

## Environmental and socioeconomic determinants of leptospirosis incidence in Colombia

Determinantes ambientales y socioeconómicos asociados con incidentes en casos de leptospirosis en Colombia

Determinantes ambientais e socioeconômicos associados a casos incidentes de leptospirose na Colômbia

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doi: 10.1590/0102-311X00118417

### Abstract

*Human leptospirosis is an infection that most often affects tropical countries. Since 2007, Colombia requires the notification of disease cases, enabling the observation of an increase in cases in recent years. The objectives of this article were to analyze environmental and socioeconomic variables and to evaluate their relationship with human leptospirosis cases. This is an ecological study on human leptospirosis cases aggregated by municipality and reported between 2007 and 2016. Spatial aggregation assessment was made using the Getis-Ord Gi method, and negative binomial regression was used to evaluate the relationship between environmental and socioeconomic variables with human leptospirosis. During the study period, 9,928 cases of human leptospirosis were reported, and 58.9% of municipalities reported at least one case. Four hotspots of human leptospirosis, including 18 municipalities, were identified. The results of the negative binomial model confirmed the importance of the effects of education, poverty and some climatic variables on the decadal incidence rate of human leptospirosis. Our results confirm the importance of socioeconomic determinants such as social marginality associated with violence and education, as well as ecological variables such as rainfall, height above sea level and forest coverage on the incidence rate of human leptospirosis at municipal scale.*

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*Leptospirosis; Environment; Socioeconomic Factors; Ecological Studies*



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## Introduction

Leptospirosis is a disease caused by pathogenic bacteria of the *Leptospira* genus, affecting both humans and animals <sup>1</sup>. Leptospirosis is one of the most common zoonoses worldwide, although it affects tropical countries most often <sup>2</sup>. The infection is usually transmitted to humans via water contaminated by animal urine that comes in direct contact with cutaneous lesions, the eyes or mucous membranes. Leptospirosis was a predominantly rural occupational risk until major urbanization occurred during the 20th century. Transmission risk is associated with climate, natural disasters, poverty and marginality <sup>3</sup>.

In Colombia, leptospirosis has been analyzed mainly from an animal health perspective, as it is prevalent in canines <sup>4,5,6</sup>, bovines <sup>7,8</sup>, pigs <sup>9</sup> and primates <sup>10,11</sup>. A prevalence of over 90% in *Rattus rattus*, *Rattus norvegicus* and *Mus musculus* has also been documented <sup>12,13</sup>. However, in humans, some studies have reported seroprevalences ranging from 6% to 27.7% <sup>14</sup>, and the circulation of 17 serovars has been recorded in the country <sup>15,16</sup>.

Since 2007, mandatory notification of human leptospirosis has been implemented by the Colombian National Surveillance System (SIVIGILA); subsequently, an increase in cases related to rainy and flood seasons has been observed in recent years <sup>17</sup>. The annual incidence of the disease in Colombia has been estimated to be 1.6 cases per 1,000,000 inhabitants <sup>18</sup>. However, in 2010, an incidence of 2.9 cases per 100,000 inhabitants was reported <sup>15</sup>. In 2012, the incidence was 2.2, with 25 confirmed deaths, for a 0.5 per 1,000,000 inhabitants mortality and 2.4% lethality <sup>19</sup>.

The ecology of human leptospirosis involves a complex interaction among *Leptospira*, reservoir animals, humans and the environment where they coexist. Human leptospirosis is associated with overpopulation, poor sanitation and inadequate health systems in urban areas of developing countries, whereas in developed countries, where infections are currently rising in number, it is associated with outdoor recreational activities <sup>20</sup>. However, in rural areas, transmission is associated with crop and livestock activities, and transmission risk increases during warm and rainy periods <sup>20</sup>. In urban areas, inadequate basic sanitation conditions enabled environments conducive to rodent-associated transmission. Other mammals, such as shrews, porcupines, domestic animals, as well as reptiles and amphibians <sup>21</sup>, are also considered infection sources for humans.

In Rio de Janeiro, Brazil, human leptospirosis cases are associated with heavy flooding occurring 3 to 20 days before the onset of the disease <sup>22</sup>. The 1 to 2 months latency period between heavy rains and cases reported on the island of Réunion in the Indian Ocean is also consistent with the survival time of the pathogen in flooded areas and a 1 to 3 weeks period of human leptospirosis incubation <sup>23</sup>.

This study aimed to evaluate the relationships between a set of environmental and socioeco-nomic variables and human leptospirosis cases that occurred in Colombia from 2007 to 2016, at municipal level.