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Towards Canine Rabies Elimination in Cebu, Philippines: Assessment of Health Economic Data

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Summary

Rabies is endemic in the Philippines. In 2010, with support from the Bill and Melinda Gates Foundation, a canine rabies elimination project was initiated in the Philippine Archipelago of Visayan. We conducted an analysis of dog vaccination and human PEP costs for dog bite patients in a highly urbanized area and a low-income rural municipality in Cebu Province, Philippines, from 2010 to 2012. Our findings indicated that eliminating rabies in dogs through mass vaccination is more cost-effective than treating rabies exposures in humans. The average costs (in USD) per human life saved through PEP were $1620.28 in Cebu City and $1498 in Carmen. Costs per dog vaccinated ranged from $1.18 to $5.79 in Cebu City and $2.15 to $3.38 in Carmen. Mass dog vaccination campaigns conducted in each village were more cost-effective than fixed-site campaigns. The costs of dog vaccination can be reduced further through bulk vaccine purchase by the national government or large donor agency, for example the BMGF. As communities achieve canine rabies elimination, more judicious use of PEP will result in significant public savings. The study affirms the willingness of local governments to invest and reassure donors of their cooperation and resource contribution to sustain disease elimination efforts.

Introduction

Rabies is a neglected zoonotic disease that continues to be a significant cause of human and animal deaths in many parts of the world (Anderson and Shwiff, 2015). For many countries in Asia, Africa and Latin America, canine rabies is endemic and the majority of human rabies exposure results from dog bites to children (Government of the Philippines, 2010, n.d.). Reliable data indicating the actual incidence of human rabies exposure are scarce or non-existent in many countries, leading to the widespread belief that the global number of human deaths is significantly underreported (Knobel et al., 2005; Miranda and Meslin, 2006; WHO, 2013). As a result, rabies impacts are often considered insignificant by policymakers, which ultimately results in inadequate political pressure to implement disease control measures.

Rabies has a case fatality rate of almost 100% but is completely preventable with timely intervention of post-exposure prophylaxis (PEP). Prevention of rabies in humans is complicated by the fact that it is often the case that those most commonly exposed to canine rabies (e.g. children and the poor) also lack the resources necessary to treat or prevent exposure. As the relationship between humans and dogs is a main epidemiological driver, the elimination of rabies in dog populations through vaccination campaigns

is necessary to prevent human rabies exposure. As a first step towards examining the feasibility of the global elimination of canine rabies, The World Health Organizations' (WHO) Department of Control of Neglected Tropical Diseases received a grant from the Bill and Melinda Gates Foundation (BMGF) to demonstrate the feasibility of, and promote an evidence-based strategy for, controlling and eliminating human rabies in low-income countries through the vaccination of dogs against rabies. The five-year project (2008–2013) was implemented in endemic regions of three countries: the United Republic of Tanzania (East Africa), Kwa-Zulu Natal (South Africa) and the Visayan Archipelago (Philippines). The BMGF, the UBS Optimus Foundation and the Global Alliance for Rabies Control (GARC) combined efforts to undertake an evaluation of the costs and public health savings across rabies control project sites. Government-led canine rabies elimination strategies have succeeded in many countries around the world, resulting in substantial fiscal savings (Schneider et al., 2007; Shwiff et al., 2007, 2008; Narrod et al., 2012) . It has been demonstrated that collective, inter-sectoral cooperative strategies are most successful in eliminating canine rabies and reducing the associated financial burden (Bogel and Meslin, 1990; Shwiff et al., 2008). Regardless of who initiates rabies management, the economically efficient implementation of management efforts requires a comprehensive understanding of the costs associated with vaccination.

The Philippines, which ranks among the top ten countries worldwide for human rabies deaths, passed the Anti-Rabies Act of 2007, which declared a National policy to control, prevent the spread, and eventually eradicate human and animal rabies, and established the need for responsible pet ownership (Government of the Philippines, 2007). The Visayan Archipelago in the Philippines consists of numerous islands (e.g. Bohol, Cebu, Leyte, Masbate, Negros, Panay and Samar) surrounded by the Visayan Sea and is one of the principal geographic regions in the nation (Fig. 1). The Cebu Province consists of Cebu Island and over 150 surrounding islands with an area of 4943 km^2. Cebu City is the highly urbanized capital of the province with an estimated population of 866 171 (as of 2010). Dog vaccination and PEP programmes exist in the province and are subsidized by national and local governments as well as contributions from dog owners and animal bite patients.

Dog vaccination efforts in Cebu were intensified in 2009 when the project became a demonstration site supported by the BMGF. Our objectives were to estimate the cost per dog vaccinated, cost of PEP administration and cost per human life saved utilizing data collected during 2010–2012 from a highly urbanized city and a low-income rural municipality in the Cebu Province for the Visayan Archipelago project. An assessment of health economics data is a crucial step towards guiding cost-effective management strategies and determining the benefits of canine rabies elimination.

Methods

Vaccination campaigns occur annually in the Philippines. This study analysed the costs of the campaigns occurring

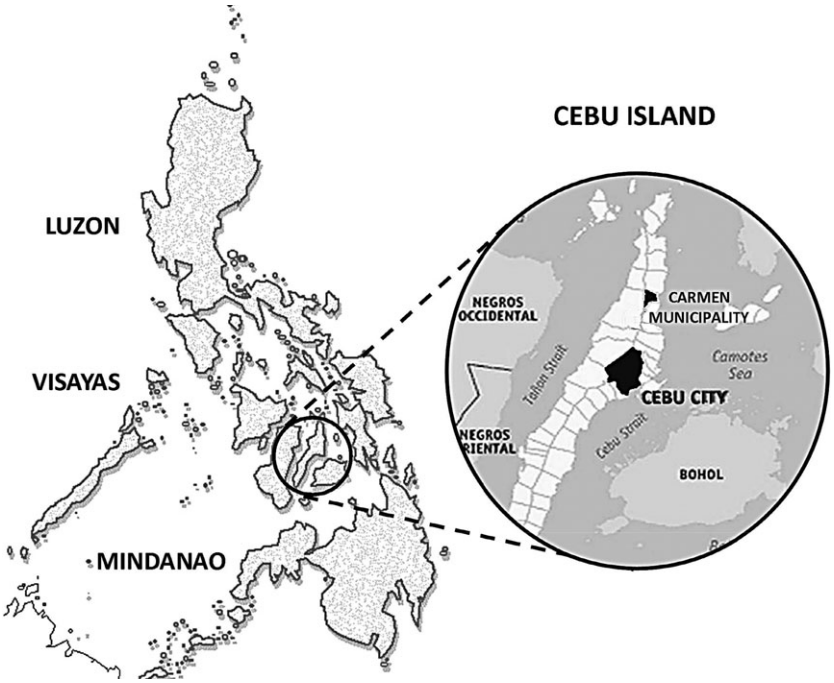

Fig. 1. Map of Cebu, Philippines.

from 2010 to 2012. All costs associated with animal and human vaccination over these periods are considered, including multiple follow-up visits for humans as well as repeat dog vaccination efforts in any given location. Costs were not analysed on per trip, or per visit basis, but rather the location including all visits and campaigns in that location over the year.

Cost data for dog vaccinations and PEP administration were collected for the study period 2010–2012 for two local government units (LGUs): Cebu City, to represent a highly urbanized city and Carmen Municipality, to represent a low-income rural area (Fig. 1). Cebu City had 36 confirmed dog cases and three confirmed human cases over this time period. Carmen had five dog cases and one confirmed human case.

The total costs for dog and human vaccination were calculated using the estimation of several parameters (Table 1). These costs were then divided into cost components and funding sources (Figs 2–5). In all cost analysis, personnel and staff costs were pro-rated to account for estimated time spent on rabies-related work and were based on interviews conducted with personnel. Funding sources included BMGF through the WHO, Department of Health (DOH), Department of Agriculture (DA), Cebu Provincial government, Cebu City government, Carmen Municipal government, dog owners in the form of registration fees, and contributions by other organizations with projects in the area such as the Japan International Cooperation Agency (JICA) in Cebu City. In the case of dog vaccinations, provincial budgets included contributions by the DOH.

Table 1. Parameters required to estimate dog and human vaccination costs

Parameter	Definition
Dog vaccination costs (V)	All biologics used for dog vaccination campaigns
PEP (PEP)	Vaccines, RIG and other supplies
Supplies and equipment (SE)	Syringes, coolers and other equipment associated with the use of biologics
Surveillance (Sv)	Testing animals for rabies
Personnel (P)	Salaries and other personnel costs
Social mobilization (SM)	Public notification efforts prior to vaccination campaign
PrEP (Pr)	Pre-exposure vaccination and subsequent boosters for selected staff
IEC activities (IEC)	Information and education campaigns
Mass vaccination costs (M)	Accommodation and meals for mass vaccination events
Number of dogs vaccinated (N_D)	Total number of dogs vaccinated in 2010
Total cost of human vaccination (TC_{PEP})	PEP + Sv + P + IEP
Number of humans vaccinated (N_H)	Total number of human exposure cases
Total cost of dog vaccination campaigns (TC_D)	V + SE + P + SM + Pr + IEC + M

To compute the number of tissue culture vaccine vials, we took the proportion of patients who received PVRV and PCEC, as costs vary between the two, and assumed that a patient received the same type of vaccine for all the succeeding doses, if any. The proportions of patients who went for one, two, three and four visits were then estimated. We assumed 0.1 ml wastage for the PVRV and 0.2 ml wastage for the PCEC. To compute RIG costs, it was assumed that two vials were used for patients above 15 years old and 1 vial for patients 15 years old and younger. For dog rabies surveillance, all costs related to running the direct fluorescent antibody test (FAT) for rabies diagnosis were considered. The cost of training was also considered, as well as the pre-exposure prophylaxis that laboratory staff received.

Cost per human life saved was calculated by assuming that 3% of patients were bitten by a rabid dog, as per estimates by the Research Institute for Tropical Medicine Rabies Clinic (Miranda, 2005; Quiambao et al., 2005). We assume that the PEP regime was completed by the 3% of patients who were exposed to rabies, and that there was 100% patient survival after PEP treatment. The total cost of PEP treatment is then divided by the number of patients assumed to have been bitten by a rabid dog. All costs are reported in US dollars (USD) and were converted from Philippine pesos (PHP) based on applicable exchange rates for each of the 3 years.[1]

Results

Dog vaccination costs

With no mass vaccination campaigns in Cebu City in 2010, only 11.7% of the dog population was vaccinated at a total cost of $46,244. This increased significantly to 86.4% in 2011 and 88.5% in 2012 with implementation of the BMGF mass vaccination campaigns. Cost per dog vaccinated was computed by dividing the total cost with the total number of dogs vaccinated in a given year. In 2010, the cost per dog vaccinated in Cebu City was $5.79, falling to $1.28 in 2011 and $1.18 in 2012 when mass dog vaccination campaigns were conducted (Table 2). This drop in cost per dog vaccinated was due to the increased vaccination coverage in 2011 and 2012.

Personnel costs were high in 2010, at 65% of the total cost, due to low vaccination coverage, but decreased to approximately 40% of the total cost in 2011 and 2012 as vaccination coverage increased and more dogs were vaccinated leading to economies of scale. The share of vaccines, supplies and equipment was highest in 2011 at 51% (Fig. 2). Across all 3 years, the largest source of funding in

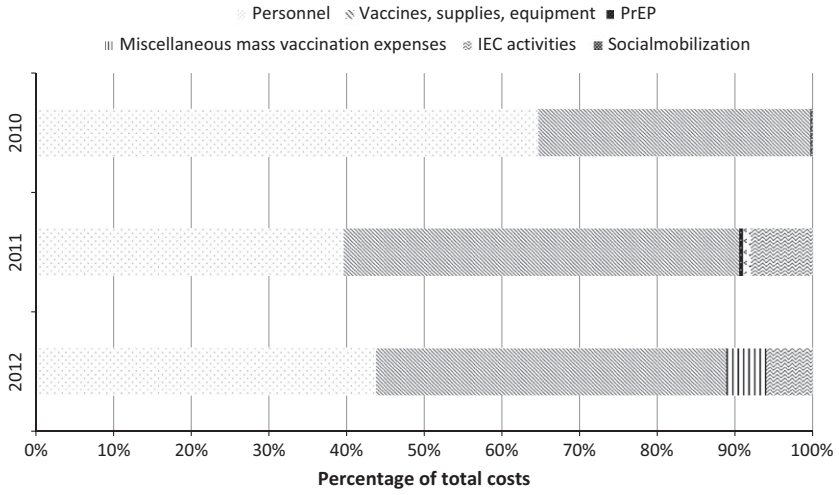

Fig. 2. Dog Vaccination Cost by Component, 2010–2012, Cebu City.

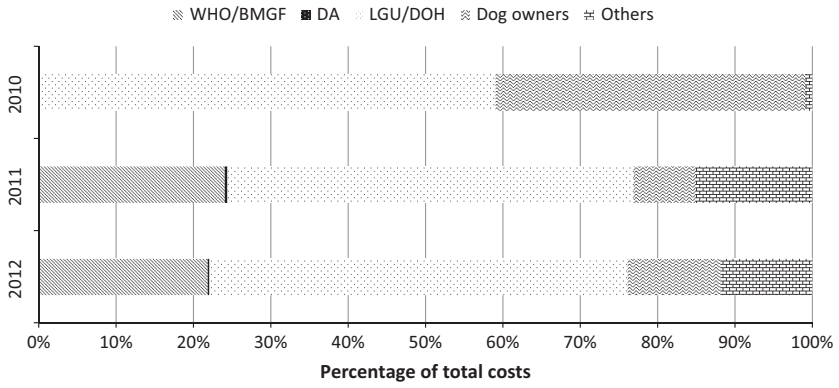

Fig. 3. Dog Vaccination Cost by Funding Source, 2010–2012, Cebu City.

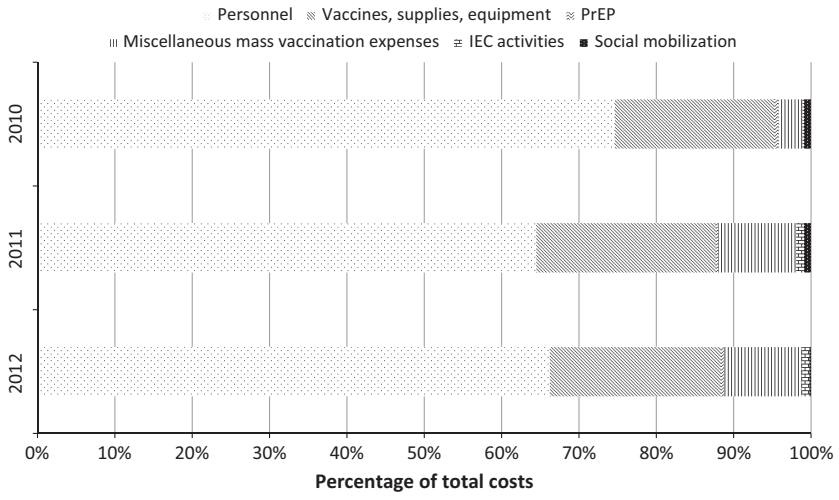

Fig. 4. Dog Vaccination Cost by Component, 2010–2012, Carmen.

Cebu City was the local government. Dog owners also provided a significant contribution in 2010 but this declined in 2011 and 2012 when dog registration fees were waived. The project sites received the BMGF vaccines in 2011 which resulted in a significant increase in BMGF contribution during 2011 and 2012 (Fig. 3).

In 2010, dog vaccination coverage in Carmen was 61.5%. Similar to Cebu City, the mass vaccination campaigns

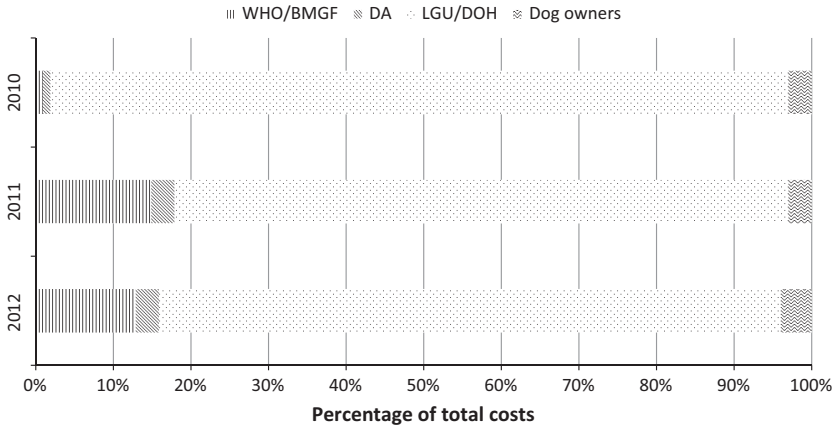

Fig. 5. Dog Vaccination Cost by Funding Source, 2010–2012, Carmen.

Table 2. Dog vaccination cost in USD, 2010–2012, Cebu City

	2010	2011	2012
Vaccination coverage	11.69%	86.39%	88.45%
Total cost	46 244	74 706	70 483
Cost per dog vaccinated	5.79	1.28	1.18

increased coverage to 100% in 2011 and 84.6% in 2012. Total cost of vaccination for Carmen in 2010 was $6,150, and cost per dog vaccinated was $3.38 (Table 3). This was reduced to $2.15 in 2011 and $2.58 in 2012. The largest component of the total cost was related to personnel, which ranged from 65% to 75% across all 3 years. Vaccines, supplies and equipment were approximately 20% of the total cost across all years (Fig. 4). The biggest sources of funding were the provincial, DOH and municipal governments, at 95% in 2010 with a slight decrease in 2011 and 2012 with the BMGF presence (Fig. 5). Dog owners contributed nearly 4% each year. Contribution from the BMGF was 15% in 2011 and 13% in 2012.

PEP

In 2010, 4270 animal bite patients sought PEP in the two animal bite treatment centres (ABTC) located in Cebu City. Of these patients, 43.8% completed all four doses of the PEP. The total cost for the year was $198 853 with the cost per patient at $46.57. It was assumed that each patient received on average 3 PEP treatments. For 2010, the cost per patient who completed the PEP regimen of four treatments was $62.09, with a cost per PEP treatment of $15.52. Costs were similar for 2011 and 2012 even with one additional ABTC established. The average cost per human life saved for the 3 years was $1620 (Table 4).

Table 3. Dog vaccination cost in USD, 2010–2012, Carmen

	2010	2011	2012
Vaccination coverage	61.46%	100%	84.62%
Total cost	6150	9823	9998
Cost per dog vaccinated	3.38	2.15	2.58

The largest component of the total cost was the vaccines, supplies and equipment component, at approximately 88% for all years. The vaccine alone costs roughly $10 per dose. Dog surveillance accounted for roughly 3% of the total cost (Fig. 6). The proportion of dogs testing positive ranged from 24% to 40% over the 3 years. In 2010, 334 animal bite patients came from Carmen. Of those patients, 25% received all four doses of PEP. The total cost of PEP was $13,747 and the cost per patient was $41.16 with per treatment cost of $13.72. These were similar in 2011 and 2012 (Fig. 7). Notably, the cost per patient who completed the PEP series increased in 2012. This was due to an increase in the number of animal samples submitted for testing during that year. Cost per human life saved averaged $1,498 over the 3 years (Table 5).

Similar to Cebu City, the largest component of the total cost in Carmen was the vaccines, supplies and equipment. There were no dog surveillance costs in 2010. In 2012, surveillance was 36% of the total cost (Fig. 8). The proportion

Table 4. PEP cost in USD, 2010–2012, Cebu City

	2010	2011	2012
Total number of patients	4270	4897	6398
PEP completion rate	43.75%	43.72%	43.69%
Total cost	198 853	253 479	303 861
Cost per PEP treatment	15.52	17.25	15.83
Cost per patient with complete PEP	62.09	69.01	63.32
Cost per human life saved	1552.33	1725.41	1583.10

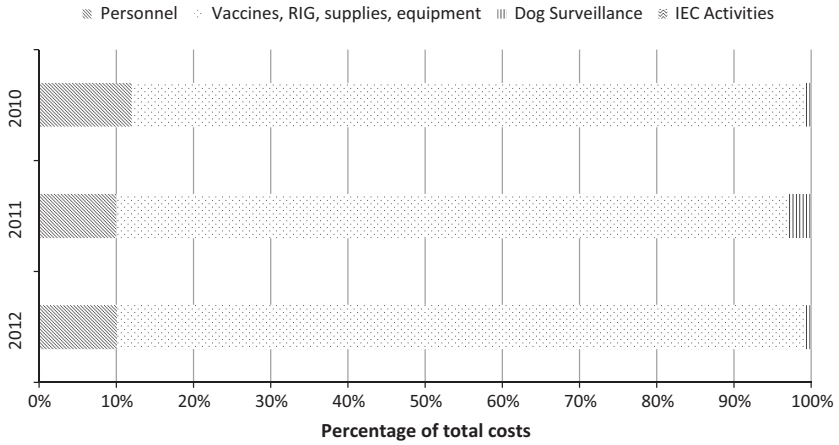

Fig. 6. PEP Cost by Component, 2010–2012, Cebu City.

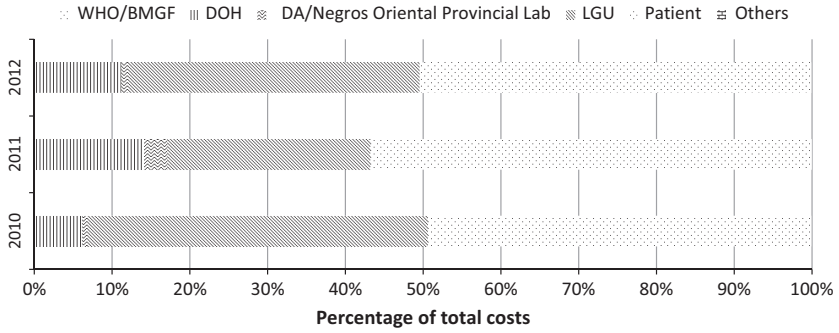

Fig. 7. PEP Cost by Funding Source, 2010–2012, Cebu City.

Table 5. PEP cost in USD, 2010–2012, Carmen

	2010	2011	2012
Total number of patients	334	266	316
PEP completion rate	25%	25%	25%
Total cost	13,747	11,823	15,564
Cost per PEP treatment	13.72	14.81	16.41
Cost per patient with complete PEP	54.88	59.26	65.66
Cost per human life saved	1371.91	1481.56	1641.77

of dogs testing positive ranged from 3% to 75% over the 2 years. Patient out-of-pocket expenditure was the largest funding source of the total cost (Fig. 9).

Discussion

Movement towards the successful elimination of canine rabies depends in part on choosing cost-effective interventions to prevent human rabies exposure. Previous studies have indicated the most cost-effective method of preventing human rabies deaths is through the mass vaccination of dogs, as opposed to treating exposed humans (Fishbein et al., 1991; Meltzer and Rupprecht, 1998; OIE, 2011; Anderson and Shwiff, 2015; Partners for Rabies Prevention, n.d.). Our analysis supports this and additionally provides information on the cost per dog vaccinated and the cost per human life saved, crucial components to determining a cost-effective global elimination plan for canine rabies.

Over the 3 years of this study, there was a significant drop in the cost per dog vaccinated resulting from an increase in the annual total number of dogs vaccinated. In 2010, only 11% of the dog population in Cebu City was vaccinated and 61% in Carmen. It has been estimated that a vaccination rate of <70% may maintain rabies in dog populations (Miranda, 2005). By 2012, almost 90% of the dogs in Cebu City were vaccinated as a result of the mass campaign programmes. In Cebu City, costs for 2010–2012 indicated that mass dog vaccination campaigns at the village level were more cost-effective compared to fixed-site or clinic vaccination. In terms of the cost components of mass dog vaccination campaigns, our analysis found that the single largest relative contributor to dog vaccination costs and campaigns in the two study areas were personnel costs which ranged from 40% to 65% of total costs. In addition, based on WHO purchasing records and survey data from Philippine veterinarians in May 2013, we found that dog vaccines were purchased for $0.25 per dose by the WHO, and for $0.44 to $1.40 per dose by LGUs which also

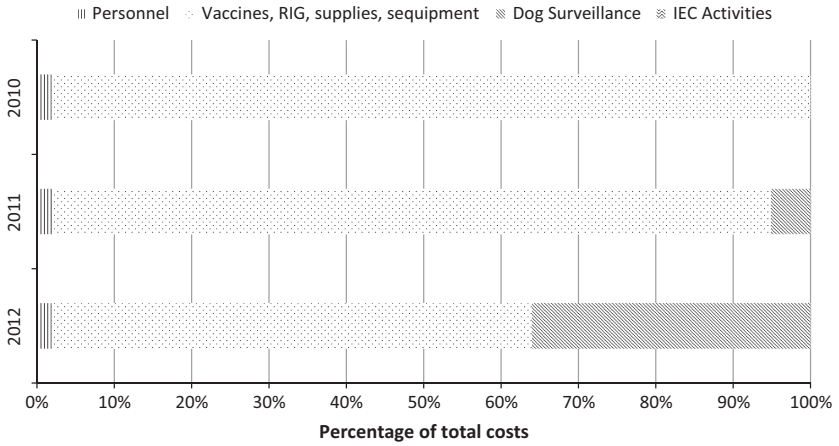

Fig. 8. PEP Cost by Component, 2010–2012, Carmen.

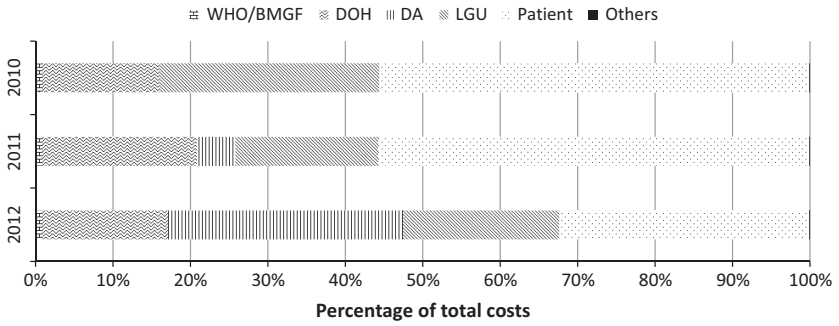

Fig. 9. PEP Cost by Funding Source, 2010–2012, Carmen.

contributed to reductions in the cost per dog vaccinated (Miranda, 2013).

This analysis highlighted potential synergistic funding opportunities for mass vaccination of dogs. A potential source of increased funding originates from the dog owners themselves. First, when outside donors, such as BMGF, contributed to these campaigns, there was an increase in public funding, 35% in Carmen and 83% in Cebu City. This was likely due to more aggressive advocacy to the local chief executives from the well-known funders such as the BMGF and led to a significant increase in the number of dogs vaccinated. Second, data indicated that dog owners contributed roughly 10% of the total funding for 2011–2012 in Cebu City and roughly 4% in Carmen. There were several factors that influence the level of funding contributed by dog owners. These included local ordinances and legislation although these are only as relevant as the ability to enforce them. The willingness to pay by the dog owners could be increased by advocacy and education. Social pressure can also be powerful tool of enforcement and participation (Zinsstag et al., 2007).

This analysis confirmed that health interventions on the human side while successful are also less cost-effective than on the canine side. In addition, the rate of completion of costly PEP was very low for Cebu City (43%) and Carmen (25%), which indicates that between 57% and 75% of potentially exposed individuals are not completing the PEP series once they have started. This non-compliance could be caused by a variety of factors, including capture and rabies determination of offending dog, excessive burden of costs (e.g. clinic visits, transportation, etc.) to the patient, inability to take time off work, and lapse in education or awareness of the dangers of exposure to rabies. Future studies should analyse these possible factors to determine which are most influential and possibly motivate policy aimed at improving compliance with the PEP schedule.

Successful elimination also depends on an understanding of the intra- and inter-species dynamics as well as the threat of reintroduction from bordering provinces and countries. In the Philippines, wildlife does not play a significant role in the rabies epidemiology. Cases involving wildlife are rare and stem primarily from the canine cycle. Rabies is transmitted almost exclusively from canine to canine or from canine to wildlife. While wildlife may not play an integral role in the rabies epidemiology in the Philippines, wildlife can and does contribute to the overall cost of rabies elimination in many other parts of the world. A thorough cost-benefit analysis then must include these wildlife intervention strategies, if any, to present a more accurate picture.

Surrounding provinces and countries also pose a reintroduction threat. As areas of the Philippines approach elimination, efforts have begun shifting towards surrounding

provinces where rabies is still relatively problematic. The Philippines project leaders have been working to establish similar programmes in surrounding areas in order to expand the elimination area or, at the very least, to protect its borders. This is performed by providing technical assistance, training and, where needed, small loans of essential equipment.

Other possible intervention strategies include population control and oral rabies vaccination (ORV) bait distribution. There is no culling of dogs and very small numbers are removed by welfare organizations. Given the relative insignificance of wildlife as a contributor of the problem, ORV baits are not used. Wild dogs are captured using specialized veterinary equipment, vaccinated and released. Education campaigns are common and frequent. There is also significant animal movement and veterinary quarantine controls that are used for inter-island travel.

The programme has been successful in reducing the number of deaths in the project area and reducing the number of confirmed canine rabies cases. Animal and human case data are available over the project timeframe for Cebu Province and City, and Carmen Municipality. Laboratory-confirmed canine rabies cases in all three locations increased from 21 in 2010 to 53 in 2011 then decreased to 49 in 2012. Human deaths in the three areas saw a downward trend over the 3 years with 10 in 2010, 9 in 2011 and 7 in 2012.

There were several limitations to this analysis. The detailed and specific nature of the data collected only allowed for two sites to be examined while maintaining uniformity. Given that many of the cost estimates were based on information gathered from interviews, there was a possibility for recall bias for the retrospective information from key informants. We were unable to disaggregate the data to determine the number of PEP patients who did in fact require the full series and those who were vaccinated unnecessarily. Not all indirect costs were captured as we were unable to collect data on the opportunity costs of patients receiving PEP or the transportation costs associated with their treatment. These findings may not be generalized to other locations as they represented the two extremes in the Philippines, a higher income urban area and a lower income rural area, which only represent Cebu City and Carmen Municipality, respectively. Future studies related to canine rabies in the Philippines could make use of additional data which may enable a more complete assessment of both the costs and benefits of dog vaccination programmes in other areas.

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Note

[1]2010: USD 1 = PHP 44.50, 2011: USD 1 = PHP 44.41, 2012: USD 1 = PHP 42.60.

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