Incidence of Leptospirosis infection in the East Zone of Sao Paulo City, Brazil

Kátia Eiko Miyazato1, Alexandre LA Fonseca1, Luciana Z Caputto1, Katya C Rocha2, Ligia A Azzalis3, Virginia BC Junqueira3, Edimar C Pereira3, Loide C Chaves4, David Feder5, Roseli Corazzini5, Luiz Carlos De Abreu5, Vitor E Valenti6, Sheylla Nadjane Batista Lacerda2,5, Flávia C Goulart5 and Fernando LA Fonseca3,5*

Abstract

Background: Leptospirosis is a zoonosis which is spread through contaminated running water. This contamination is seriously affected by the flooding which occurs in the area surrounding the Aricanduva river. The transmission of the disease results mainly from the contact of water with soil contaminated by the urine of infected animals. We aimed to conduct an epidemiological survey on Leptospirosis cases in Sao Paulo East Zone area.

Method: The analysis conducted in this study was based on data collected from the health authorities of that region close the Aricanduva river between 2007 and 2008 years, which give the rates of confirmed cases, mortality and death from human Leptospirosis. Other information concerned with the relationships among rainfall index, points of flooding and incidence of Leptospirosis.

Results: We observed a direct and important water contamination. Records of flooding points and dates of the reported cases in the region showed a direct relationship from which the period of higher rainfall also recorded an increase in cases. The annual record of the city and the region and rainfall regions also presented correlation.

Conclusion: The association between the indices of flooding and Leptospirosis cases indicates that preventive measures are necessary to avoid exposing the community.

Keywords: Epidemiological survey, Precipitation index, Points of flooding, Laboratory methods

Background

Leptospirosis is a zoonosis (disease transmitted by animals), acute and infectious disease caused by the bacterium Leptospira interrogans [1]. According to the manual of the Brazilian Secretariat of Health Surveillance [2], Leptospirosis is transmitted to humans by the urine of mice and rats. After heavy rains, the water carries bacteria from rats’ and mice’s urines to homes and public roads. Generally, outbreaks of Leptospirosis begin one week after the floods [3].

The number of human cases ranges in the year based on higher rainfall and according to the sanitation infrastructure of the region. In urban areas, the most contact with the agent occurs mainly during flooding periods [2].

Different areas in Brazil are affected by Leptospirosis. For instance, the state of Rio Grande do Sul has a high incidence of leptospirosis, with about 10 cases per 100 000 inhabitants, higher than the national average (3.5 cases per 100 000 inhabitants). Most cases (86%) correspond to males and rural residents (69%). The probable location of infection, indicated by epidemiological investigation of cases indicates both the workplace and home as a principal means of contact with the agent [2].

In the East zone of São Paulo, the area of the Aricanduva river belongs entirely to Sao Paulo city, comprising all or part of the Districts of Penha, Birmingham, Carrao, Vila Matilde, Aricanduva, Vila Formosa, City Leader, Park Carmo, Jose Bonifacio, Sapopemba, Sao Matheus, Iguatemi and Sao Rafael. Regionally, these districts are administered by the AR’s (Regional Health
incidence of the disease. The calculation of the incidence coefficient expresses the number of new cases of a disease in a given place and time in the same place and time of developing the disease and for the same period \( \times 10^4 \).

Data were obtained from DATASUS, since it is reportable disease to make the diagnosis the health professional must make the notification. Based on these data we made the figures for the eastern district of the city of São Paulo, all data. The notification occurs on the place of medical care, i.e. Unity of Basic Health region. Thus, this is related to UBS place of residence of the patient.

### Results

In São Paulo city, in 2007, in a population of 10,886,518 inhabitants we observed 29,394 cases of deaths (Table 1). Among these deaths 4,025 were related to infectious or parasitic diseases, which are often related to problems of sanitation or diseases, such as Leptospirosis.

### Table 1 Information regarding population and mortality in the East zone of São Paulo City

| Estimated population in 2007 |
|----------------------------|
| People Residents          | 10,886,518 |
| Inhabitants               |            |
| Hospital deaths - infectious and parasitic diseases | 4,025 |
| Deaths                     | 29,394     |
| Adm Distr and Borough | CC07 | IC07 | D07 | M07 | CC08 | IC08 | D08 | M08 | 2007 | 2008 |
|---------------------|------|------|-----|-----|------|------|-----|-----|------|------|
| SP ARICANDUVA       | 3    | 1.16 | -   | -   | 1    | 0.39 | -   | -   | 259,005 | 258,072 |
| ARICANDUVA          | .1   | 1.06 | -   | -   | -    | -    | -   | -   | 94,009  | 93,905  |
| CARRAO              | -    | -    | -   | -   | 1    | 1.38 | -   | -   | 72,997  | 72,386  |
| VILA FORMOSA        | 2    | 2.17 | -   | -   | -    | -    | -   | -   | 91,999  | 91,781  |
| SP CID TIRADENTES   | 6    | 233  | 1   | 16.67 | 1 | 0.38 | -   | -   | 257,029 | 265,531 |
| CIDADE TIRADENTES   | 6    | 233  | 1   | 16.67 | 1 | 0.38 | -   | -   | 257,029 | 265,531 |
| SP ERMELINO MATAR   | 5    | 2.42 | 1   | 20   | -    | -    | -   | -   | 206,470 | 206,545 |
| ERMELINO MATARAZZO  | 3    | 2.72 | -   | -   | -    | -    | -   | -   | 110,419 | 110,735 |
| PONTE RASA          | 2    | 2.08 | 1   | 50   | -    | -    | -   | -   | 96,051  | 95,810  |
| SP GUAIANASES       | 5    | 1.75 | 1   | 20   | 1    | 0.34 | -   | -   | 286,520 | 289,874 |
| GUAIANASES          | 2    | 1.89 | -   | -   | 1    | 0.94 | -   | -   | 105,684 | 106,421 |
| LAJEADO             | 3    | 1.66 | 1   | 33.33 | - | -    | -   | -   | 180,836 | 183,453 |
| SP ITAIM PAULISTA   | 12   | 3.07 | 1   | 8.33 | 4    | 1.01 | -   | -   | 391,106 | 394,513 |
| VILA CURUÇÁ         | 5    | 3.22 | -   | -   | 2    | 1.28 | -   | -   | 155,138 | 156,002 |
| ITAIM PAULISTA      | 7    | 2.97 | 1   | 14.29 | 2 | 0.84 | -   | -   | 235,968 | 238,511 |
| SP ITAQUERA         | 13   | 2.55 | 5   | 38.46 | 2 | 0.39 | 1   | 50  | 510,101 | 512,040 |
| CIDADE LÍDER        | 3    | 2.40 | 2   | 66.67 | - | -    | -   | -   | 124,778 | 125,589 |
| PARQUE DO CARMO     | 1    | 1.48 | -   | -   | 1    | 1.47 | -   | -   | 67,634  | 67,986  |
| ITAQUERA            | 4    | 1.90 | 2   | 50   | 1    | 0.47 | 1   | 100 | 210,956 | 211,858 |
| JOSÉ BONIFÁCIO      | 5    | 4.68 | 1   | 20   | -    | -    | -   | -   | 106,733 | 106,607 |
| VILA LEOPOLDINA     | -    | -    | -   | -   | -    | -    | -   | -   | 26,877  | 26,874  |
| SP MOÓCA            | 2    | 0.70 | -   | -   | 5    | 1.76 | 2   | 40  | 286,503 | 284,060 |
| ÁGUA RASA           | 1    | 1.24 | -   | -   | 1    | 1.25 | -   | -   | 80,533  | 79,893  |
| BELEM               | 1    | 2.85 | -   | -   | 2    | 5.78 | 1   | 50  | 35,104  | 34,610  |
| BRÁS                | -    | -    | -   | -   | 1    | 4.69 | 1   | 100 | 21,691  | 21,319  |
| MOÓCA               | -    | -    | -   | -   | -    | -    | -   | -   | 58,589  | 58,046  |
| PARI                | -    | -    | -   | -   | -    | -    | -   | -   | 12,356  | 12,099  |
| TATUAPÉ             | -    | -    | -   | -   | -    | -    | -   | -   | 75,200  | 74,903  |
| SP PENHA            | 17   | 3.58 | 2   | 11.76 | - | -    | -   | -   | 475,121 | 474,920 |
| CANGAÍBA           | 6    | 4.10 | 1   | 16.67 | - | -    | -   | -   | 146,465 | 147,383 |
| PENHA               | 6    | 4.98 | -   | -   | 1    | 4.07 | 1   | 100 | 120,449 | 120,013 |
| ARTUR ALVIM         | 2    | 1.85 | -   | -   | -    | -    | -   | -   | 107,979 | 107,609 |
| VILA MATILDE        | 3    | 2.99 | 1   | 33.33 | - | -    | -   | -   | 100,228 | 99,915  |
| SP SÃO MATEUS       | 10   | 2.34 | 4   | 40   | 3    | 0.69 | 3   | 100 | 427,552 | 432,949 |
| IGUATEMI            | 4    | 3.13 | 1   | 25   | 3    | 2.29 | 3   | 100 | 127,796 | 130,976 |
| SÃO MATEUS          | 1    | 0.64 | -   | -   | -    | -    | -   | -   | 156,966 | 156,877 |
| SÃO RAFAEL          | 5    | 3.50 | 3   | 60   | -    | -    | -   | -   | 143,060 | 145,096 |
| SP SÃO MIGUEL       | 13   | 3.21 | 1   | 7.69 | 2    | 0.49 | 1   | 50  | 404,923 | 407,815 |
| JARDIM HELENA       | 8    | 5.44 | -   | -   | -    | -    | -   | -   | 147,124 | 147,923 |
| SÃO MIGUEL          | 3    | 3.16 | 1   | 33.33 | 1 | 1.06 | 1   | 100 | 94,890  | 94,602  |
| VILA JACUÍ          | 2    | 1.23 | -   | -   | 1    | 0.60 | -   | -   | 162,909 | 165,290 |
| SP VL MARIA/GUIL    | 5    | 1.76 | 2   | 40   | 3    | 1.06 | 2   | 66.67 | 284,337 | 281,972 |
| VILA GUILHERME      | 2    | 4.48 | -   | -   | 1    | 2.27 | -   | -   | 44,634  | 44,042  |
| VILA MARIA          | 2    | 1.85 | 1   | 50   | 1    | 0.93 | 1   | 100 | 108,089 | 107,380 |
| VILA MEDEIROS       | 1    | 0.76 | 1   | 100  | 1    | 0.77 | 1   | 100 | 131,614 | 130,550 |
| SP VL FRUD/SAPOP    | 11   | 2.13 | 3   | 27.27 | - | -    | -   | -   | 515,847 | 514,622 |
Table 2 Leptospirose in Sao Paulo and surrounding areas - by administrative district and the east zone subprefecture by year 2007/2008 (Continued)

| Adm Distr and Borough | CC07 | IC07 | D07 | M07 | CC08 | IC08 | D08 | M08 | 2007      | 2008      |
|-----------------------|------|------|-----|-----|------|------|-----|-----|-----------|-----------|
| SAPOLAMBA             | 9    | 3.11 | 3   | -   | -    | -    | -   | -   | 289,069   | 289,599   |
| SÃO LUCAS             | 1    | 0.76 | -   | -   | -    | -    | -   | -   | 131,520   | 130,573   |
| VILA PRUDENTE         | 1    | 1.05 | -   | -   | -    | -    | -   | -   | 95,258    | 94,450    |
| Total                 | 205  | 2.38 | 42  | 20.49 | 44 | 0.51 | 18  | 40.91 | 8,609,028 | 8,645,826 |

Confirmed Cases (CC, per 100,000 inhabitants), Incidence Coefficients (IC, %), Death (D) and Mortality (M). Data source from DATASUS [11].

Table 3 Leptospirose in Sao Paulo and surrounding areas in 2007/2008

| Adm Distr and Borough | CC07 | IC07 | D07 | M07 | CC08 | IC08 | D08 | M08 | 2007 | 2008 |
|-----------------------|------|------|-----|-----|------|------|-----|-----|------|------|
| SP ARICANDUVA         | 3    | 1.16 | -   | -   | 1    | 0.39 | -   | -   | 259,005 | 258,072 |
| SP ITAQUERA           | 13   | 2.55 | 5   | 38.46 | 2   | 0.39 | 1   | 50  | 510,101 | 512,040 |
| SP MOOCA              | 2    | 0.70 | -   | -   | 5    | 1.76 | 2   | 40  | 286,503 | 284,060 |
| SP PENHA              | 17   | 3.58 | 2   | 11.76 | -   | -    | -   | -   | 475,121 | 474,920 |
| SP SÃO MATEUS         | 10   | 2.34 | 4   | 40   | 3    | 0.69 | 3   | 100 | 427,552 | 432,949 |
| Total                 | 90   | 2.30 | 22  | 24.44 | 22  | 0.56 | 12  | 54.55 | 3,916,564 | 3,924,082 |

Data source from DATASUS [11].

Table 4 Records of flooding areas in 2007 and 2008 in Sao Paulo East Zone and Sao Paulo City

| Year | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | Total |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 2007 | 12  | 23  | 22  | 25  | -   | -   | 1   | -   | -   | 4   | 4   | 11  | 101   |
| 2008 | 19  | 50  | 7   | -   | -   | -   | -   | 3   | -   | 2   | 8   | 9   | 98    |

Data were obtained from the Database of the Unified Health System (DATASUS) [11].

Table 5 Leptospirose cases reported in Aricanduva river area and Sao Paulo East Zone in 2007 and 2008

| Year | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | 2007 | 2008 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| 2007 |     |     | 5   | 8   | 14  | 7   | 11  | 13  | 2   | 2   | 1   | 5   | 3    | 73   |
| 2008 | 0   | 3   | 1   | 4   | 2   | 5   | 2   | 1   | 1   | 1   | 1   | 1   | 23   |
The disease incidence decreased between 2007 and 2008 in Sao Paulo State. The incidence coefficient decreased from 1.87 to 1.40 and the incidence of mortality reduced from 14.12 to 12.67.

In 2008, it was reported a population of 41,011,635 inhabitants in Sao Paulo State. Among them it was confirmed 576 cases with 73 deaths recorded. In Sao Paulo city it was found 10,990,2449 inhabitants. Among them it was recorded 172 cases with 33 deaths.

According to Table 2, in 2007, the East zone of São Paulo city presented 205 cases with 42 deaths. In 2008 it was observed 44 cases with 18 deaths.

It was observed that between 2007 and 2008, there was also a significant decrease in Leptospirosis cases in the East zone of Sao Paulo. The incidence coefficient decreased from 2.38 in 2007 to 0.51 in 2008. However, mortality coefficient increased from 20.49 in 2007 to 40.91 in 2008.

Table 3 indicates that among total cases reported in the East zone of Sao Paulo the area of Aricanduva river and surroundings areas presented 90 cases with 22 deaths in 2007 and 22 cases with 12 deaths in 2008.

In the region spanning the Aricanduva river we also observed a decrease in cases of Leptospirosis. It was reported an incidence coefficient reduction from 2.30 in 2007 to 0.56 in 2008 and a increased mortality from 24.44 in 2007 to 54.55 in 2008.

Tables 4 and 5, mentioned the districts of Sao Paulo East zone neighborhood with spots of flooding identified by the DATASUS [11].

Figure 1 and Figure 2 present the columns of confirmed cases of Leptospirosis. Data were obtained from the Database of the Unified Health System (DATASUS) [12]. The figures are represented by lines of indices of flooding areas. These data were collected from the site of the Center for Emergency Management of São Paulo (CGE) [13].
Discussion

This study was undertaken to investigate epidemiological data of Leptospirosis cases in the East zone of Sao Paulo city, SP, Brazil and also to evaluate the association between rainfall and the incidence of the Leptospirosis. The comparative study of 2007 data, among the cases of Leptospirosis and the flooding that occurred in the region of Aricanduva East Zone and around areas has shown a direct and important water contamination. Records of flooding points and dates of the reported cases in the region showed a direct relationship from which the period of higher rainfall was coincident with an increase in cases. The annual record of the municipality and the region under study and rainfall regions also allowed an association between the values. There was a substantial decrease between 2007 and 2008 in the records of cases of Leptospirosis in the region Aricanduva and the East Zone, however, an increased rate of mortality of the disease was observed.

In our study, the notification of Leptospirosis cases was compromised because the incubation of the bacteria may be long and the patient often seek health care from the onset of symptoms. Leptospirosis may be easily confused with other diseases and its diagnoses require laboratory monitoring of classical clinical and epidemiological data. Often, the confirmation of Leptospirosis appears only one time after contact with the contamination.

The data obtained in spite of confirming a direct contamination by water, it may not determine the actual rate of cases on the outskirts of the contaminated region of the Aricanduva river. Since these data are variable because many of the itinerant confirmed cases of hospitalization obtained in DATASUS sites [11] in 2009 are admission and residence, which does not specify the exact site of infection, not all patients seeking health services occurred near the site of exposure. Moreover, not all cases were reported, many cases are unnoticed and may be confused with a bad flu and laboratory tests can not always detect the classical bacilli *Leptospira*. The time for diagnosis of the disease is very important and laboratory techniques currently developed assist in achieving a more rapid, accurate and makes the treatment more effective [13-16].

Previous studies have already investigated this issue [17-19]. In the study of de Oliveira et al. [20], data on the morbidity and mortality of leptospirosis was collected from Rio de Janeiro’s Municipal Health and Civil Defense Department. The authors concluded that there is a direct correlation between the incidence of leptospirosis and rainfall. Nevertheless, they emphasized that the oscillation of the number of cases is not only determined by rainfall, since other factors influence this dynamic, such as sanitation, in addition to environmental and social factors. Another study [21] indicated that for every 20 mm precipitation, there was an average increase of 31.5% in hospital admissions in Sao Paulo. A different group of researchers [22] reported in Sao Paulo that in the rainy season, it also increases in other districts, probably due to the proximity of rivers and streams while in the dry season, the localities where cases appear coincide with the areas of poorest housing conditions.

As a main finding, our epidemiological study indicates that the Aricanduva river region and surrounding areas are worth to be further investigated. We also suggest additional projects in order to attenuate the flooding caused by rainfall in this area and, as a consequence, reduce the cases of Leptospirosis and others diseases caused by similar mechanism.

Conclusion

There was a substantial decrease of Leptospirosis cases in 2008 compared to 2007 in the region Aricanduva, however, there was an increased rate of mortality caused by Leptospirosis. The associations between the indices of flooding and confirmed cases showed that preventive measures are necessary in order to avoid exposing the community to waterborne diseases such as Leptospirosis and thereby prevent possible outbreaks of disease.

Competing interest

We declare no conflict of interest.

Authors’ contribution

KEM, ALAF, LIZC, KCR, LAA, VBCJ, ECP, LCC, DF, RC, LGDA, VEV, SNBL, FCG and FLAF participated in the acquisition of data and revision of the manuscript. KEM, LGDA, VEV and FLAF determined the design, interpreted the data and drafted the manuscript. All authors read and gave final approval for the version submitted for publication.

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Author details

1IPESFSP (Instituto Paulista de Ensino em Saúde de São Paulo), Alameda Franca, 1604, São Paulo, SP 01422-001, Brazil. 2Departamento de Patologia, Faculdade de Medicina do ABC, Av. Príncipe de Gales, 821, Santo André, SP 09060-650, Brazil. 3Instituto de Ciências Químicas, Ambientais e Farmacêuticas, Universidade Federal de São Paulo, UNIFESP, Rua Prof. Artur Redel, 275, Diadema 09972-270, Brazil. 4Departamento de Enfermagem, Faculdade de Medicina do ABC, Av. Príncipe de Gales, 821, Santo André, SP 09060-650, Brazil. 5Departamento de Morfologia e Fisiologia, Faculdade de Medicina do ABC, Av. Príncipe de Gales, 821, Santo André, SP 09060-650, Brazil. 6Departamento de Fonoaudiologia, Faculdade de Filosofia e Ciências, Universidade Estadual Paulista, UNESP, Av. Higino Muzzi Filho, 737, Marília, SP 17.525-900, Brazil.

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References

1. Lim VK. Leptospirosis: a re-emerging infection. Malays J Pathol 2011, 33:1-5.
2. MS - MINISTÉRIO DA SAÚDE. Manual de Leptospirose. 2004. www.svs.saude. sp.gov.br.
3. Medeiros Fda R, Spichler A, Athanazio DA. Leptospirosis-associated disturbances of blood vessels, lungs and hemostasis. Acta Trop 2010, 115:155–162.
4. SEMELA - Secretaria Municipal de Planejamento (Health Secretariat of Sao Paulo): Rainfall atlas of Sao Paulo State. 2008. http://atlasambiental.prefeitura. sp.gov.br/?id=9-9k.
5. PMSP: Prefeitura da Cidade de São Paulo e Secretaria Municipal de Infraestrutura e Obras: City Hall of Sao Paulo and the Municipal Infrastructure and Works Secretariat. 2008. http://www2.prefeitura.sp.gov.br/secretarias/infraestruturaurbana/piscinose/0014/portal/secretarias/infraestruturaurbana/piscinose/0004.

6. CVE Epidemiological Surveillance Center: Tables incidences of Leptospirosis. 2009. http://www.cve.saude.sp.gov.br.

7. Rhim JW, Go EJ, Lee KY, Youn YS, Kim MS, Park SH, Kim JC, Kang JH: Pandemic 2009 H1N1 virus infection in children and adults: A cohort study at a single hospital throughout the epidemic. Int Arch Med 2012, 5:13.

8. Drezett J, Kurobe FC, Nobumoto CT, Pedroso D, Blake M, Valenti VE, Vanderlei LC, Adami F, Vanderlei FM, De Araujo Moreso SQ, Ventamatti MA, Reis AO, De Mello Monteiro CB, Rossi RC, De Abreu LC: Hydatidiform mole resulting from sexual violence. Int Arch Med 2012, 5:8.

9. Louriz M, Mahraoui C, Azzouzi A, El Fassy Fihri MT, Zeggwagh AA, Abidi K, Ferhati D, Echerchef EK, Kettani SF, Takhineche R, Belayachi J, Zekraoui A, Seifani Y, Charif Cheflaoui AM, Abouqal R: Clinical features of the initial cases of 2009 pandemic influenza A (H1N1) virus infection in an university hospital of Morocco. Int Arch Med 2010, 3:26.

10. Madani N, Rosenthal FD, Dendane T, Abidi K, Zeggwagh AA, Abouqal R: Health-care associated infections rates, length of stay, and bacterial resistance in an intensive care unit of Morocco: findings of the International Nosocomial Infection Control Consortium (INICC). Int Arch Med 2009, 2:29.

11. DATASUS: Banco de dados do Sistema Único de Saúde: Database of the Unified Health System. http://w3.datasus.gov.br/datasus/datasus.php.

12. Brenner DJ, Kaufmann AF, Sulzer KR, Steigerwalt AG, Rogers FC, Weyant RS: Further determination of DNA relatedness between serogroups and serovars in the family Leptospiraceae with a proposal for Leptospira alexanderi sp. nov. and four new Leptospira genomospecies. Int J Syst Bacteriol 1999, 49:839–858.

13. Leveti PN, Morey RE, Galloway RL, Steigerwalt AG: Leptospira broomii sp. nov., isolated from humans with leptospirosis. Int J Syst Evol Microbiol 2006, 56:671–673.

14. Matthiás MA, Ricaldi JN, Cespedes M, Díaz MM, Galloway RL, Saito M, Steigerwalt AG, Patra KP, Ore CV, Gotuzzo E, Gilman RH, Leveti PN, Vinetz JM: Human leptospirosis caused by a new, antigenically unique Leptospira associated with a Rattus species reservoir in the Peruvian Amazon. PLoS Negl Trop Dis 2008, 2:e213.

15. Pavan ME, Brituegna B, Pettinani MJ, Caírõ F: Multiple-locus variable-number tandem repeat analysis of reference strains used for the diagnosis of leptospirosis in Argentina. Rev Argent Microbiol 2011, 43:251–255.

16. De Albuquerque Filho AP, De Araújo JG, De Souza IQ, Martins LC, De Oliveira MI, Da Silva MJ, Montarroyos UR, Miranda Filho Dde B: Valuation of a case definition for leptospirosis diagnosis in patients with acute severe febrile disease admitted in reference hospitals at the State of Pernambuco, Brazil. Rev Soc Bras Med Trop 2011, 44:735–739.

17. Soconocvich C, Angelakis E, Renvoisé A, Fournier PE, Marié JL, Davoust B, Stein A, Rouault D: Studies, flooding, rats, and leptospirosis in Marseille, France. Int J Infect Dis 2011, 15:e710–e715.

18. De Melo CB, Reis RB, Ko AI, Barreto CNN, Lima AP, Da Silva AM: Geographical distribution of leptospirosis in Aracaju, State of Sergipe from 2001 to 2007. Rev Soc Bras Med Trop 2011, 44:475–480.

19. Alderman K, Turner LR, Tong S: Floods and human health: a systematic review. Environ Int 2012, 47:57–47.

20. De Oliveira TVS, Marinho DP, Neta CC, Kligerman DC: Climate variables, living conditions and the health of the population: leptospirosis in the city of Rio de Janeiro from 1996 to 2009. Cinc Saud Col 2012, 17:1569–1576.

21. Coelho MS, Massad E: The impact of climate on Leptospirosis in São Paulo, Brazil. Int J Biometeorol 2012, 56:233–241.

22. Soares TS, Latorre Mdo R, Laporta GZ, Buzar MR: Spatial and seasonal analysis on leptospirosis in the municipality of São Paulo, Southeastern Brazil, 1998 to 2006. Rev Saude Publica 2010, 44:283–291.