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Using Mapping, Global Positioning System (GPS) and Smart Phone Technology in Rabies Control Program in Kotagiri, Nilgiris District, India

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ABSTRACT

In this study, we utilized a catch-vaccinate-release approach for dogs in a canine rabies vaccination program in Kotagiri municipality, India. Following vaccination, surveys on dog population and their vaccination status was undertaken. A bespoke smartphone 'Mission Rabies' application was developed to facilitate data entry and team management. This global positioning system (GPS) enabled application captured the location of all vaccinated dogs and dogs sighted on post-vaccination surveys. In areas where coverage was below 70%, catching teams were re-deployed to vaccinate additional dogs followed by repeat survey. Out of 248 dogs captured, only 210 dogs were vaccinated because of the previous vaccination history within a year, and refusal of owner due to their misconceptions. In survey, 147 dogs were sighted of which 77 were seen marked with paints indicating a vaccination coverage of 52.4%. The total estimated dog population was found to be 475. Our study demonstrated that mobile technology enabled efficient team management and real-time data entry and analysis. The vaccination approach outlined in this study can serve as a guideline for rapid vaccination of large numbers of dogs with a high coverage rate in free roaming dog populations in India in the future.

Keywords: *Rabies, Vaccination, Mark, Capture, Dog, Population*

INTRODUCTION

Rabies is one of the deadliest zoonotic diseases responsible for more than 59,000 human deaths annually across the world (Fooks *et al.,* 2014, Hampson *et al.,* 2015). It is also the most lethal infectious disease with a case fatality rate of 100% even with advanced medical intervention (Fooks *et al.,* 2014). Rabies is a viral neurological disease affecting all mammals, including human beings. Canine rabies has been reported as one of the neglected diseases in the developing world (Lankester F *et* *al.,* 2014). The annual global cost of rabies has been estimated to be 8.6 billion US dollars and accounts for over 3.7 million disability-adjusted life years (Hampson K *et al.,* 2015).

In many developing countries, dogs are allowed to roam freely and are the principal reservoir for the disease, with almost all human cases of rabies contracted from bites of an infected dog (WHO, 2013). However, this disease is preventable. Mass vaccination of the dog population has been shown to be effective in eliminating this disease from many countries (Hampson *et al.,* 2015, Vigilato *et al.,* 2013 and Wells, 1954). This has led to the broad belief that the global elimination of canine transmitted rabies is possible through mass dog vaccination (Hampson *et al.,* 2009, Lembo *et al.,* 2010 and Morters *et al.,* 2014). Despite the feasibility of eliminating both canine and human rabies through widespread canine vaccination programmes, there is still limited investment for large scale dog vaccinations in endemic areas of many African and Asian countries (Hampson *et al.,* 2015).

India alone accounts for over 35% of the global rabies burden with over 20,000 annual deaths. Despite the need to develop and undertake mass canine vaccination programmes in India, there are few published reports of successful implementation of large-scale vaccination programmes (Kakkar *et al.,* 2012, Shahid *et al.,* 2015). There is a dearth of research relating to the Indian free-roaming dog population and practical implementation of effective mass canine vaccination on a scale that could be broadened to a state-wide or even national level (Belsare *et al.,* 2013, Davlin *et al.,* 2013 and Abbas *et al.,* 2014). A major challenge to the eradication of rabies in India is ensuring epidemiologically required vaccination coverage to break the Rabies transmission cycle in the dog population. There is a broad consensus that over 70% vaccination coverage in an area is sufficient to break the transmission cycle and reduce the incidence of rabies in dog and human populations (WHO, 2013).

Central point vaccination campaigns have been effective at accessing a large enough proportion of the dog population and make an impact on canine and human rabies incidence in parts of Africa (Jibat *et al.,* 2015). However, these approaches have been ineffective in reaching a high proportion in Indian dog population where the majority of dogs are free roaming (Belsare *et al.,* 2013). To progress towards the eradication of canine transmitted rabies in India, it is essential that effective field protocols are developed which facilitate mass canine vaccination with sufficiently high vaccination coverage to break the Rabies transmission cycle. Firstly, there is a clear need to develop field strategies which allow vaccination of large numbers of free roaming dogs in urban areas. Secondly, there is a need for improved methodologies which can rapidly assess whether the vaccination coverage achieved is high enough to result in widespread protective immunity within the dog population.

This study describes the development and implementation of a mass vaccination programme in Kotagiri, India using mapping techniques and smart phone technology

MATERIALS AND METHODS

Study area

Kotagiri (11.43°N, 76.88°E) is a panchayat town in the Nilgiris district in the Indian state of Tamil Nadu (Fig. 1).

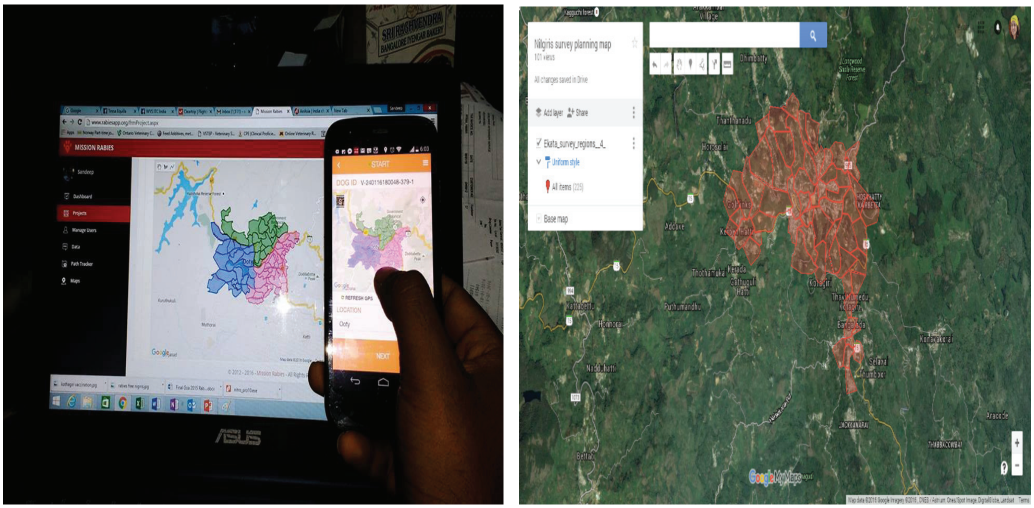

Fig. 1: Google map showing study area (left) and mobile application connected to server (right)

Study design

This study has two components: Dog vaccination and Survey. On the first day, the dogs were vaccinated and marked and followed up in the 2nd day. The survey was conducted to record the marked and unmarked dogs.

Study population

Dogs included in the study were those vaccinated, marked and released (VMR) by roaming vaccination teams and those sterilized as a part of the catch-neuter-vaccinate-return (CNVR) programme which ran in parallel to the rotating vaccination work. The study period was from 5th December 2014 to 16th April 2015.

Mission rabies application

A bespoke ‘Mission Rabies’ App was developed which enabled information about each dog vaccinated to be recorded on a smart phone on a real-time basis. This information was then synchronized via internet to a web-based server (Fig. 2). The dataset for each dog vaccinated included GPS location, manually entered ward number, action taken (vaccinated, marked and released/vaccinated and released but not marked/previously vaccinated within one year, marked/taken to clinic), sex (male/female), ownership status (presented by owner/free roaming), approximate age (<3 months, >3 months), neuter status defined by presence/absence of an ear notch routinely performed at the time of surgery (neutered/not-neutered), body condition score (BCS: emaciated (1), underweight (2), healthy weight (3), obese (4), presence of alopecia (four point score of alopecia affecting a percentage of total body surface area; normal (no hair loss), mild (<20 % hair loss), moderate (20–80 % hair loss), severe (>80 % hair loss)), other disease (transmissible venereal tumour, wounds, lameness, other). Road boundaries were displayed on the app to enable teams to navigate through the ward and stay within boundaries. Three Samsung Galaxy Core 2 phones were used, one with each vaccination team and one with the surveyor.

Vaccinate-assess-move protocol

Once restrained dogs were vaccinated intramuscularly or subcutaneously (Nobivac® Rabies, MSD Animal Health), they were marked and released. Non-toxic paint along the top and back of the head was used for marking to allow for identification on post-vaccination surveys and prevent repeated vaccination.

Post-vaccination survey protocol

Following completion of vaccinations, a surveyor travelled around the ward by motorbike navigating using the smart phone map to cover every street within the municipality boundaries. Surveys were conducted in the morning between first light and 11 am and in the late afternoon between 3 pm and dusk. Only free roaming dogs were recorded, therefore dogs tied or confined to private property were not recorded. Each dog sighted was recorded in a 'Survey form' on the 'Mission Rabies' app. The data was then synchronized to the central server via internet as described above. A 'path tracker' function was incorporated into the app to record the path travelled during the survey.

Data analysis

Data summaries and maps can be viewed in real time on the 'Mission Rabies' app backend. Calculations of vaccination coverage were undertaken in Excel 2013 (Microsoft Inc., Redmond, WA). For more detailed analysis, both vaccination and survey datasets were downloaded from the server as CSV files. Road boundaries were imported into ArcGIS Desktop 10.3 and dog sighting (survey) and vaccination locations were labelled with the road according to GPS location. Data was then exported into Excel 2013 for cleaning and analysis. Maps were prepared for presentation in

QGIS Desktop 2.6.1 (QGIS development team, Open Source Geospatial Foundation Project).

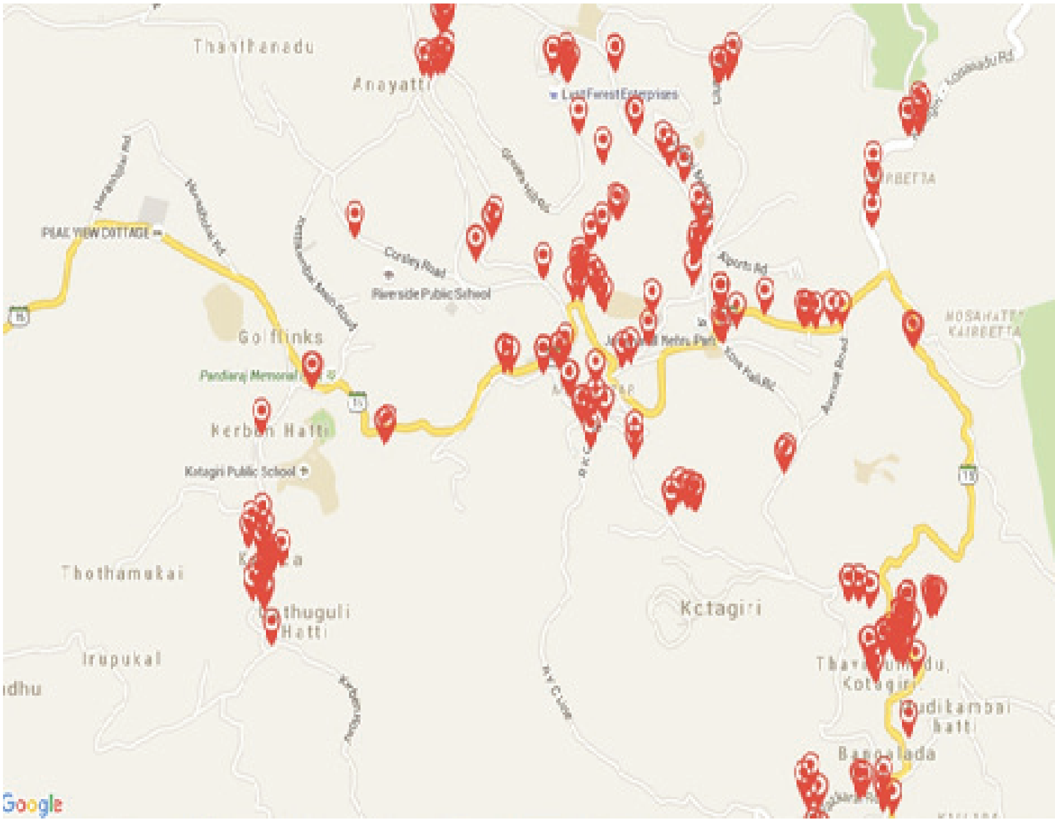

Fig. 2: Real time data and location data of vaccinated dog

RESULTS

Out of 248 dogs captured or brought by owner, 210 dogs were vaccinated as some dogs were already vaccinated within 1 year and some owners refused to vaccinate. In survey, 147 dogs were sighted of which 77 were observed marked with paints. This indicated a vaccination coverage of 52.4% (Fig. 4). The total dog population observed during the vaccination programme and survey was 475. Majority of dogs were found to be free roaming (58.8%) within vaccinate, mark and release (VMR) of which 51.4 % were male. The neuter status of free roaming and owned dog are shown in Table 1. 23.80% of the free roaming VMR population were neutered. The male-biased gender ratio is 1.74:1. Adults comprised the majority of population (87.8%) while puppy represented 12.9%. Adult and puppy vaccination with location data, vaccination coverage with location data and sterilization percentage of male and female stray dog are shown in Fig. 3, Fig. 4 and Fig. 5 respectively.

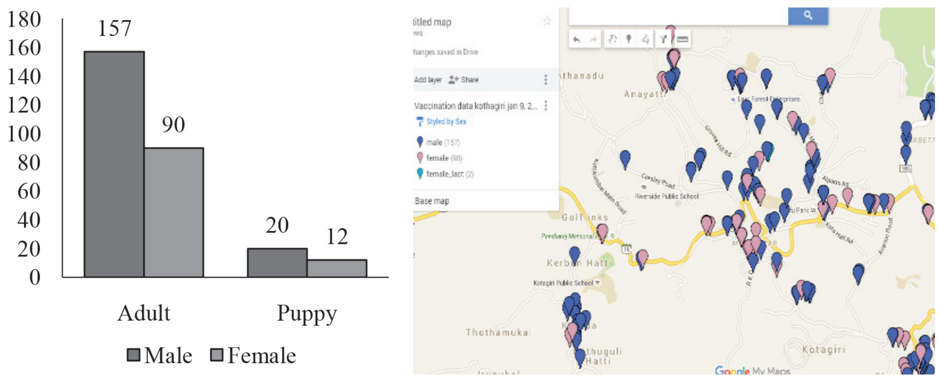

Fig. 3: Adult and puppy vaccination with location data

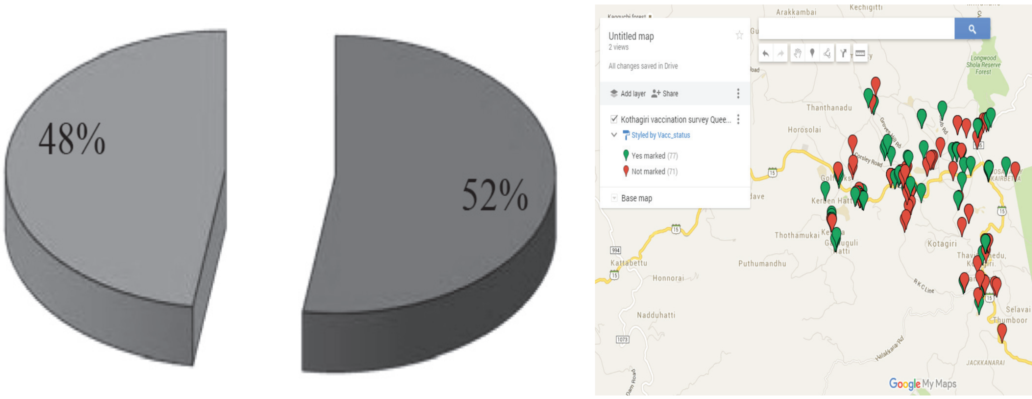

Fig. 4: Vaccination coverage with location data

Out of 147 dogs sighted, 77 were vaccinated.

Table 1: Neuter status within VMR population for owned and free roaming dog with location data

Neuter status	Free Roaming	Presented by owner	Total
Entire	69	120	189
Neutered	46	13	59
Unknown	1	-	1
Total	115	133	249

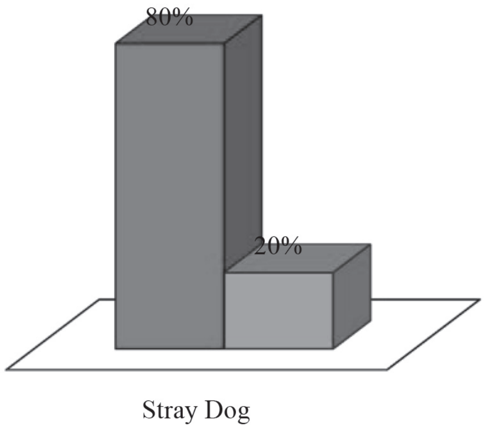

Fig. 5: Sterilization percentage of male and female stray dog

DISCUSSION

India has the highest number of human deaths from rabies globally (Hampson, *et al.,* 2015, Knobel *et al.,* 2005). The canine rabies vaccination coverage of more than 70 % dogs has been well documented in numerous countries to significantly reduce the incidence of rabies in both human and canine populations (Jibat *et al.,* 2015, Cleaveland *et al.,* 2003 and Kayali *et al.,* 2003). Despite the pressing need for effective canine rabies vaccination programmes in India owing to highest rabies burden, there have been few publications describing canine rabies vaccination strategies in the country (Kakkar *et al.,* 2012, Shahid *et al.,* 2013 and Davlin *et al.,* 2012). There is a paucity of publications which have demonstrated that a large number of dogs can be vaccinated in a short period of time maintaining a high vaccination coverage.

The vaccination coverage of 52.4% achieved in this study is higher than the similar study conducted in Indiawho found 34% (Belsare AV, 2013) and 35.5% (Reece and Chaaula, 2006) respectively. The geographical area of Kotagiri and dog handling was a challenge in our study. Likewise, misconceptions among owners hindered to achieve higher vaccination coverage (Reece and Chaaula, 2006). In a 12-month period in northwest Tanzania, Hampson *et al.,* 2009, estimated that a target vaccination coverage of 60% is sufficient to avoid coverage falling below the critical threshold of 40% between annual campaigns.

Vaccination coverage of 70% in 16 wards and in 2 wards 68.7% and 68.8%, the similar study held in Ranchi using Smart Phone Technology (Gibson *et al.,* 2015) which is more than our finding of 52.83%. Smartphone application provided specific functionality of data entry and boundaries displayed on maps, enabled efficient and simple region wise direction of catching and in overall budget for mass vaccination campaigns, the cost of using smart phones per dog vaccinated was minimal. Although mobile phone technology has been used in other epidemiological studies (Aanensen, Huntley, Feil and Spratt, 2009), this Ranchi program was the first study to report the development and implementation of a bespoke app tailored towards the collection of data relevant in canine rabies field work. This technology helped the project manager to instantly view maps of where the vaccination teams has been working or download the data in spreadsheet format for estimation of vaccination coverage enabling the prompt direction of teams back to areas with low coverage. This instant access to digitalized data saved significant management time in conversion of paper records into an electronic spreadsheet which made the application of the system more appealing and sustainable at the project management level. The resulting dataset also facilitates study of dog demographics and spatial analysis.

In this study, majority of dog werefound to be free roaming (58.8%) and were male (51.4%). This finding is lower than observed by Gibson *et al*, 2015 (free roaming 65.6%), Hibi, 2011 (male 56.5%). The male biased gender ratio is 1.74:1 observed in this study is in line with the finding of (Pal, 2001) who found it to be 1.37:1. Perception of males as better guard dogs than females has played the role and to avoid the nuisance of owning a bitch in estrus or having to deal with unwanted puppies might be the reason for the observed bias (Daniels and Bekoff, 1989, Daniels, 1983). Unlike in Africa, where a large number of dogs are owned and can be vaccinated through static point vaccine approaches (Cleaveland S *et al.,* 2003), the vast majority of dogs in Kotagiri were not identifiably owned. In this study teams used butterfly nets to catch and restrain the large number of dogs which were not amenable to handling. The use of butterfly nets has been previously described in vaccination campaigns in Bali where the majority of dogs were not amenable to handling (Morters *et al.,* 2014) and has been found to be more effective and humane than other capture methods.

CONCLUSION

The simple method of marking vaccinated dogs followed by dog-sight surveys to estimate vaccination coverage in the abundant free roaming dog populations is a cheap and effective system to estimate vaccination coverage in real-time. Mass vaccination campaigns provide an ideal opportunity for gathering information about a large cross section of the population with minimal additional effort which can then be used to better direct resources and refine effective methods. Crucially, we developed a 'Mission Rabies' smartphone application (App) which allowed for rapid entry of field data and facilitated the real time assessment of vaccination coverage. This mobile technology ensured that areas of vaccination coverage below 70 % were immediately detected, thereby enabling areas with suboptimal vaccination coverage to be revisited by vaccination teams. If the same approach is rolled out more extensively across rabies endemic areas including Nepal, this vaccination strategy has the potential to significantly reduce the incidence of rabies in both dog and human populations. Killing dogs does not stop the disease. Additionally, for developing countries including India and Nepal, open source software like ArcGIS for mapping and epitools for collection of data relevant in canine rabies field can be applied.

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