
(6) Médio Vale do Itajaí	819 (15.5)	10.23	14.61	150.45	5.93	5.44
(7) Grande Florianópoli	1,001 (19.0)	8.24	11.77	154.84	6.10	6.46
(8) Midwest	5 (0.9)	2.32	3.31	171.00	6.73	0.29
(9) Alto Vale	42 (0.8)	1.28	1.83	149.67	5.87	0.28
(10) Alto Uruguai	123 (2.3)	7.43	10.61	176.64	6.99	0.70
(11) Northeast	1,458 (27.6)	13.99	19.99	186.81	7.36	7.80
(12) Planalto Norte	77 (1.5)	1.81	2.86	141.16	5.56	0.55
(13) Serra Catarinense	24 (0.5)	0.70	1.00	150.81	5.94	0.16
(14) Extremo Sul	44 (0.8)	2.03	2.90	151.64	5.97	0.29
(15) Carbonífera	141 (2.7)	3.01	4.30	155.09	6.11	0.91
(16) Laguna	301 (5.7)	7.48	10.69	136.44	5.37	2.21
State of Santa Catarina	5,274 (100.00)	5.54	7.91	158.69	100	2.02

Mean rate: number of cases of leptospirosis/100,000 inhabitants (population in 2010); RR: relative risk; C/PI: cases of leptospirosis/pluviometric index.

The average number of cases of leptospirosis by rainfall rate for Santa Catarina was 2.02 cases per mm of rain. This number varied from 0.16 cases/PI in Serra Catarinense to 7.8 cases/PI in the Northeast region. Of the five regions previously described as possessing the highest rates of leptospirosis, four of them (Foz do Rio Itajaí, Médio Vale do Itajaí, Grande Florianópolis, and the Northeast region) presented the highest numbers of cases generated per unit of PI, representing 71.8% of the total cases of leptospirosis generated throughout Santa Catarina, in the period of study.

Figure 3 presents differences when comparing the four Health Regions with the highest and the lowest rainfall levels.

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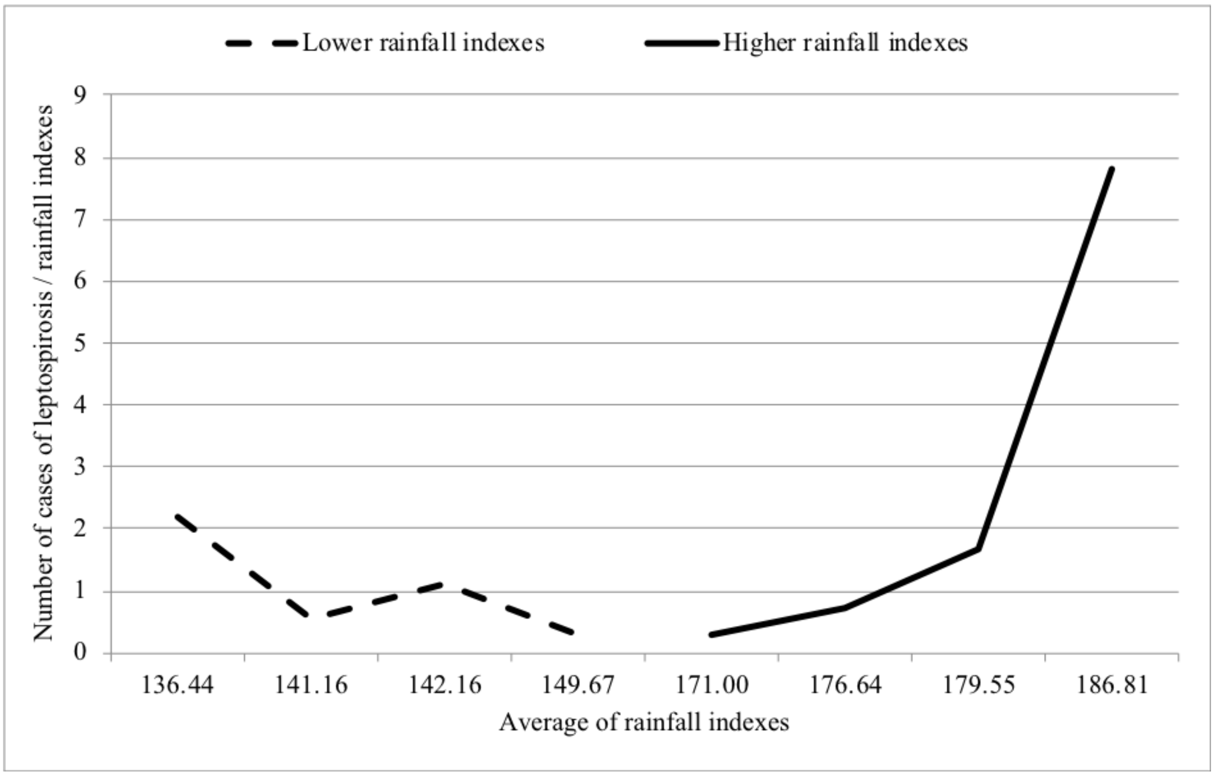

Figure 3. Cases of leptospirosis according to the rainfall indexes (lower and higher) in the Health Regions. Santa Catarina, Brazil, 2005–2015.

The results of the linear regression for Santa Catarina, stratified by Health Regions and seasons, are presented in Table 2. At this stage of the analysis, an investigation on the temporal trend in the incidence of leptospirosis was conducted, based on the months for two seasons, October to March (higher rainfall levels) and April to September (lower rainfall levels). Upon observing the results for Santa Catarina, the average rates of leptospirosis approach those of the regions with greater occurrence of the disease in the period, as well as to seasonal periods observed individually, both those with higher and lower rainfall rates. Still, based on the MPV, Santa Catarina presented temporal trend of monthly increase in the rates of leptospirosis, in the period of higher rainfall rates; and a decrease in the period with lower ones.

Table 2. Linear regression for temporal trend of leptospirosis according to seasonal periods and Health Regions of Santa Catarina (2005–2015).

Health Region	Seasonal periods													
	October – March						April – September						Total	
	Index	R	R^2	MPV	Trend	p-value	Index	r	R^2	MPV	Trend	p-value	Index	p-value
Northeast	19.82	0.87	0.75	33.6	Increasing	0.024	8.16	-0.79	0.63	-14.0	Stability	0.060	13.99	0.007
Médio Vale do Itajaí	15.87	0.29	0.09	50.3	Stability	0.574	4.60	0.16	0.03	18.8	Stability	0.764	10.23	0.002
Far West	14.46	0.88	0.77	37.7	Increasing	0.022	7.91	-0.78	0.61	3.4	Stability	0.068	11.18	0.042
Foz do Rio Itajaí	11.91	-0.07	0.04	102.5	Stability	0.901	3.39	0.36	0.13	34.9	Stability	0.485	7.65	0.236
Grande Florianópolis	10.89	0.90	0.80	27.0	Increasing	0.017	5.58	-0.72	0.52	-4.4	Stability	0.101	8.24	0.003
Laguna	9.64	0.91	0.82	25.1	Increasing	0.013	5.31	0.24	0.06	9.3	Stability	0.644	7.48	0.002
Alto Uruguai	8.41	- 0.84	0.71	32.1	Increasing	0.035	6.4	-0.79	0.63	-19.4	Decreasing	0.057	7.43	0.516
West	5.83	- 0.78	0.61	27.9	Stability	0.187	4.5	- 0.69	0.48	- 15.24	Stability	0.125	5.15	0.373
Alto Vale Itajaí	5.64	- 0.06	0.01	9.4	Stability	0.261	4.08	0.69	0.48	43.5	Stability	0.127	4.83	0.316
Carbonífera	3.93	- 0.88	0.78	62.1	Stability	0.071	2.1	0.43	0.19	41.1	Stability	0.388	3.01	0.006
Midwest	3.15	0.87	0.75	74.5	Increasing	0.025	1.48	-0.62	0.39	-73.6	Stability	0.187	2.32	0.148
Far South	2.58	0.46	0.21	22.3	Stability	0.362	1.47	0.12	0.01	68.3	Stability	0.981	2.03	0.122
Planalto Norte	2.07	0.47	0.22	91.5	Stability	0.351	1.55	-0.45	0.20	100.3	Stability	0.373	1.81	0.495
Alto Vale	1.94	0.45	0.20	73.2	Stability	0.380	0.61	-0.79	0.63	-37.5	Decreasing	0.059	1.28	0.097
Xanxerê	1.76	0.62	0.39	20.5	Stability	0.188	0.71	-0.52	0.27	0.0	Stability	0.286	1.23	0.056
Serra Catarinense	0.93	0.85	0.72	59.3	Increasing	0.032	0.46	-0.18	0.03	-36.7	Stability	0.738	0.70	0.051
State of Santa Catarina	9.74	0.83	0.69	25.09	Increasing	0.040	4.32	0.60	0.36	-3.05	Stability	0.212	5.43	0.020

Index: number of cases of leptospirosis / 100,000 inhabitants (population in 2010); R: correlation coefficient; R^2: determination coefficient; MPV: monthly percentage variation.

Results of the linear regression showed a positive correlation among rates of leptospirosis and rainfall in the period with the greatest rainfall volume (r = 0.83), in the same way, the coefficient of determination (R^2) for the same period was 69% in the variability of disease rates .

Still, at the same time, the MPV points to an average monthly increase of approximately 25% in the number of cases of leptospirosis. In the period from April to September, it was possible to observer a positive correlation (r = 0.60), an explanatory power for the rates of leptospirosis as a consequence of Santa Catarina's rainfall volumes (R^2 = 0.36), and an average drop (MPV) of 3.05% in the interpretation of the monthly trend.

Results of the linear regression stratified by Health Region showed a trend of increasing rates of disease associated with the volume of rainfall for the period with higher rainfall indexes (October to March) for all regions, regardless of the magnitude of the average rates of leptospirosis. In the period (2005–2015), disease rates ranged from 0.93 cases/100,000 inhabitants in Serra Catarinense to 19.82/100,000 in the Northeast region. Correlations among rates of leptospirosis and rainfall volume (r > 0.80) accompanied by their explanatory powers (R^2) were found in this period in the Northeast, the Far West, Grande Florianópolis, Laguna, Alto Uruguai, Carbonífera, Midwest, and Serra Catarinense regions.

Upon observing the eight Health Regions with the highest rates of leptospirosis and the greatest ratios of cases by precipitation index, the average rate of leptospirosis ranged from 12.1 cases per 100,000 inhabitants (higher rainfall levels) to 5.73 cases/100,000 inhabitants (lower rainfall levels), a drop of 52.7%. On the other hand, for the eight Health Regions with the lowest rates and lowest rainfall indexes, this variation was 2.75 to 1.56 cases/100,000 inhabitants (a decrease of 43.3%).

In turn, among the eight Health Regions with the highest rates, MPV dropped from 42.1 to 1.7% (96% decrease), when comparing the periods of higher rates and rainfall (October to March) to the period of lower rates and rainfall (April to September). For the eight regions with less high rates and rainfall, MPV dropped from 51.6% in the period from October to March, to 13.2%, in the period from April to September (a decrease of 74.4%).

DISCUSSION

The present study, upon investigating the seasonal leptospirosis variability, confirmed the assertion that correlates rainier periods to the increase in the number of cases of the disease.

The investigation of the association between leptospirosis rates and the regional dimension, although heterogeneous, identified a relationship between the incidence of the disease and the rainfall variation. The current study highlights that the distribution of cases in Santa Catarina, over the period examined (2005–2015), was related to the regions that had the largest volumes of rains and floods. The annual precipitation records[14] support these results. The floods that occurred in the years 2008 and 2011 coincided with the highest incidence rates of the disease in the period. Costa et al.[16] found a higher incidence of the disease in flood areas, given that the countries located in the tropics were responsible for 73% of estimated cases of leptospirosis in the world. Pelissari et al.[11], in a systematic review, identified seven studies conducted in Brazil, which associated the occurrence of leptospirosis with rain and/or flooding.

The study by Coelho and Massad[17], held in São Paulo, showed a correlation between the climatic parameters and leptospirosis incidence. Oliveira et al.[18] and Pereira et al.[19] identified that the disease incidence was related to rainfall. It is worth mentioning that these studies have also identified the disease occurring in different seasons and pointed to the need for an active search in other periods, detecting thus, other factors associated with the disease, regardless of the rain.

The current research stratified by Health Regions, upon taking into account the heterogeneity in the distribution of rainfall in Santa Catarina, brings important information under the focus of the geography of leptospirosis in the state. The Northeast, the Far West, Médio Vale do Itajaí, Grande Florianópolis, and Foz do Rio Itajaí accounted for more than three-quarters of the cases. The Northeast region alone was responsible for almost 30%.

A variation of rainfall rates per month in Santa Catarina has been reported by Coan et al.[13], being that the highest values occurred in the north coast, between the months of October and March, and the lowest ones in the south coast, in the months from April to September, with greater precipitation in the vale do Rio Itajaí and in the west of the State. These data corroborate the findings of the present study, which identified in these regions and in the same periods the occurrence of higher rates of incidence of leptospirosis.

A study conducted in Portugal by Mottola[20], in the Autonomous Region of the Azores, in particular on the islands of São Miguel and Terceira, found that the incidence rate is ten times higher when compared to the mainland. This situation was justified by the conditions of moisture and average temperatures of subtropical climate in the region of the islands, thereby promoting the spread of leptospirosis, with a greater number of cases registered from September to January.

In Brazil, Paula[21], upon describing the occurrence of leptospirosis and its spatial distribution, identified that, generally speaking, the highest incidence of the disease took place from October to March, with some regions registering distinct rainfall rates, with rainy seasons in the fall, such as the Northeastern coast.

In the same way, Guimarães et al.[7], Oliveira et al.[18], and Dutra et al.[22] identified the occurrence of leptospirosis in different periods of the year, with peak incidence of the disease associated with the precipitation index and, above all, obeying the regional characteristics.

Lastly, the rainfall levels and the registration of cases were markedly associated with the period of greater rainfall by Health Regions, including the months from October to March.

The highest rates were found for the Northeast and the Far West regions, and the lowest for Serra Catarinense and Xanxerê. Results of the linear regression according to the Health Region and seasonal period, for the period with higher rainfall levels, show a monthly increase in the rates of leptospirosis for all regions ranging from 20 to 100%. On the other hand, lower high rates along with the significant variations in correlation averages, as it is the case of the Midwest and Serra Catarinense Health Regions, suggest more abrupt periods of increased rainfall, accompanied by a significant increase of leptospirosis cases in shorter periods. These results contrast with quite different and irregular occurrences, upon observing the results for the seasonal period with the lowest rainfall levels, with lower rates of disease and with a large number of regions showing negative monthly percentage variations.

The stratification of the results, in accordance with the eight regions and the highest rates of leptospirosis and the highest cases-rainfall ratio, pointed out not only to the influence of rainfall levels in the rates of leptospirosis, represented by the two seasonal periods, in the occurrence of new cases of the disease. It is also observed, importantly, the cumulative effect of rainfall on the incidence of the disease. This situation is illustrated when comparing the ratio of new cases by rainfall, linearly following the growth rates for the eight regions with higher rainfall and leptospirosis rates ($r = 0.91$; $p = 0.013$), in contrast to the same ratio among the eight regions, with less high rainfall and lower rates of leptospirosis, where this relationship was not observed ($r = 0.24$; $p = 0.644$).

Several studies[7,22-24] which present the temporal trend of leptospirosis and rainfall rates confirm results of the present research. Results from Guimarães et al.[7], in addition to corroborating the association between rainfall and disease, emphasize that the relative risk for the occurrence of leptospirosis, in comparison with the period of higher rainfall (November to March), presented more than twice the risk ($RR > 2.0$; $p < 0.01$), in relation to the month of lowest rainfall (August), and point to a causal relationship upon comparing incidences in two different periods. These results are in line with the present study, showing a RR of more than three times ($RR > 3.0$; $p < 0.01$) in the incidence of leptospirosis, when comparing the period from December to March with the month of August.

In the same way, Dutra et al.[22], in Minas Gerais State, Brazil, upon investigating the occurrence of the disease over the months, from 1998 to 2012, observed that leptospirosis rates showed an increasing trend in the rainy months. On the other hand, Pereira et al.[19], when studying the trend and seasonality of leptospirosis in Brazil, found that although the growth of the disease was not detected in the studied period (2008–2012), correlating the results through a series adjusted by seasonality suggested the presence of a seasonal component of the historical series with strong temporal relationship, also noting that the pursuit of the disease is more active during rainy periods. Finally, Buzzar[23], upon analyzing the epidemiological profile of leptospirosis in São Paulo (2007–2011), also found that the disease focused in all 28 groups of epidemiological surveillance, throughout the year and with clear seasonality, according to the findings of the present study.

It is emphasized that the control of leptospirosis is based on interventions on one or more links known to the epidemiological chain, with potential ability to interrupt it. Based on the analyzes performed in this study for Santa Catarina, it can be said that the preventive measures and the fight against leptospirosis should be established at the municipal level. This approach may provide the details necessary for the identification of critical areas and their population who are at greater risk of contracting the disease.

It is noteworthy, however, that the morbidity data related to leptospirosis may be underestimated in this analysis, due to the fact that this is a disease that can be confused with other febrile conditions. In addition, most of the notifications are from hospital records, consequently of those cases that exhibit more severe forms of the illness.

It should be noted that a potentiating factor in the spread of leptospirosis is to be present in heavy seasonal rains that cause floods, even when the rains are of lesser volume, once that the waterproofing of the soil interferes in the absorption of water and favors the flooding increase. It is also believed that in periods with more rains and, consequently, more floods, the leptospirosis dissemination is larger, both for the population and for health professionals, and, of course, the demand for health services is faster, with earlier and more appropriate diagnosis and treatment.

In conclusion, leptospirosis focused in all the 16 Health Regions. Four regions caught our attention (Northeast, Grande Florianópolis, Médio Vale do Itajaí, Foz do Rio Itajaí), responsible in its entirety for 71.8% of the cases in Santa Catarina. The Northeast, Grande Florianópolis, Médio Vale do Itajaí, Foz do Rio Itajaí and Far West regions presented higher risks of leptospirosis incidence.

CONFLICT OF INTERESTS

There is no conflict of interests.

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AUTHORS’ CONTRIBUTION

João Ghizzo Filho was responsible for the conception of the study design and data collection. Nazaré Otília Nazário contributed with the writing of the manuscript and its revision. Paulo Fontoura Freitas carried out data analysis and interpretation. Gustavo de Araujo Pinto and Rodrigo Dias Nunes approved the final version of the manuscript to be published. Aline Daiane Schlindwein was responsible for the final revision of the manuscript.

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