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Analysis of two different mass vaccination strategies against rabies in dogs and cats.

[*Análise de duas estratégias diferentes de vacinação em massa contra a raiva em cães e gatos.*]

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ABSTRACT

This study evaluated whether there were differences in vaccination coverage rates between municipalities with different vaccination strategies regarding the species and the coverage rates during different day periods. The vaccination period was categorized as M1 (morning; 09h00 am - 11h00 am), M2 (morning/afternoon; 11h00 am - 01h00 pm), M3 (afternoon; 01h00 pm - 03h00 pm), and M4 (afternoon; 03h00 pm – 05h00 pm). A repeated measures model compared the vaccination rate between periods and municipalities. The interaction between time and municipality was statistically significant ($P < 0.01$), indicating that the vaccination rate difference between periods depended on the municipality analyzed. Results of the difference between proportions analysis revealed that municipality B vaccinated 3.3% (2.2%-4.4%, 95% confidence limits) less dogs and 20.1% (17.9%-22.4%, 95% confidence limits) less cats than the municipality A. In municipality A, the vaccination rate in period M1 was higher than in periods M3 ($P = 0.07$) and M4 ($P < 0.01$). The vaccination rate was higher in M2 than in M4 ($P < 0.01$). In municipality B, the vaccination rate in period M1 was higher than in M2 ($P = 0.01$). The vaccination rate in M2 was lower than that observed in M3 ($P = 0.01$) and M4 ($P = 0.01$). Based on these results, mass vaccination campaigns have better results during the week, with the highest vaccination rate at lunchtime.

Keywords: rabies, health planning, immunization programs, dogs, cats

RESUMO

O objetivo do presente estudo foi avaliar se houve diferença entre a taxa de cobertura vacinal entre dois municípios com diferentes estratégias de vacinação, considerando-se as espécies e as taxas de cobertura durante os períodos do dia. O período de vacinação durante o dia foi categorizado em: M1 (manhã: 09h-11h), M2 (manhã/noite: 11h-13h), M3 (tarde: 13h-15h) e M4 (tarde: 15h-17h). Um modelo de medidas repetidas foi utilizado para comparar a taxa de vacinação entre períodos do dia e cidades. A interação entre período e município foi estatisticamente significativa (P<0,01), indicando que a diferença na taxa de vacinação entre os períodos foi dependente do município analisado. Os resultados da análise de diferença entre proporções revelaram que o município B vacinou 3,3% (2,2%-4,4%, limites de confiança de 95%) menos cães e 20,1% (17,9%-22,4%, limites de confiança de 95%) menos gatos do que o município A. No município A, a taxa de vacinação no período M1 foi maior do que nos períodos M3 (P=0,07) e M4 (P<0,01). Além disso, a taxa de vacinação foi maior no M2 do que no M4 (P<0,01). No município B, a taxa de vacinação no período M1 foi maior do que no M2 (P=0,01). A taxa de vacinação em M2 foi inferior à observada no M3 (P=0,01) e no M4 (P=0,01). Com base nos resultados apresentados, é possível concluir que as campanhas de vacinação em massa apresentam melhor resultado quando realizadas durante a semana, com horário do almoço apresentando maior taxa de vacinação.

Palavras-chave: raiva, planejamento em saúde, programas de imunização, cães, gatos

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INTRODUCTION

Rabies is a viral disease that affects both animals and humans, causing acute encephalitis and leading to a fatal outcome. The disease is caused by the *Lyssavirus* genus, with the Rabies virus being the most well-known member. The natural hosts of the virus are mammals, with domestic and wild carnivores, such as dogs, cats, and foxes, being the most important reservoirs for transmission to humans (Rupprecht *et al.*, 2002).

The virus is usually transmitted through the saliva of an infected animal, usually through a bite or scratch, with the virus then traveling to the central nervous system through the peripheral nerves. The virus can also be transmitted through inhalation of infected aerosols, particularly in bat-associated cases (Fooks *et al.*, 2014).

Clinical signs of rabies in animals can vary, but typically include behavioral changes, such as aggression or lethargy, and neurological symptoms, such as seizures and paralysis. Control measures for rabies in animals include vaccination, population management, and public education (Cleaveland *et al.*, 2014).

Rabies is still one of the main global zoonosis, considered the seventh most important infectious disease in the world and is endemic on all continents, except for Oceania and Antarctica. Annually, it is estimated that 40,000 to 70,000 people die from this disease worldwide. The disease is also of great economic importance, leading to the loss of approximately 300 million dollars in Latin America, 80 million of which in Brazil alone (Megid *et al.*, 2016). The economic losses caused by the disease worldwide are estimated at 8.6 billion dollars per year (Rabies, 2020).

Despite its low mortality, the lethality of rabies is 100%, and its control is essential for human and animal health (Rabies, 2018). Domestic dogs and cats, bats and some species of wild carnivores are the main reservoirs of the rabies virus, with the first two species being the main sources of zoonosis transmission to humans in developing countries (Fornazari and Langoni, 2014).

The eradication and control of rabies must be carried out based on three pillars: 1) mass vaccination of the canine population (since 95 to 99% of rabies cases have their origin in bites of dogs infected with the virus); 2) preventive vaccination in humans, and 3) administration of anti-rabies serum in humans after accidents with suspicious animals (Rabies, 2018).

Before starting a vaccination campaign, it's important to evaluate the epidemiological situation, considering factors like virus variants, presence of rabies, and involvement of wild animals. Based on this, the appropriate vaccination campaign can be chosen. Professionals should be selected and trained, and logistics planned. It's essential to analyze the events after the campaign, including the number of vaccinated animals and cases of rabies. A 75% vaccination rate is recommended for an immune barrier against the disease. (São Paulo, 2004; Brasil, 2016; São Paulo, 2019).

In order to contribute to the study of the logistics of free owner-charged mass vaccination campaigns, the present study aimed to compare the number of vaccinated animals according to pre-established periods, in two municipalities in the state of Sao Paulo, which adopt different vaccination strategies, aiming: 1.To verify if there was a difference in the proportion of dogs and cats between the municipalities; 2. To verify if there was a difference in the vaccination rate between these municipalities; 3. To Compare the vaccination rate by period, in each municipality.

METHODS

The present study was approved by the FMZV – UNESP – Botucatu Ethical Committee under the Protocol 0082/2017.

The municipality "A" is located at the center of the State of Sao Paulo, approximately 239 km from the municipality of Sao Paulo. It has a territorial area of 1482,642 km^2 and an estimated population of 148,130 inhabitants. The number of dogs and cats in municipality A were estimated by the Pasteur Institute as 27.735 dogs and 3.834 cats representing 1 dog for each 5,34 inhabitants and 1 cat for each 38,63 inhabitants. At his municipality vaccination occurs during the week, with no break for lunch and the vaccinators remained from 09h00 to 17h00.

Municipality "B" is located approximately 300 km from the capital of the State of Sao Paulo. It has a territorial area of 809,541 km^2 and an estimated population of 68,990 inhabitants. The number of dogs and cats in municipality B were 8.815 dogs and 2.184 cats representing 1 dog for each 7.82 inhabitants and 1 cat for each 31.58 inhabitants. At his municipality vaccination occurs during two weekends, with a break for lunch and the vaccinators remained also from 09h00 to 17h00. Both municipalities do not perform animal census.

A retrospective study of the dynamics of animal movement during vaccination activities was carried out in these two municipalities. Databases resulting from the mass vaccination campaign in both municipalities in 2014 were used. Data was provided from the animal registration forms completed during the vaccination activities.

Registration forms are common in both municipalities and contain basic information about the animal and its owner, such as address, owner and animal name, sex, apparent breed, vaccination history, among others. Each registration form contains 20 lines, making it possible to record up to 20 animals per sheet.

To calculate the rate of vaccinated animals as a function of time, the start and end time of completion of that sheet was registered. This calculation was performed based on the number of animals vaccinated in each period divided by the duration (in minutes) that the form remained open. This procedure allowed calculating the number of vaccinated animals per minute (animals/minute). The vaccination rate was transformed to the logarithmic scale to achieve a normal distribution. The vaccination period during the day was categorized into: M1 (morning; 9am-11am), M2 (morning/evening; 11am-1pm), M3 (afternoon; 1pm-3pm) and M4 (afternoon, 3pm-5pm).

The data were tabulated in an electronic spreadsheet and later analyzed as follows: the descriptive statistics of the data were elaborated through the distribution of frequencies through double-entry tables (conjugate of two series in a single table).

The difference between proportions was calculated with PROC FREQ risk diff function, from SAS Software (SAS Institute, Cary, NC, USA). A repeated measures model (PROC MIXED) was used to compare the vaccination rate between times of day, municipalities, and vaccinated species. Interaction terms between municipality and period, and municipality and species were included in the model to test the hypothesis that the difference in vaccination rate between periods and between species was dependent on the municipality where the campaign took place. An auto regressive covariance structure was used to model the correlation between measures repeated within the same day. Tukey's test was used to adjust the "p" values resulting from multiple comparisons. All the statistical discussion was made with 0.05 significance and 95% confidence level.

RESULTS

Results of the difference between proportions analysis revealed that the municipality B vaccinated 3.3% (2.2%-4.4%, 95% confidence limits) less dogs and 20.1% (17.9%-22.4%, 95% confidence limits) less cats than the municipality A (Table 1).

Table 1. Proportions of vaccinated dogs and cats at the A and B municipality. Botucatu 2023

	Municipality A			Municipality B			
Species	Expected Coverage (N)	Vaccinated	%	Expected Coverage (N)	Vaccinated	%	Proportions by municipalities 95% confidence limits
Dogs	20801	13288	63.88	6611	3659	55.34	0.033(0.022;0.044)*
Cats	2875	2072	72.06	1638	454	27.71	0.201(0.179;0.224)*
Total	23676	15360	64.87	8249	4113	49.86	

* Statistical significance ($p<0.001$).

Results of the multivariate analysis (Table 2) revealed that there was difference in the vaccination rate between period and municipality (P < 0.001), indicating that the difference in the vaccination rate between the periods was dependent on the analyzed municipality.

At the municipality A, the vaccination rate in period M2 was higher than in periods M1 (P=0.07) and M3 (P<0.01). Furthermore, the vaccination rate was higher in M1 than in M4 (P<0.01). In municipality B, the vaccination rate in period M1 was higher than in M2 (P=0.01). The vaccination rate in M2 was lower than that observed in M3 (P=0.01) and M4 (P=0.01), as can be seen in the Figure 1.

Table 2. Difference of vaccination rates (log10) by municipalities and period Botucatu 2023

	Media (Standard error)	P value
Municipality * Period		< 0.0001
A * M1	-0.5246 (0.02552)	
A * M2	-0.5482 (0.03223)	
A * M3	-0.6234 (0.03084)	
A * M4	-0.8116 (0.03884)	
B * M1	-0.5568 (0.04176)	
B * M2	- 0.9004 (0.09890)	
B * M3	-0.5500 (0.04957)	
B * M4	-0.6014 (0.06275)	

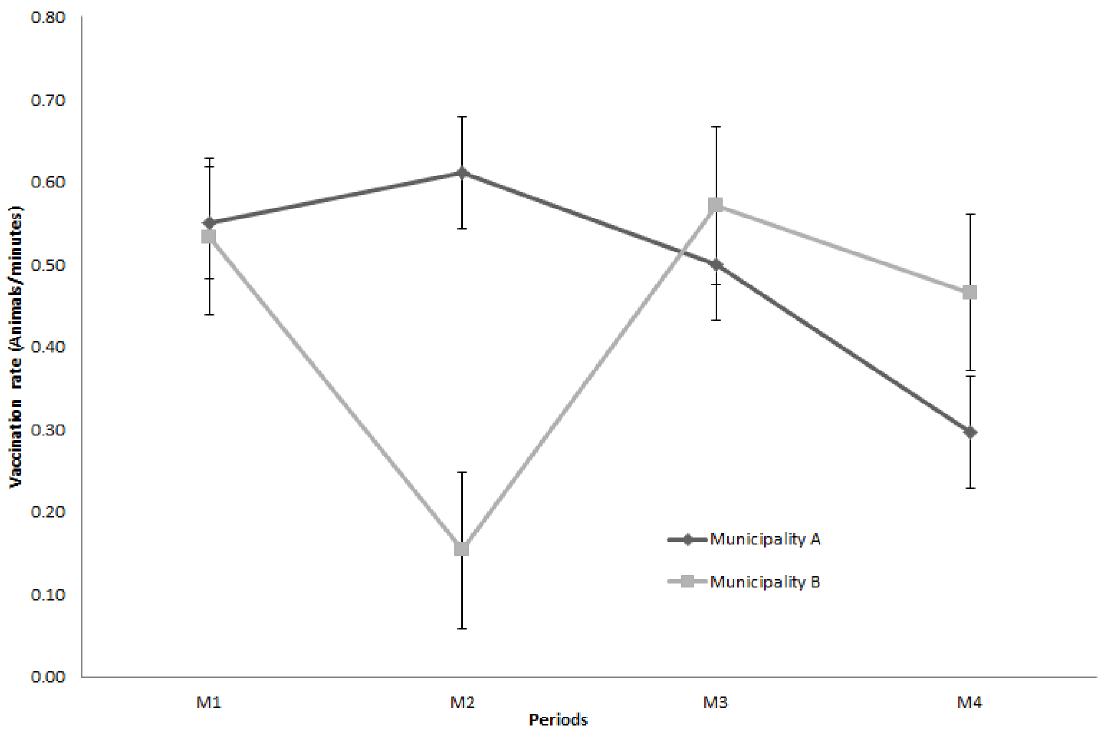

Figure 1. Vaccination rate at different periods of the day according to the municipality. Botucatu, 2022.

DISCUSSION

Despite the ratio of inhabitants per dog or cat in both municipalities seem close, it was possible to observe that municipality B vaccinated proportionally less dogs and cats than municipality A. In municipality A, the vaccination campaign was not interrupted by the lunch break, and the frequency was higher at the lunchtime period and lower at the end. In municipality B, where there is a lunch break, the frequency was lower at the beginning of the period, it was much reduced during the lunch period and has its peak in the post-lunch period, as may be seen in Figure 1. This may be related to the fact that, although on weekends, owners have more free time to take their animals to the vaccination stations. During the week there is no break for lunch and owners have more days available to decide when to take your animals.

Municipality A has a strong education program that highlights the significance of vaccinating cats against rabies. This is due to the epidemiological fact that non-vampire bats in the urban area are often found to be positive for rabies. In contrast, the situation was not yet recognized in Municipality B. In a study conducted by Oliveira-Neto *et al*. (2018), it was discovered that out of 100 animals tutors evaluated, only 29 were aware that cats can also transmit rabies. This may explain the low coverage in municipality B where the existence of an education program is unknown.

It was possible to observe that both municipalities did not achieve the coverage of ≥70% recommended by the WHO, except for cats in the municipality A. These results disagree with finds from Davlin and VonVille (2012) that in a systematic review of 29 papers related to rabies vaccination campaigns, concluded that the great majority of the campaigns achieved coverage ≥70%. Léchenne *et al.* (2016) also found a coverage ≥70% but in a 37-day campaign, revealing that the duration of the campaign must be an important factor to achieve the coverage.

The fact that neither of the two municipalities reached the vaccination target may be related to errors in estimating the populations of dogs and cats. Relying on a single factor for assessing cat and dog populations and vaccination rates, as suggested by the WHO and the Pasteur Institute of São Paulo, can lead to imprecise results, according to Dias *et al*. (2004). This may explain the different vaccination coverage levels between municipalities, especially among cats.

Considering the rate of vaccination (Durr *et al.*, 2009) concluded that owner-charged result in lower coverage than in free campaigns.

Despite that a further discussion of our findings was not possible due to the absence of papers with the same methodology (Undurraga *et al*., 2017) find that a mobile static point associated with capture and release strategy shows the best coverage.

Regarding the period of the vaccination (Belotto, 1988) analyzing the results of the mass vaccination campaigns from 1980 to 1985 revealed that campaigns that occurs from 08h00 A.M. to 05h00 P.M. with no breaks, are efficient to promote rabies prevention. These results agree with our findings.

CONCLUSIONS

Therefore, based in the data from the present research, it was possible to conclude that different mass vaccination strategies may have direct impact at the proportion of dogs and cats vaccinated, especially when there´s a disruption during the vaccination period.

It was also possible to conclude that vaccination campaigns that take place on Saturdays, with a lunch break, may not be an efficient mass vaccination strategy, since the delay in resuming the vaccination rate can compromise vaccination coverage.

In addition, we conclude that the concentration in the number of vaccinated animals is higher in the first two periods of the day, in those municipalities that carry out the campaign during the week, with special emphasis on lunchtime, which remains with a frequency like the beginning of activities, possibly because many owners use this period to take their animals to the vaccination posts.

We also conclude that a continuous education program about the importance of rabies vaccination, can improve vaccination coverage for cats.

This information can contribute to the more efficient planning of any mass vaccination activities and allows to determine the best lunch time for vaccination teams, as well as the amount of material and vaccine doses used in these periods.

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