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Factors Associated with Dog Rabies Vaccination in Bohol, Philippines: Results of a Cross-Sectional Cluster Survey Conducted Following the Island-Wide Rabies Elimination Campaign

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Summary

The Philippines has a long history of rabies control efforts in their dog populations; however, long-term success of such programmes and the goal of rabies elimination have not yet been realized. The Bohol Rabies Prevention and Elimination Program was developed as an innovative approach to canine rabies control in 2007. The objective of this study was to assess canine rabies vaccination coverage in the owned-dog population in Bohol and to describe factors associated with rabies vaccination two years after implementation of the programme. We utilized a cross-sectional cluster survey based on the World Health Organization's Expanded Programme on Immunization coverage survey technique. We sampled 460 households and collected data on 539 dogs residing within these households. Seventy-seven percent of surveyed households reported owning at least one dog. The human to dog ratio was approximately 4 : 1, and the mean number of dogs owned per household was 1.6. Based on this ratio, we calculated an owned-dog population of almost 300 000. Overall, 71% of dogs were reported as having been vaccinated for rabies at some time in their lives; however, only 64% of dogs were reported as having been recently vaccinated. Dogs in our study were young (median age = 24 months). The odds of vaccination increased with increasing age. Dogs aged 12 – 23 months had 4.6 times the odds of vaccination compared to dogs aged 3 – 11 months (95% CI 1.8 – 12.0; $P = 0.002$). Confinement of the dog both day and night was also associated with increased odds of vaccination (OR = 2.1; 95% CI 0.9 – 4.9; $P = 0.07$), and this result approached statistical significance. While the programme is on track to meet its goal of 80% vaccination coverage, educational efforts should focus on the need to confine dogs and vaccinate young dogs.

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Keywords

rabies; dog; cross-sectional; Philippines; cluster survey

Introduction

Rabies is an ancient disease. Laws governing rabid dogs have been found as far back as 2300 BC (Baer, 2007). It is plausible that rabies has been a problem in humans since the dog was first domesticated around 14 000 years ago (Rupprecht et al., 2008). Exposure to rabid dogs accounts for 99% or more of all human cases (WHO, 1992), and 99% of those human cases arise in the 80+ countries where canine rabies is still endemic (WHO, 2005a). The present canine rabies problem is unique to the developing world, and it is estimated that 55 000 people die from rabies in Africa and Asia every year (Knobel et al., 2005). Most developed countries have either eliminated rabies completely or reduced it to wildlife reservoirs (WHO, 2005a). With an estimated 500 million dogs worldwide (Macpherson, Meslin, & Wandeler, 2000), and half the world's human population living in areas where canine rabies is a real threat (WHO, 2005a), effective canine rabies control programmes are essential to controlling the disease in humans. Both empirical and statistical evidence suggests that maintaining rabies vaccination coverage of 70% in the dog population is effective in controlling the disease in dogs (Coleman & Dye, 1996).

Rabies affects Asia disproportionately. At least 31 000 human deaths due to rabies occur in Asia every year (Knobel et al., 2005). Yet, successful models for rabies elimination exist in Asia. Japan, Taiwan, and peninsular Malaysia have all eliminated endemic rabies in dogs (WHO, 2002). In the Philippines, epidemiological studies on rabies in both humans and animals began as early as the 1960s, and compulsory vaccination of dogs was instituted in Manila during the 1950s (Fishbein et al., 1991). In 2007, the Republic of the Philippines enacted RA 9482, better known as, "The Rabies Act of 2007", with the goal of national elimination of human rabies by 2020 (Republic of the Philippines, 2011).

The Visayas region of the Philippines has been the target of rabies control programmes in recent years due to the high incidence of the disease in this area. Specifically, the Province of Bohol introduced the Rabies Prevention and Eradication Program beginning in 2007 (Dodet, 2010). Major components of this programme include vaccination of at least 80% of the dog population and to eliminate stray dogs completely. The first island-wide vaccination campaign was conducted in 2007 using *Rabisin*® (Merial Animal Health), a vaccine offering 2-year protection. The campaign has continued annually thereafter. As a result of the programme, only one human rabies case has been reported in Bohol since 2008 (Global Alliance for Rabies Control, 2011).

The aims of this study were to describe the dog population in Bohol and to examine what factors are associated with rabies vaccination. As Bohol is the subject of an ongoing rabies control programme, it is our hope that both programme evaluation and dog population studies will be conducted on an annual basis, and that this baseline data will help determine the direction of future studies.

Methods

Study Population

This study was conducted in Bohol, Philippines. The Province of Bohol consists of 48 municipalities. A barangay is the smallest governmental unit in the Philippines (Green et al., 2002). Within each municipality there are between 8 (Corella) and 67 (Loon) barangays for a total of 1109 barangays on the island. The smallest barangay is Tiwi, in the municipality of Loon, with a population of 84. The largest barangay is Cogon, in the municipality of Tagbilaran City, with a population of 17 266. The total population of Bohol is 1 230 110 (2007 census data).

Data collection

The data for this study came from a cross-sectional survey administered by the Office of the Provincial Veterinarian (OPV) on the island of Bohol during June and July of 2009. We utilized a modified version of multistage cluster sampling technique with population proportional to size (PPS) sampling with replacement that was based on the World Health Organization Expanded Programme on Immunization (EPI) coverage survey technique (WHO, 2005b; Henderson & Sundaresan, 1982; Bennet et al., 1991; Lemeshow & Robinson, 1985). Based on *a priori* evidence, we assumed a design effect of 1.18. We determined a sample size of 460 households, consisting of 46 clusters (barangays) and 10 households per cluster, was both adequate and feasible to estimate rabies vaccination coverage in the dog population.

In the first stage of data collection, we enumerated the population size of each barangay based on census data and arranged them in alphabetical order. The sampling interval was determined by dividing the total population of Bohol (1 230 110) by the number of clusters we wished to collect (46). The first cluster (barangay) was selected using a randomly generated 5-digit number and matching it to the first barangay in our list with a cumulative population greater than or equal to the random number. Cluster 2 was identified by adding the sampling interval to the random number. Subsequent clusters were selected by adding the sampling interval to the previously generated number until a total of 46 clusters were identified. Clusters that were located within the same municipality were retained, and when the end of the list was reached before all 46 clusters were selected, then selection continued at the top of the list.

Once all 46 clusters were identified, selection of the household was done using simple random sampling in the field. The basic sampling unit was the individual household, and a household was defined as those individuals who shared a kitchen. Households were typically selected using a list obtained in the barangay of all the households. If this was not available, we obtained a list of all the streets. Numbers were assigned to each household or street and corresponding numbers were placed in a hat. One member of the field team drew a number from the hat. The correspondingly numbered household or street was the starting point of the survey. Only the street and/or the first household were randomly selected. Each subsequent household was chosen by going to the next closest front door of the previous household. If no one was at home in the selected household, then the next closest front door to that house was selected. Households were selected in this manner until a total of 10 household questionnaires were obtained in each cluster.

The survey consisted of two distinct questionnaires, and it was administered to any household member age 15 or older who agreed to participate. Questionnaires were administered during the daytime and households were not revisited. Interviews were conducted either in English or in the local dialect. The first questionnaire was designed to collect household demographics such as interviewee age, sex, relationship to head of household, total number of household members, number of children less than 15 years in the household, and whether the head of household was employed. We also assessed knowledge, attitudes, and practices regarding rabies and the rabies elimination campaign in Bohol as part of the first questionnaire. The results of this questionnaire will be the subject of a later manuscript. The second questionnaire, which is the focus of this paper, was designed to collect information on individual dogs within dog-owning households and to assess dog density and dog rabies vaccination coverage. We collected age, sex, vaccination status, vaccination date, and primary function on every dog within the sampled household, regardless of how many dogs were present in the household. In addition, we asked about confinement of the dog, how and where the dog was acquired, and if male dogs had been castrated.

Regarding vaccination status, we first asked respondents if the dog had ever been vaccinated. If the respondent answered, 'yes', we then asked the date (month and year) of the dog's most recent vaccination. Finally, we asked respondents to present proof of vaccination (certificate or collar). Although few respondents were able to produce either their dog's certificate or collar, we felt that most respondents accurately reported their dog's vaccination status. Thus, we chose to classify dogs as 'vaccinated' if they were reported as having received at least one rabies vaccination in their lifetime, regardless of whether the respondent could present proof of vaccination.

Data Analysis

We utilized Intercooled STATA Version 10 (Stata Corporation, College Station, TX, USA) for all statistical analyses. Data were analyzed using the survey commands in STATA. Multivariate logistic regression analysis was used to determine odds ratios and assess potential associations between dog vaccination status and several household demographic variables (employment status of head of household, whether the household had children less than 15 years of age, and if anyone in the household had ever known someone with rabies) as well as the dog variables of interest from the second questionnaire. For the purposes of the univariate and multivariate analyses, we excluded puppies less than 3 months of age (n = 8) since none of these dogs were vaccinated and, due to the timing of the last vaccination campaign, it is unlikely they would have had the opportunity to be vaccinated.

An odds ratio was considered significant at the 0.05 significance level. For the purposes of constructing a multivariate model, we included any variable of interest that had a significance level of 0.25 in the univariate analyses (Hosmer & Lemeshow, 2000). Variables were then eliminated from the model using a stepwise backward approach. If removing the variable changed the odds ratios of any of the other point estimates in the model by 10% or more, that variable was retained in the final model.

Results

The number of clusters (barangays) selected within each municipality using the modified EPI with PPS sampling design is shown in Figure 1. Looking at this figure, it appears that the sampling method worked well as municipalities with larger populations typically had a greater number of clusters selected, while those municipalities with smaller populations were less likely to be selected for inclusion in the study.

We interviewed a total of 460 households representing 37 of the 48 municipalities in Bohol and collected information on 541 dogs residing in these households. Overall, dog ownership is common in Bohol. We found that 354 (77%) of the surveyed households reported owning at least one dog, and 118 (33%) of dog-owning households owned more than one dog. The mean number of dogs owned was 1.6 (SD + 1.1). For every one dog, there were approximately 4 humans. Assuming this ratio holds true throughout the island, we would expect the owned-dog population of Bohol to be approximately 299 297.

Vaccination status

We collected data on vaccination status for 539 of the 541 dogs in our sample. A total of 381 (71%) of the 539 dogs in our study were reported to have been vaccinated for rabies at some time in their lives. However, when respondents were asked when the dog was vaccinated, only 344 (64%) of dogs were reported recently vaccinated in 2008 or 2009. In addition, owners were able to show either the vaccination/registration certificate or collar for only 40% of dogs that were reported vaccinated. Twenty-nine percent of dogs had never been vaccinated in their lifetime. Table 1 shows the most common reasons given for not vaccinating.

The local government was the most common source of vaccination (65% of dogs). Only 3% of dogs were vaccinated by a private veterinarian. Most respondents had paid some amount of money for vaccination of the dog (88%). The mean amount paid among respondents who reported paying for the vaccination was 75.49 Philippine Pesos (approximately 1.74 USD).

Age structure

The dogs in our sample were young, typically around 2 years of age (median = 24.0 months; range = 1 – 240). Vaccinated dogs were older (median = 36.0 months; range = 3 – 240) than unvaccinated dogs (median = 12 months; range = 1 – 216). Puppies < 3 months of age were virtually never vaccinated, which is most likely due to the timing of the last vaccination campaign. However, we observed that only 43% of dogs between the ages of 3 – 11 months of age had ever been vaccinated compared to 73% of those between the ages of 1 – 2 years. In addition, dogs < 1 year of age made up almost 16% of the entire dog population in Bohol. Figure 2 shows vaccination status by age group.

Sex characteristics

Male dogs were preferred to female dogs in Bohol and were about twice as abundant. We found a female to male sex ratio of 1 : 2. Males were also more frequently reported to be vaccinated than females, 74% versus 64%, respectively. Male dogs were also older (median = 35.0 months; range = 2 – 240) than female dogs (median = 22.5 months; range = 1 – 144). Figure 3 shows the age and sex composition of dogs included in our survey.

Reproduction

Approximately 33% of male dogs were castrated in Bohol, representing 22% of all dogs. Vaccinated dogs were significantly more likely to be castrated male dogs ($P<0.001$). We did not ask about female sterilization, since it is very rare that a female dog has been spayed, mainly due to the cost involved. We did not observe any significant association between vaccination and pregnant female dogs. We also collected information on the number and fate of puppies produced by female dogs in our survey. The median number of litters produced in the past year was 2 with a range of 1 – 10. The median number of puppies delivered in the last whelping was 4 with a range of 1 – 8. However, the median number of puppies surviving beyond 1 month of age was only 2 with a range of 0 – 7. Table 2 shows reproductive status by vaccination.

Dog acquisition, purpose and management

Most dogs were acquired as gifts (61%) and functioned as guard dogs (75%). A majority of dog owners reported that their dog was confined both night and day (67%). Any confinement (day, night or both day and night) of a dog was significantly associated with vaccination ($P = 0.001$, $P = 0.005$, and $P = 0.01$, respectively). An additional 5% of dogs were reported to be leashed both day and night. However, few dogs (29%) were reported by the interviewer to reside at a residence that had a fence capable of restraining the dog. Table 3 shows the dog characteristics by vaccination status.

Multivariate model

The results of our univariate and multivariate analyses are summarized in Table 4. We found that the dog's age was positively associated with vaccination, and this finding was statistically significant, even after eliminating dogs < 3 months of age from our analyses. Compared to dogs between the ages of 3 and 11 months, the odds of vaccination were approximately 4.6 times greater for dogs between the ages of 12 and 23 months ($P = 0.002$) and approximately 11.7 times greater for dogs between the ages of 36 and 47 months ($P = 0.002$). We also found that dogs had approximately twice the odds of being vaccinated if they were confined both day and night to the household premises, and this result approached statistical significance ($P = 0.07$) in the multivariate model.

Female sex appeared to be associated with lower vaccination coverage in the univariate analysis; however, this effect disappeared when age was controlled for in the model. While females are less often vaccinated, this is most likely due to the fact that females are generally younger than males, and younger dogs are less often vaccinated. Odds of vaccination also increased if the owner was employed (OR = 2.1; $P = 0.07$) and decreased if there was a child under the age of 15 in the household (OR = 0.6; $P = 0.11$); however, only owner employment approached statistical significance in the final multivariate model.

Discussion

Dog ecology and demography studies are essential to the planning and long-term success of dog rabies vaccination and disease elimination campaigns (WHO, 1992). With this in mind, we have attempted to gain insight into the owned dog population of Bohol. The prevalence of dog ownership is high in Bohol, with 77% of sampled households owning at least one dog. In contrast, in the United States, approximately 37% of households own one or more dogs (AVMA, 2007). Previous studies in the Philippines have reported household dog-ownership ranging from 40% to 69% (Robinson et al., 1996; Estrada et al., 2001). However, the mean number of dogs owned in Bohol (approximately 1.6) is similar to that of the U.S. (1.7; AVMA, 2007) and lower than that found in many other developing countries (Beran, 1982; Fishbein et al., 1992; Robinson et al., 1996; Kitala et al., 2001; Awoyomi et al., 2007; Knobel et al., 2008).

As with most developing countries, a large proportion of the owned-dog population in Bohol is young, with 16% of the dog population < 1 year of age and a median age of approximately 2 years. However, compared to some countries in Africa and Asia, the median age of dogs in Bohol was higher. De Balogh et al. (1993) reported a median age of 1 year for dogs residing in a semi-rural village in Zambia (urban dogs in Zambia had a median age of 2 years). Kitala et al. (2001) found that dogs in Kenya had a mean age of only 1.9 years. Even among studies conducted in the Philippines, dogs in Bohol, on average, lived considerably longer. Estrada et al. (2001) found that female dogs in Mindoro, La Union, Philippines had a mean age of 1.7 years, while the mean age of male dogs was only 0.4 years. Similarly, Robinson et al. (1996) found a median age of 1 year for dogs in Sorsogon Province, Philippines. Although, dogs in Bohol were not as long-lived as dogs in the Coquimbo region of Chile, with a median age of 3.0 years (Acosta-Jamett et al., 2010) nor those in Thungsong District, Thailand (Kongkaew et al., 2004), where the mean age was 2.6 years, and compared to dogs in the developed world, lifespan is much shorter among the dogs of Bohol. Owned-dogs in the U.S. have a mean age of approximately 4.5 years (WHO, 1987), while a survey of dogs in Britain reported that 11 years was the approximate mean age at death (Michell, 1999). Aside from the issue of dog welfare, the primary problem with a young dog population is that they are less likely to be vaccinated (Flores-Ibarra and Estrella-Valenzuela, 2004; Suzuki et al., 2008; Kaare et al., 2009), and a younger dog population increases the need for more frequent vaccination campaigns (WHO, 1987). Not surprisingly, we found that the odds of dog vaccination in our sample increased dramatically with increasing age, and this finding was highly significant.

We determined the sex ratio of male to female dogs in Bohol is 2 : 1. This trend has been observed repeatedly in developing countries (Beran and Frith, 1988; Brooks, 1990; Kongkaew et al., 2004; Acosta-Jamett et al., 2010). Male dogs are preferred since the primary function of the dog in Bohol is guarding. Since castration of male dogs is cheaper and more readily available than spaying of female dogs, this is not necessarily a bad trend. However, intact male dogs are often implicated in the spread of rabies due to their inclination towards roaming and fighting (WHO, 2005a); therefore, it is essential that male dogs be castrated. We found that about a third of male dogs, representing 22% of all dogs in Bohol, are castrated. This is higher than some other developing countries such as Chile (3%; Acosta-Jamett et al., 2010), Zimbabwe (16%; Butler and Bingham, 2000), and Mexico (5%; Flores-Ibarra and Estrella-Valenzuela, 2004; Ortega Pacheco et al., 2007) but lower than Thailand (37%; Kongkaew et al., 2004) and Bolivia (33%; Suzuki et al., 2008).

We found that rabies vaccination coverage in dogs in Bohol was approximately 71%, although only 64% reported having had their dog vaccinated within the previous year (2008 or 2009). It is possible that respondents were simply unaware of when their dog was last vaccinated; however, since few could actually produce a registration card and dogs were seldom seen wearing their registration collars, it was not possible to verify whether or when dogs were actually vaccinated, and this was one of the limitations of our study.

Dogs in our survey were most often not vaccinated due to the unavailability of the dog or the owner at the time vaccination was offered. A small number of dogs were not vaccinated due to an inability to restrain them, and the odds of vaccination were 2.1 times greater in dogs that were confined day and night. In addition, there is still a belief that young dogs cannot be vaccinated, despite the WHO recommendation that age should not be a limiting factor in vaccination (WHO, 1992). Interestingly, we did not find that the fee charged for vaccination/registration prevented many dogs from being vaccinated.

Conclusion

Based on our results, we feel that the programme can be improved in several ways. A more foolproof system for keeping track of vaccinated (registered) dogs needs to be explored further as the identification of vaccinated dogs is crucial to programme evaluation. Offering vaccinations on multiple days at varying times in the same location will help reduce the number of dogs missed by a single vaccination clinic as will encouraging residents to keep their dogs confined or restrained, especially prior to the vaccination campaign. Confinement of a dog may also improve its docility as well as encourage healthy interaction between humans and dogs. Finally, additional public education is needed to counteract the belief that young dogs cannot be vaccinated.

If Bohol and the Philippine governments are able to maintain their level of commitment to controlling rabies, it is clear that the long-term success of the programme is on track. It is also clear that maintaining vaccination coverage of at least 70% in the dog population can prevent rabies in humans. Due to their intense and successful efforts, the Bohol Rabies Elimination program won the highly competitive Galing Pook award in 2011 in recognition of the achievements of local government units (Global Alliance for Rabies Control, 2011). As long as the government is able to receive continued support to sustain these efforts, both the dog and human population of Bohol will be protected from death from rabies.

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Impacts

- The Visayas region of the Philippines has introduced new rabies control programmes in recent years; therefore, studies on dog populations and factors associated with rabies vaccination are vital.
- Dog ownership is common in Bohol with a human to dog ratio of 4 : 1, yielding an estimated owned dog population of almost 300,000.
- Overall, 71% of dogs were reported vaccinated at some point in their lives. Age was significantly associated with vaccination. Dogs aged 12 to 23 months had 4.6 times greater odds of vaccination than those aged 3 to 11 months (P = 0.002).

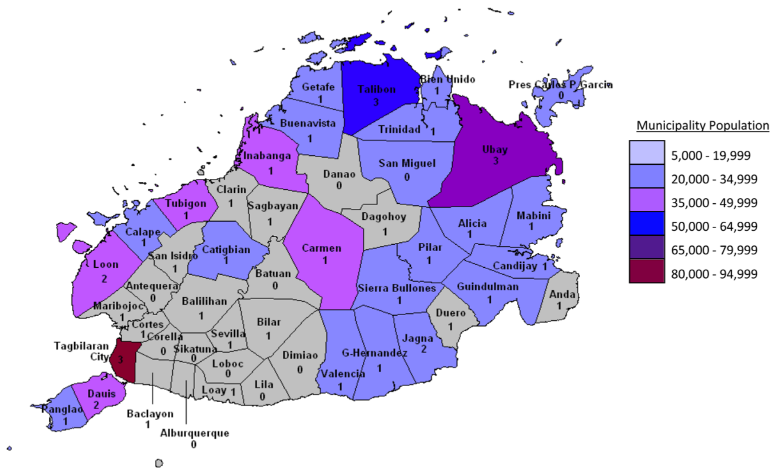

Figure 1.

Population (2007) and number of clusters selected using EPI sampling method with population proportional to size (PPS) by municipality, Bohol, Philippines, 2009 [Map was made using the Epi Map feature in Epi Info (Epi Info™ Version 3.5.1, The Centers for Disease Control and Prevention, Atlanta, GA, USA) and with Bohol shape files downloaded from the Natural Resources Database (http://www.nrdb.co.uk/)].

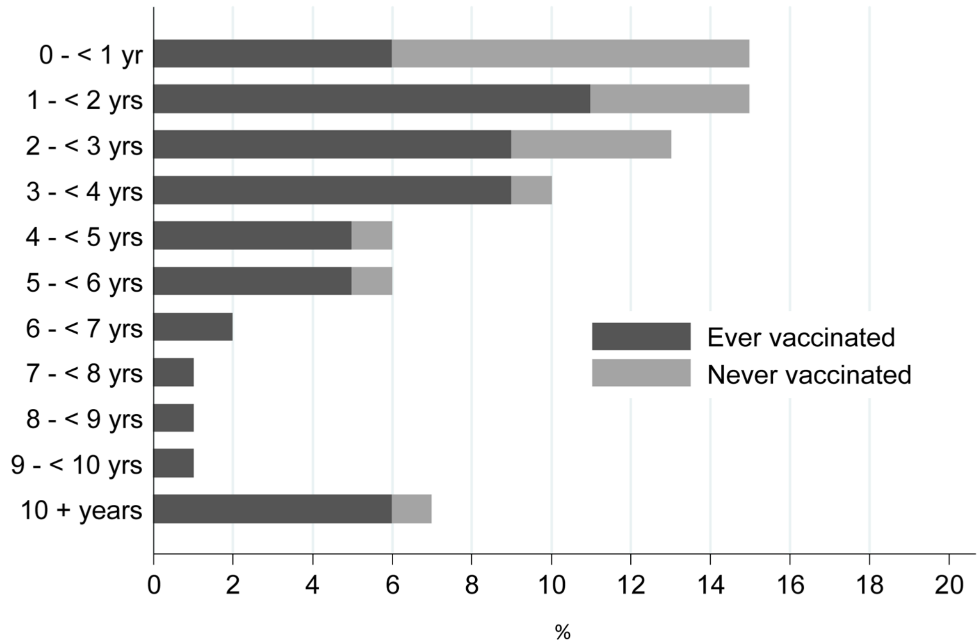

Fig. 2.
Vaccination status by age group as percentage of all dogs (n = 539; Data on age were missing for 118 dogs), Bohol, 2009.

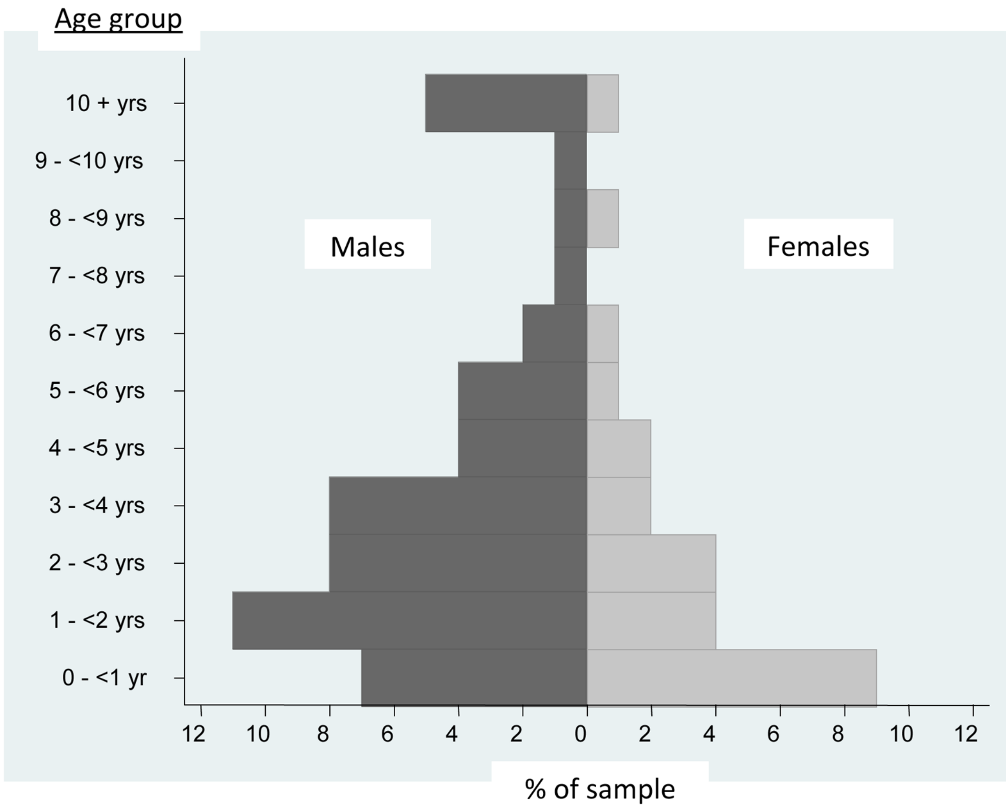

Fig. 3.
Age distribution by sex as percentage of all dogs (n = 539; Data on age were missing for 118 dogs), Bohol, 2009.

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Table 1

Primary reason dog has never been vaccinated

	Unvaccinated dogs (n = 158) n (%)
Either respondent or dog not there when vaccine was offered	32 (20)
Dog was believed to be too young	28 (18)
Unable to restrain dog	22 (14)
Dog acquired after vaccination campaign	14 (9)
Vaccine too expensive or no money to pay	12 (8)
Fear of injury or adverse reaction to vaccine	3 (2)
Could not travel to vaccine centre	2 (1)
Unaware of campaign	2 (1)
Other	13 (8)

Table 2

Reproductive characteristics by vaccination status of the 539 dogs included in the survey

	All Dogs (n = 539) n (%)	Vaccinated Dogs (n = 381) n (%)	Unvaccinated Dogs (n = 158) n (%)	χ^2 (*P*-value)
Sex				
Male	358 (66)	265 (70)	92 (58)	5.98 (0.01)
Female	181 (34)	116 (30)	65 (41)	
Castrated male				
Yes	117 (22)	106 (25)	11 (6)	22.67 (<0.001)
No	222 (41)	149 (34)	73 (41)	
Pregnant female				
Yes	24 (4)	16 (4)	8 (4)	0.06 (0.80)
No	111 (21)	71 (16)	40 (22)	

Table 3

Dog characteristics by vaccination status of the 539 dogs included in the survey

	All Dogs (n = 539) n (%)	Vaccinated Dogs (n = 381) n (%)	Unvaccinated Dogs (n = 158) n (%)	χ^2 (p-value)
How was dog acquired				
Gift	327 (61)	225 (59)	102 (65)	
Purchased	67 (12)	54 (14)	13 (8)	
Born in household	112 (21)	78 (20)	34 (22)	(0.13)[a]
Found	11 (2)	7 (2)	4 (3)	
Other	13 (2)	12 (3)	1 (1)	
Owner confines dog during day				
Yes	388 (72)	290 (76)	98 (62)	11.00 (0.001)
No	151 (28)	91 (24)	60 (38)	
Owner confines dog during night				
Yes	374 (69)	278 (73)	96 (61)	7.83 (0.005)
No	165 (31)	103 (27)	62 (39)	
Owner confines dog during the day and night				
Yes	360 (67)	267 (70)	93 (59)	6.34 (0.01)
No	179 (33)	114 (30)	65 (41)	
Dog's function				
Guard	394 (75)	273 (73)	121 (80)	
Pet/companion	54 (10)	34 (9)	20 (13)	11.00 (0.004)
Both guard and pet	79 (15)	68 (18)	11 (7)	
Dog resides in multiple dog household				
Yes	312 (58)	226 (59)	86 (54)	
No	227 (42)	155 (41)	72 (46)	1.09 (0.30)

[a]Fisher's exact test *P*-value

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Table 4

Results of univariate and multivariate logistic regression of factors associated with rabies vaccination in dogs in Bohol[a]

Variable	Univariate OR (95% CI)	*P*-value	Multivariate OR (95% CI)	*P*-value
HH Employed				
Yes	2.1 (1.3 – 3.6)	0.01	2.1 (0.9 – 4.8)	0.07
No	Referent	Referent	Referent	Referent
Child under 15				
Yes	0.5 (0.3 – 0.9)	0.02	0.6 (0.3 – 1.1)	0.1
No	Referent	Referent	Referent	Referent
Ever known someone with rabies				
Yes	1.1 (0.6 – 2.0)	0.8		
No	Referent	Referent		
Dog sex				
Female	0.7 (0.4 – 1.0)	0.01	1.0 (0.5 – 1.9)	0.9
Male	Referent	Referent	Referent	Referent
Dog age				
3 – 11 months	Referent	Referent	Referent	Referent
12 – 23 months	3.7 (1.7 – 8.3)	0.002	4.6 (1.8 – 12.0)	0.002
24 – 35 months	3.4 (1.4 – 8.1)	0.01	4.5 (1.6 – 12.9)	0.006
36 – 47 months	10.7 (3.5 – 32.7)	<0.001	11.7 (2.5 – 53.4)	0.002
48 + months	9.4 (4.4 – 20.3)	<0.001	26.8 (3.9 – 186.1)	0.001
Dog resides in a multiple dog household				
Yes	1.2 (0.8 – 1.9)	0.30		
No	Referent	Referent		
Distance from OPV	−0.003[b] (−0.01 to 0.01)	0.53		
How dog was acquired				
Found	Referent	Referent		
Gift	1.3 (0.4 – 4.3)	0.71		
Purchased	2.4 (0.5 – 11.1)	0.26		
Born in household	1.3 (0.4 – 4.3)	0.65		
Dog came from different municipality				
Yes	1.8 (0.8 – 3.8)	0.15		
No	Referent	Referent		
Months in current household	0.03[b] (0.01 – 0.04)	<0.001	−0.004[b] (−0.03 to 0.018)	0.72
Dog function				
Guard	Referent	Referent		
Pet	0.8 (0.3 – 1.7)	0.49		
Both pet and guard	2.7 (1.1 – 6.6)	0.03		
Owner confines dog day and night				
Yes	1.6 (0.9 – 3.2)	0.14	2.1 (0.9 – 4.9)	0.07
No	Referent	Referent	Referent	Referent

[a]Excluding 8 dogs < 3 months of age and 2 dogs where vaccination status was unknown; n = 531

[b]Beta coefficient