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Use of geographic information systems in rabies vaccination campaigns

ABSTRACT

OBJECTIVE: To develop a method to assist in the design and assessment of animal rabies control campaigns.

METHODS: A methodology was developed based on geographic information systems to estimate the animal (canine and feline) population and density per census tract and per subregion (known as "Subprefeituras") in the city of São Paulo (Southeastern Brazil) in 2002. The number of vaccination units in a given region was estimated to achieve a certain proportion of vaccination coverage. Census database was used for the human population, as well as estimates ratios of dog:inhabitant and cat:inhabitant.

RESULTS: Estimated figures were 1,490,500 dogs and 226,954 cats in the city, i.e. an animal population density of 1138.14 owned animals per km^2. In the 2002 campaign, 926,462 were vaccinated, resulting in a vaccination coverage of 54%. The estimated number of vaccination units to be able to reach a 70%-vaccination coverage, by vaccinating 700 animals per unit on average, was 1,729. These estimates are presented as maps of animal density according to census tracts and "Subprefeituras".

CONCLUSIONS: The methodology used in the study may be applied in a systematic way to the design and evaluation of rabies vaccination campaigns, enabling the identification of areas of critical vaccination coverage.

DESCRIPTORS: Rabies Vaccines, supply & distribution. Mass Immunization, organization & administration. Geographic Information Systems, utilization. Veterinary Public Health.

INTRODUCTION

Preventing animal rabies is the most important tool in controlling human rabies in urban areas.[6] The main control measures are immunizing dogs and cats (through mass immunization campaigns) and controlling the stray dog population (through catching, sterilization and euthanasia), carried out by the city administration.

The *Centro de Controle de Zoonoses* (São Paulo Zoonoses Control Center – CCZ) considers that the maximum number of animals immunized per day at a primary immunization unit should be 700, in order not to affect the quality of the rabies vaccination services due to logistic constraints. In 2002, over 1 100 animals were immunized in approximately 25% of the primary immunization units. In addition to the long waiting lines, this situation affects the quality of the service rendered.[a]

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[a] Centro de Controle de Zoonoses. Proposta para descentralização da campanha de vacinação contra raiva animal no município de São Paulo *[A proposal for the decentralizaion of vaccination campaigns against animal rabies in the city of São Paulo].* São Paulo; 2003. [Unpublished]

According to the literature, immunization can prevent the infection in 60 to 80% of the animals.[2,3,9] Coleman & Dye[3] (1996), through mathematical models estimated that a critical animal immunization coverage of 70% would prevent a rabies epidemic in 96.5% of the cases they studied.

Sallum et al[8] (2000) estimated a rabies antibody seroprevalence of 16.5% among strays in the city of São Paulo. This low antibody seroprevalence in strays, associated to the possibility of rabies virus infection in other animas, shows the need of strategically planning mass immunization campaigns to fight animal rabies and the need of maintaining an effective system of epidemic control.

To plan and assess immunization initiatives, it is necessary to estimate the size and density of the cat and dog population for each location. With the aid of a census database for Brazilian municipalities[a] and of the geographic information system it is possible to estimate both the size of the dog and cat population in each census tract and to extend this information to include neighborhoods, districts and the municipality as a whole.

Geographic information systems can be used for gathering, storing, organizing and displaying spatial data. In addition to mapping, these systems include graphical analysis based on spatial localization, statistical analysis and modelling.[4]

With the creation of the *subprefeituras* and of the healthcare districts, the goal was to decentralize immunization campaigns against animal rabies from the city administration to each one of the healthcare districts. However, a later division of the city into *subprefeituras*, geographically and administratively replaced the former division based on healthcare districts. The *subprefeituras* are divided in administrative districts, a smaller geographical area from which more precise and more adequate data on each are generated. Currently, despite the Healthcare Secretariat adopting a different subdivision of the city (i.e. *Supervisões de Vigilância em Saúde* [Healthcare Inspection Areas]), the administrative districts are considered basic planning units, where information is generated for the entire city of São Paulo.

The objective of the present study was to develop a methodology for planning and assessing immunization campaigns against animal rabies.

METHODS

The cat and dog populations were estimated according to census tracts and *subprefeituras* for the entire city, based on information on the human population and dog/inhabitant and cat/inhabitant ratios. Dog/inhabitant ratio estimates have been carried out in several Brazilian cities.[1,5,7] For the city of São Paulo, the estimated dog/inhabitant and cat/inhabitant ratios are 1:7 and 1:46, respectively.[b]

Based on the dog and cat population we estimated animal population density, immunization coverage during the 2002 São Paulo immunization campaign against rabies, and the number of mobile primary care units needed to attain a 70% immunization coverage in each region.

The estimate for a certain census tract whose population is P_h, the canine population P_c will be measured through:

$$P_c = r_c . P_h$$

and the cat population P_f is

$$P_f = r_f . P_h$$

where r_c is the dog/inhabitant ratio, and r_f is the cat/inhabitant ratio.

For a certain immunization coverage (p_v), the number of animals to be immunized (N_v) will be expressed by

$$N_v = p_v . (P_c + P_f)$$

On the other hand, based on the formula above, and given the number of immunized animals in a certain region, immunization coverage can be estimated through

$$p_v = N_v / (P_c + P_f).$$

These relations refer to each census tract and to administrative districts, *subprefeituras* and the city as a whole, provided that P_h values refer to the respective unit of interest.

Data from the 2002 rabies immunization campaign were provided by the São Paulo CCZ. We used geographically referenced maps of the city and census data from the *Instituto Brasileiro de Geografia e Estatística* (Brazilian Census Bureau - IBGE)[a] to obtain the population of each census tracts, in addition to other variables. The census tracts were grouped so as to obtain the 96 administrative districts and, later, to obtain the 31 *subprefeituras*.

ArcView® GIS 9.2 was used to relate graphical information (georeferenced mapping) to non-graphical information (census data and immunization campaign data).

Based on these pieces of information we were able to create maps to illustrate all the variables (population, immunization coverage) breaking them down in different units of interest (census tracts, administrative districts and *subprefeituras*).

[a] Instituto Brasileiro de Geografia e Estatística. Base de informações por Setor Censitário - Censo Demográfico 2000 [CD ROM]. Rio de Janeiro; 2002.

[b] Paranhos NT. Estudo das populações canina e felina em domicílio, Município de São Paulo, 2001 [master's thesis]. São Paulo: Faculdade de Saúde Pública da USP; 2002.

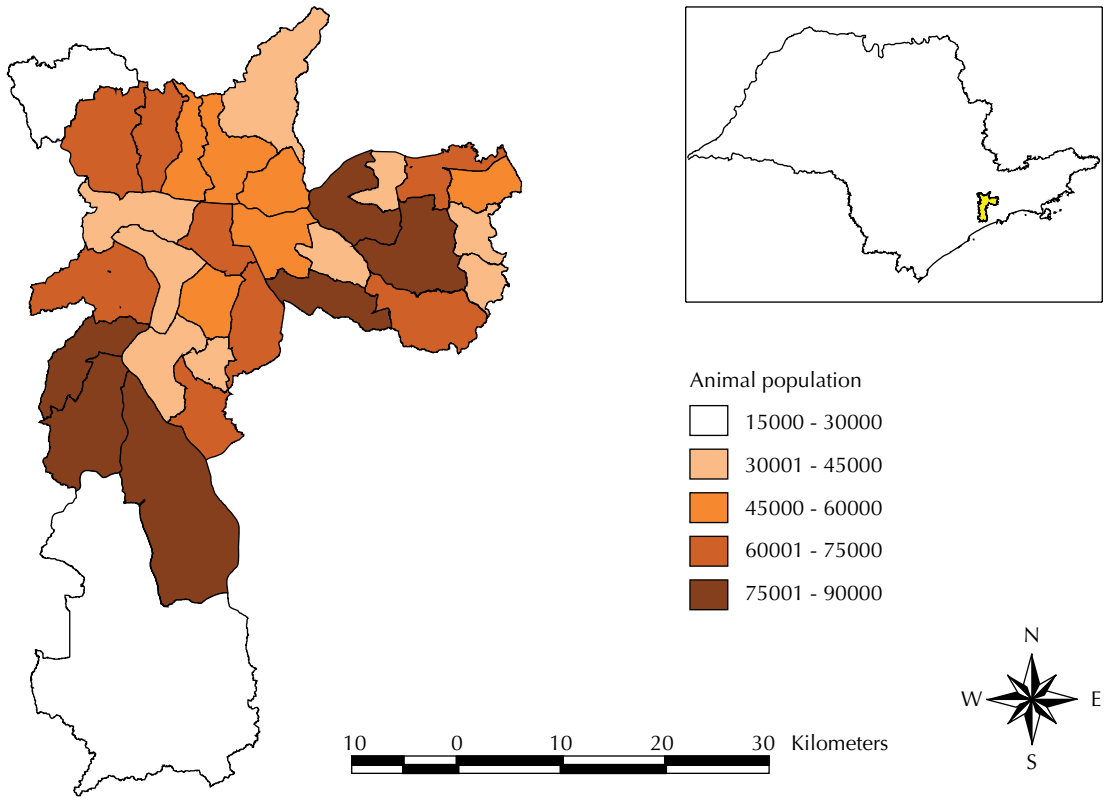

Figure 1. Animal population (dogs and cats) per *subprefeitura*. São Paulo, Southeastern Brazil, 2002.

RESULTS

Figures 1 and 2 show the distribution of animal population (cat and dog) distributed according to *subprefeituras* and census tracts, respectively, at the Lapa *subprefeitura*.

We estimated a population of 1,490,500 dogs and 226,954 cats for the city of São Paulo, totaling a population of 1,717,454 animals living in the city. The city of São Paulo spreads across 1,509 km^2,[a] and animal population density is 1,138.14 animals (dogs and cats) per km^2, among which there are 987.74 dogs per km^2 and 150.40 cats per km^2.

Figure 3 shows the population density at the Lapa *subprefeitura*, per census tract.

Figure 4 shows the immunization coverage per *subprefeitura*. In 2002, 926,462 animals were immunized in the city of São Paulo, accounting for a immunization coverage of approximately 54%.

Figure 5A shows the number of primary immunization units at the 31 *subprefeituras* during the rabies immunization campaign. Figure 5B shows the estimated number of primary immunization units needed to obtain an immunization coverage of 70%, assuming that 700 animals are immunized at each primary immunization unit per day. In the 2002 campaign, the average number of animals immunized per primary immunization unit was 788. Figure 5C shows the difference between the estimated values for a 70% immunization coverage per *subprefeitura* and the number of primary immunization units. Exception made to one *subprefeitura*, this difference was always positive, and the first and third quartiles of said difference were 10 and 24 (primary immunization units) respectively.

DISCUSSION

In regard to the spatial distribution of the animal population, the study of the Lapa *subprefeitura* shows that areas with a higher population (Figure 2) do not necessarily account for highest density (Figure 3). Whereas the number of primary immunization units in a certain area can be estimated based on the animal population, their position can be established based on the animal density, therefore, this information is vital to adequately planning mass immunization campaigns.

[a] Fundação Sistema Estadual de Análise de Dados. Área Territorial e Densidade Demográfica, segundo Subprefeituras e Distritos Administrativos do Município de São Paulo. São Paulo; 2004 [cited 2007 Jan 05]. Available from: http://www.seade.gov.br/produtos/msp/tabela_sintese.htm

Figure 2. Animal population per census tract at the Lapa *subprefeitura*. São Paulo, Southeastern Brazil, 2002

At some *subprefeituras*, the immunization coverage was above 100%, which is not reasonable. A few hypotheses can be raised to help explain this finding: animal owners from other regions may have brought their animals to these *subprefeituras*; some primary immunization units may have received resident and non-resident animals, or from neighboring areas; or, still, the 1:7 and the 1:46 ratio representing dog/inhabitant and cat/inhabitant, respectively, many not be adequate for some regions, and therefore underestimate the animal population. In this case, we suggest a study to estimate the dog/inhabitant and the cat/inhabitant ratio be carried out per administrative unit (i.e. administrative district or *subprefeitura*).

One of the limitations of this study is the role of private veterinary clinics in immunizing animals against rabies.

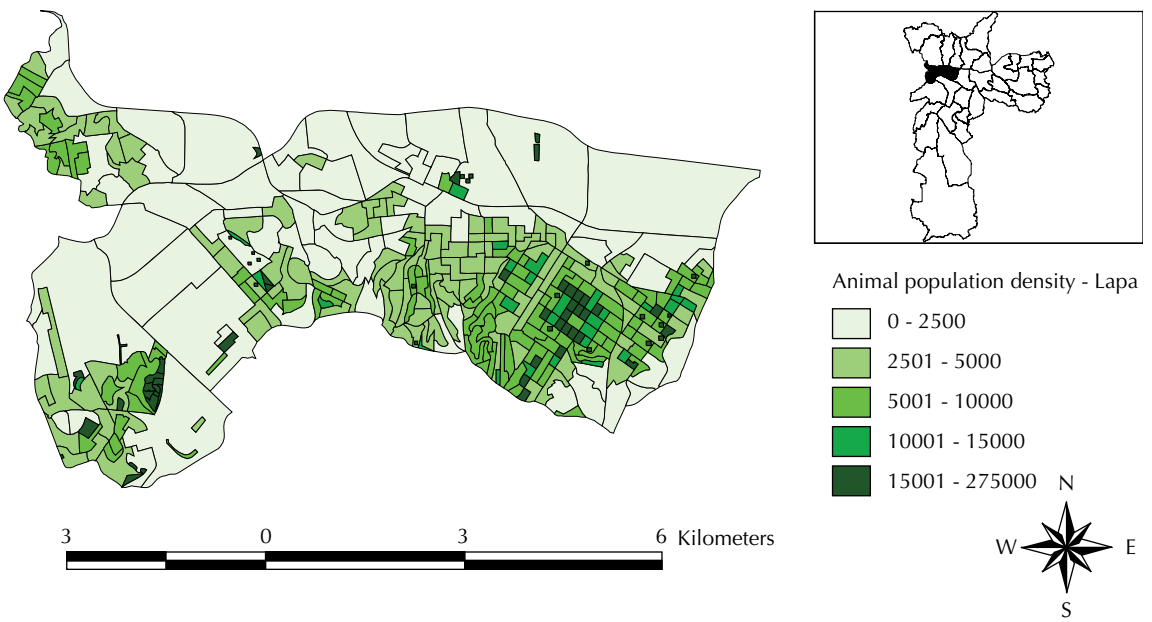

Figure 3. Animal population density (animais/km^2) per census tract at the Lapa *subprefeitura*. São Paulo, Southeastern Brazil, 2002.

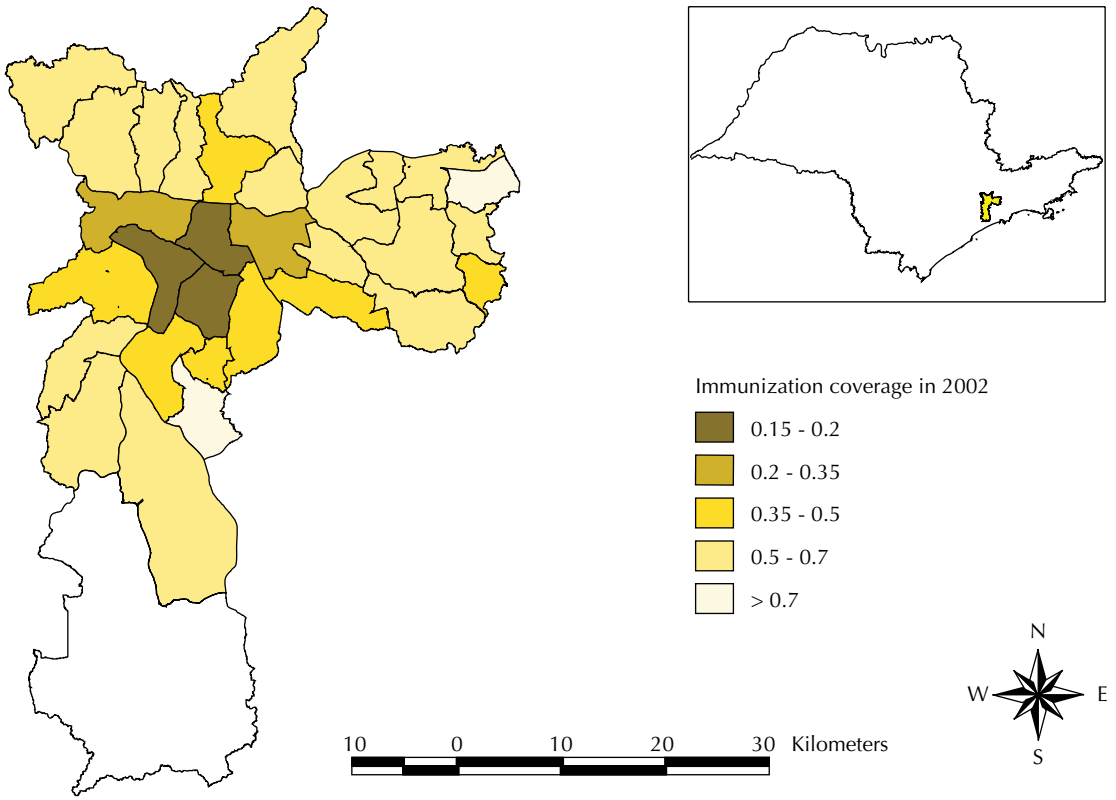

Figure 4. Immunization coverage per *subprefeituras*. São Paulo, Southeastern Brazil, 2002.

They were not included in this study due to the lack of data on the number of animals immunized at these clinics per administrative district.

The immunization coverage of 54% reached in the city of São Paulo together with the immunization performed by private clinics, suggests that the city's animal population is protected against the rabies virus. According to estimates by Coleman & Dye,[3] (1996) an immunization coverage of 70% would prevent 96.5% of the rabies epidemics. However, Sallum et al[8] (2000) estimated a rabies antibody seroprevalence of 16.5% among strays in the city of São Paulo. The low seroprevalence combined with the lack of information on the size of the population of strays, shows a risk factor that must be considered in planning actions to fight the reintroduction of the rabies virus. In addition, the participation of private veterinary clinics in immunizing animals against rabies is not only unknown, but it is also most likely to be heterogeneous, and is likely to vary according to *subprefeitura*, as does the population of strays. The greatest challenge, however, resides with the cat population that has more contact with other member of their species, in addition to chiropters and wild animal.

The difference between the number of primary immunization units in the 2002 and the estimated number in this study (Figure 5C) reflects an immunization coverage of less than 70% in the 2002 campaign, and

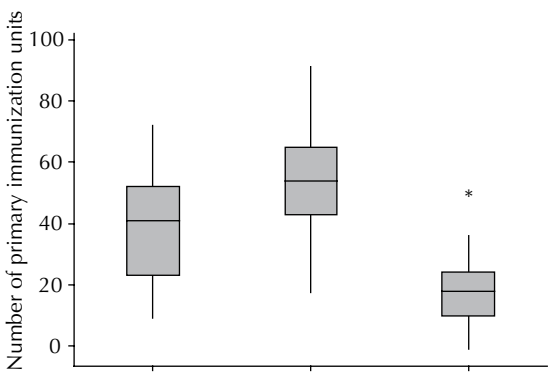

Figure 5. Number of primary immunization units per *subprefeitura* (A); estimated number of primary immunization units for an immunization coverage of 70% considering the immunization of 700 animals per unit (B); difference between B and A per *subprefeitura* (C). São Paulo, Southeastern Brazil, 2002.

the fact that most *subprefeituras* recorded an average number of over 700 animals per immunization unit. Therefore, at these *subprefeituras* the estimated 700 animals would mean an increase in the number of primary immunization units, which would not necessarily result in an increase of the immunization coverage towards 70%, but would mean an improvement in terms of quality of service.

The geographic information systems provide adequate tools to estimate the dog and cat population in the city, the animal density and the number of primary immunization units for each *subprefeitura*.

Finally, we conclude that the methodology developed in this study could be applied systematically in the mass immunization campaigns against rabies to help identify the areas of critical immunization coverage.

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