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Evaluation of chemical spraying and environmental management efficacy in areas with minor previous application of integrated control actions for visceral leishmaniasis in Brazil

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ABSTRACT

Leishmaniases are vector-borne diseases that are transmitted to humans through the bite of *Leishmania*-infected phlebotomine sand flies (Diptera:Psychodidae). The main proved vector of visceral leishmaniais (VL) in the New World – *Lutzomyia longipalpis* – is well-adapted to urban areas and has extensive distribution within the five geographical regions of Brazil. Integrated public health actions directed for the vector, domestic reservoir and humans for the control of VL are preferentially applied in municipalities with higher epidemiological risk of transmission. In this study, we evaluated the individual impact of two main vector control actions – chemical spraying and environmental management – in two districts with no reported cases of human VL. Although belonging to an endemic municipality for VL in Brazil, the integrated control actions have not been applied in these districts due to the absence of human cases. The number of *L. longipalpis* captured in a two-year period was used as indicator of the population density of the vector. After chemical spraying a tendency of reduction in *L. longipalpis* was observed but with no statistical significance compared to the control. Environmental management was effective in that reduction and it may help in the control of VL by reducing the population density of the vector in a preventive and more permanent action, perhaps associated with chemical spraying.

1. Introduction

Leishmaniases are neglected tropical diseases that are endemic in a total of 98 countries and three territories on five continents. The causative agents are over twenty different species *Leishmania* parasites and the transmission to humans occurs through the bite of infected females of phlebotomine sand flies (Diptera:Psychodidae) belonging to *Phlebotomus* (Old World) and *Lutzomyia* (New World) genus. Leishmaniases may occur under three main forms: visceral – also known as kala-azar –, cutaneous and mucocutaneous. The first is the most severe form and it is fatal in over 95% of cases, if left untreated. About 200,000 to 400,000 new cases of VL per year are estimated to occur worldwide (Alvar et al., 2012; PAHO, 2015; WHO, 2016).

Visceral leishmaniasis (VL) is autochthonous in twelve countries in the Americas, with a total of 45,490 cases registered between 2001 and 2013 and an average of 3499 cases per year (PAHO, 2015). Brazil is among the six countries in the World that account for up to 90% cases of VL, with about 3300 cases per year and estimated annual incidence between 4200 and 6300 cases (Alvar et al., 2012). In 2013, most human cases (96%) the highest incidence rate (4.35 new cases per 100,000 habitants) were reported in Brazil among eight American countries within the transmission zone of VL (PAHO, 2015). VL expansion in the affected countries can be ascribed to a set of socioeconomic, physical, and biological factors induced by human behavior that resulted in the adaptation of vectors and reservoirs to urban areas (Lainson, 1989; Rangel and Vilela, 2008). In Brazil, the main proved vector of VL – *Lutzomyia longipalpis* – is well-adapted to urban areas, with extensive distribution within the five geographical regions of the country (Guerra et al., 2004; Missawa and Dias, 2007; Rangel and Vilela, 2008; Michalsky et al., 2009; Souza et al., 2009; Dias et al., 2011; Amóra et al., 2010; Lara-Silva et al., 2015; among others).

In an effort to avoid VL expansion and spreading over the country, integrated actions for chemical vector control, removal of seropositive dogs, and early diagnosis/treatment of human cases were adopted through the Surveillance and Control Program of Visceral Leishmaniasis (SCPVL) from the Brazilian Ministry of Health (Deane, 1956; Brazilian

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Ministry of Health, 2006). Based on the average number of reported human cases of VL in the last three years (n), a given area may have sporadic ($n < 2.4$), medium ($2.4 \leq n < 4.4$), or intense ($n \geq 4.4$) epidemiological transmission risk (ETR). The control actions are preferentially applied in municipalities with high or medium ETR, in this order (Brazilian Ministry of Health, 2009). In large municipalities, the ETR may be further stratified per district. Consequently, the ETR may vary within different districts of a given municipality and be distinct from the ETR of the municipality as a whole.

The present study aimed at evaluating the impact of two main vector control actions – chemical spraying and environmental management – in two Brazilian districts with no reported cases of human VL (ETR < 2.4). Therefore, integrated control actions of the SCPVL have not been applied therein.

2. Materials and methods

2.1. Study area

The present study was conducted in Belo Horizonte (19°55′15″S, 43°56′16″W), the capital of Minas Gerais state in Brazil. The municipality occupies an area of 331.4 km^2 and it is classified as region of intense ETR for VL, as a whole, with varying ETRs in the forming districts. The studied area comprised two non-neighboring districts – *Salgado Filho* and *Miramar* – (Fig. 1) with no reported cases of VL (Lara-Silva et al., 2015). The districts belong to two different administrative regions of Belo Horizonte, namely West and Barreiro (Fig. 1). Salgado Filho district is located in the West administrative region, which comprises 100,969 domiciles distributed over an area of 36.14 km^2. The human development index (HDI) of the West region is 0.853. Miramar district belongs to the Barreiro administrative region. The region includes 92,720 domiciles in an area of 53.58 km^2, with a HDI of 0.790 (City Hall of Belo Horizonte, 2017).

Both districts under study are fully urbanized, with no borders with natural reserves, public or private forest, or rural areas. The streets are paved and the houses are provided with basic sanitation and regular garbage collection.

2.2. Data analysis

Each of the districts under study was randomly subdivided in three sections for chemical spraying (CS), environmental management (EM) or no vector control action (NA). The vector control actions were performed in parallel in both districts and the results were grouped per section. Because CS and EM were implemented at coincident months during the two-year study, four different time periods have been considered for the NA section, which corresponded to pre- or post action in CS or EM sections, respectively.

2.3. Entomological captures

Entomological captures were performed monthly in eighteen selected houses (six per section) from 5:00 p.m. to 9:00 a.m., during three consecutive nights always in the first week of each month (Fig. 1). The captures started in September 2010 and ended in August 2012. Two HP light traps (Pugedo et al., 2005) were concomitantly mounted in the peri- and intradomiciles, in a total of 36 traps. The houses were selected based on previous canine cases of VL in the neighborhood and environmental conditions that favor the rearing of phlebotomine sand flies – presence of peridomicile, vegetation, domestic animals, and accumulated organic matter – in accordance to SCPVL guidelines (Brazilian Ministry of Health, 2006). The distribution of canine VL was obtained from a previous census survey performed by trained agents from the Zoonosis Control Center of the Health Department of Belo Horizonte, in 2010.

The number of captured specimens was used as indicator of the population density of *L. longipalpis*. Captured phlebotomine sand flies of both genders were stored in 70% ethanol until species identification using specific descriptions, taxonomic keys, and comparison with specimens from the Reference Collection of Phlebotomine Sand Flies of the Centro de Pesquisas René Rachou/FIOCRUZ. We adopted the species classification proposed by Young and Duncan (1994).

2.4. Chemical spraying (CS)

CS was performed by trained agents from the Department of Public Health of Belo Horizonte (SMS/BH) according to the recommended procedures of the SCPVL. Internal (intra-domicile) and external walls of

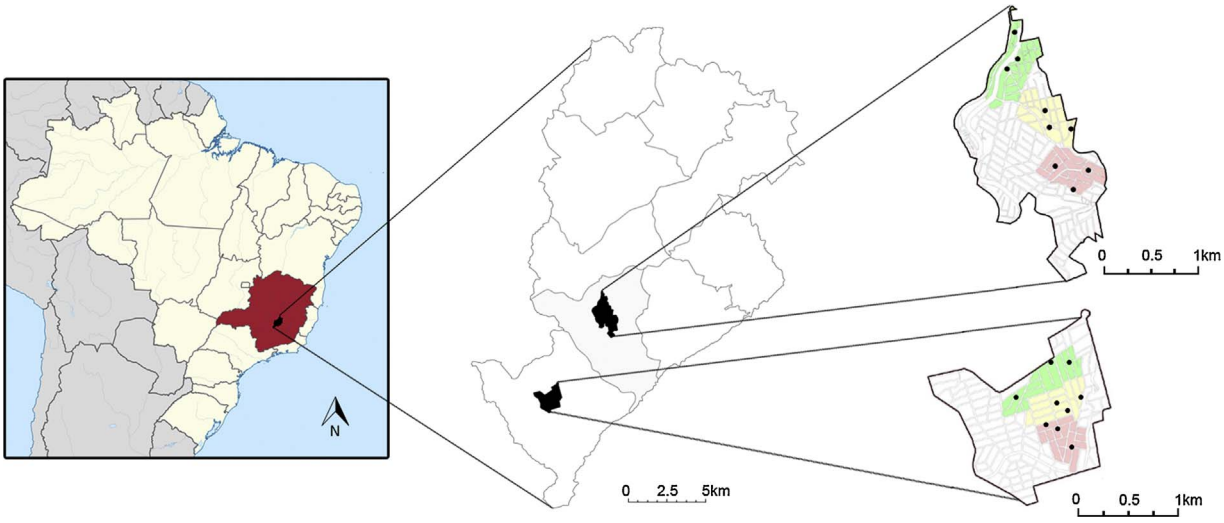

Fig. 1. Geographical localization of the studied areas where the efficacy of chemical spraying and environmental management were evaluated. Left: Brazil map with Minas Gerais state identified in red and Belo Horizonte municipality shadowed in black. Middle: Present subdivision of Belo Horizonte in nine administrative regions. The districts under study, in the respective administrative regions, are colored in black: Salgado Filho (West region, on top) and Miramar (Barreiro region, on bottom). Right: street blocks of Salgado Filho (top) and Miramar (bottom) districts with identification of the sections submitted to vector control actions: environmental management (green), no action (yellow), chemical spraying (pink). Entomological capture sites are marked by black dots. Period of study: September 2010 to August 2012. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)