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Cost-description of a pilot parenteral vaccination campaign against rabies in dogs in N'Djaména, Chad

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Summary In the discussion about policies and strategies for rabies prevention in developing countries, intervention costs arise as a major issue. In a pilot mass vaccination campaign against rabies in N'Djaména, Chad, 3000 dogs were vaccinated. We assessed vaccination coverage and cost, showing the cost per dog vaccinated for the public sector and for society. An extrapolation to city level calculated the approximate cost of vaccinating all 23 600 dogs in N'Djaména. In the pilot mass campaign with 3000 dogs the average cost per dog was 1.69 €. to the public and the full societal cost was 2.45 €. If all 23 600 dogs in N'Djaména were vaccinated, the average cost would fall to 1.16 € to the public and 1.93 € to society. Private sector costs account for 31% of the cost to vaccinate 3000 dogs, and 40% of the cost to vaccinate 23 600 dogs. Mass dog vaccination could be a comparatively cheap and ethical way to both control the disease in animals and prevent human cases and exposure, especially in developing countries. The cost-effectiveness of dog vaccination compared with treating victims of dog bites for prevention of human rabies should be further assessed and documented.

keywords dog rabies, N'Djaména, African cities, parenteral vaccination, costing

Introduction

Most human rabies deaths occur in tropical developing countries (Warrell & Warrell 1995), with 24 000–70 000 people estimated to die of rabies each year in Africa and Asia (Knobel *et al.* 2005). The domestic dog is the main vector for human rabies and exposure (Wandeler *et al.* 1993). Development of clinical diseases in humans can be prevented through appropriate post-exposure prophylaxis (PEP), which is however, not always available and affordable in developing countries. Canine rabies could be controlled and human rabies and exposure could be prevented through vaccination of the animal vector. The World Health Organization (WHO) estimates the threshold vaccination coverage for eradication in a dog population empirically at about 70% (WHO 1987), a figure supported by theoretical studies estimating threshold coverage in a transmission model (Coleman & Dye 1996). Constraints to achieving adequate coverage through dog mass vaccination are inaccessible dogs and insufficient community participation. There are, however examples of successful dog vaccination programs (Beran 1991; Schneider *et al.* 2005). With limited resources, the question of costs of intervention becomes crucial in the discussion of which strategy of prevention to use. Bögel *et al.* showed that over a period of 15 years, dog vaccination combined with post-exposure treatment for exposed patients is more cost-effective than PEP alone, where the virus still circulates in the dog population (Bögel & Meslin 1990). However, in many countries and settings, little is still known about the real cost of intervention through mass vaccination of dogs, and quantitative data are urgently needed to evaluate the cost-effectiveness of different rabies control strategies in developing countries, which are currently under review by WHO (Meslin F, personal communication).

In the framework of a research partnership between the Swiss Tropical Institute (STI), the Laboratoire de Recherches Vétérinaries et Zootechniques de Farcha (LRVZ) and the Centre de Support en Santé Internationale au Tchad (CSSI/T), we conducted a study on canine rabies in N'Djaména, Chad. The study consisted of an incidence study, a demographic assessment of the urban dog population and a parenteral pilot vaccination campaign providing, for the first time, an opportunity to examine the costs of vaccinating dogs in an African urban setting. Dog rabies is endemic in N'Djaména with a yearly incidence of 1.4 per 1000 unvaccinated dogs (Kayali *et al.* 2003a) and a long history of rabies case reports (Oussiguéré A, personal

communication). A representative household survey on knowledge, attitudes and practices towards rabies in the urban population of N'Djaména revealed that 19% of all owned dogs were vaccinated (presence of a vaccination certificate). For the interviewed dog owners, the most important constraints to vaccination were transport and the cost of the vaccine (Mindekem *et al.* 2005). Exposed persons do not receive a full-course treatment, and often start PEP with a delay because of shortages of vaccine or financial constraints (Mindekem *et al.* 2005). There is no official intervention strategy against rabies in Chad. With the pilot mass vaccination high vaccination coverage of 64–87% was reached in the dog population because of good community and owner participation in the campaign (in which vaccine was provided free of charge) and the low number of ownerless dogs (Kayali *et al.* 2003b). This paper presents a detailed description of the cost to vaccinate 3000 dogs in a pilot parenteral campaign, and a cost extrapolation to the dog population of the city of N'Djaména, with the aim of contributing to the policy discussion on rabies control in African cities of the Sahel.

Materials and methods

Study site

In 2001 N'Djaména had a human population of 775 020 inhabitants (Ministère du plan et de la cooperation & Ministère de l'interieur et de la sécurité 2001) and an estimated dog population of 23 560 (95% confidence limits: 14 570; 37 898) dogs (Mindekem *et al.* 2005). Three study zones, two with an area of 1 km^2 and one with an area of 0.25 km^2 were chosen in residential N'Djaména for parenteral mass vaccination of 3000 dogs at ambulant vaccination points (VP). The dog population including ownerless dogs was then estimated for each study site, using a capture-mark-recapture approach and Bayesian methodology adapted from (Matter *et al.* 2000), and rabies vaccination coverage in the dog population was calculated for each study zone Kayali *et al.* (2003b).

Vaccination campaign

Prior to the vaccination an information day was held in each zone to distribute posters and to announce the vaccination with a loudspeaker. The campaign supervisors informed the district administrations and met there with local chiefs (heads of small administrative units in the town) who represent traditional and administrative authority. The local chiefs contributed to mobilise dog owners to participate in the campaign. Veterinary technicians working in the campaign had a training day with their supervisors prior to the mass vaccination. In zones I and II, 2 days of vaccination were held and 1 day in zone III. Dogs were vaccinated and marked at eight ambulant VPs, each of them operated by two veterinary technicians and the respective local chief. Two persons supervised the campaign. Staff and equipment were taken to the VPs by a pick-up car. One vehicle circulated between VPs in order to assure the supply of material and vaccine. At the VPs and in the car, the vaccine was kept on ice in cool-boxes. Vaccination points were furthermore equipped with chairs and tables to do the documentation. For each dog there was a separate syringe with needle used, and a vaccination certificate was given to the owner. Each vaccinated dog was marked with a plastic collar. During the campaign PEP was available by the project, but was not used and was not accounted for by the cost analysis.

Cost-description

Public and private sector cost were considered for the cost of the pilot mass vaccination campaign (Table 2). The costs are presented as additional public and societal cost per dog vaccinated (1–3).

$$\begin{aligned}\text{Public cost} = {} & \text{Marginal vaccination cost} \\ & + \text{Equipment of VPs} + \text{Staff per diem} \\ & + \text{Transportation} + \text{Information},\end{aligned} \quad (1)$$

$$\text{Private cost} = \text{Lost worktime} + \text{Transportation}, \quad (2)$$

$$\text{Societal cost} = \text{Public cost} + \text{Private cost}. \quad (3)$$

Marginal costs for each additional dog, and proportional costs among the total societal cost are also calculated. Costs for the canine anti-rabies vaccine Rabisin® were determined from prices quoted by the local importer in N'Djaména, and included information-posters and collars to mark vaccinated dogs. Syringes with needles were bought from the 'Centrale Pharmaceutique d'Achats' (public central pharmacy) in N'Djaména, importing generics and medical products for the public health services. Vaccination certificates were printed locally. Chairs and tables were provided free of charge by local chiefs. Cool-boxes were taken at no charge from the LRVZ, CSSI/T and the local veterinary clinic. Ice-bars, documentation material and bamboo fences (seko) were bought at the market. The vehicles were rented. Staffs were paid a per diem for the vaccination days and the training day, and for those who were involved, the information campaign, and local chiefs were paid for their presence

during the vaccination. To assess private sector cost we assumed that a dog owner would use 1 h of his work time (opportunity cost of work) when he took the dog to the VP for vaccination. To calculate the income loss we assumed an average monthly income of 80 000 FCFA (Franc de la Communauté Financière Africaine; maximum cost, given the high unemployment rate) for 20 work days of 8 h/day. Transportation cost was considered negligible as VPs were distributed homogenously over the study area and within walking distance (<500 m) of the households.

Based on the demographic estimate of the dog population in N'Djaména (Mindekem *et al.* 2005), a cost extrapolation was carried out for the whole city, considering the mean and 95% confidence limits of the dog population estimate. For this, 23 600 (95% confidence limits: 14 600; 38 000) doses of vaccine together with the same amount of syringes with needles and vaccination certificates would need to be purchased. The daily vaccination capacity of one VP is 100 dogs (Kayali *et al.* 2003b), giving a total of 15 days (95% confidence limits: 9; 24 days) to vaccinate 23 600 dogs with 16 VPs. As the VPs would move to a different zone every 2 days, the population would be informed by megaphone and posters before and during the campaign, which needs between 8 and 12 days of input (at least 8 days to take into account all the eight administrative districts of N'Djaména). The supervisors would need 8 days to visit and inform each one of the eight district administrations. Vaccination points would be equipped as above and operated by the same number of people per VP, and two people would still be in charge of supervision. Cool-boxes would have to be rented from a local provider of furniture. Two pick-up cars would be needed for transportation of equipment and staff. Private costs of vaccination are estimated on the same basis as for the pilot campaign. As the costs of the pilot campaign are observed, no ranges were used in the analysis (Table 1). Prices were considered as stable but the throughput of dogs vaccinated is variable. Marginal cost is recalculated for upper and lower confidence limits of the dog population estimate. The average and 95% confidence limits of the dog population estimate in N'djaména were approximated by a negative binomial frequency distribution (Mindekem *et al.* 2005). Since the dog population was the only variable parameter, no further sensitivity analysis was performed. We should bear in mind that the expected vaccination coverage will be close to 70% (Kayali *et al.* 2003b).

Ethical considerations

This study did not involve interventions on humans and hence did not undergo ethical examination. All involved personnel were vaccinated against rabies. During the vaccination campaign the research team maintained stocks of human rabies vaccine to provide post-exposure treatment to persons exposed to suspected rabid dog bites.

Results

The cost items have been grouped into (i) public sector marginal cost for vaccine, syringes and needles, varying with output number of dogs vaccinated, (ii) public sector cost not varying with output number, including the equipment of VPs, top-up of salaries, transportation and information and (iii) private sector cost. All cost are listed in Table 1 for the pilot campaign and Table 2 for the extrapolation for an estimated average of 23 600 (95% confidence interval 23 600 dogs; 38 000 dogs) dogs, respectively. Costs are presented in Euro, using an exchange rate of 1 Euro = 655 FCFA (XOF) (http://www.oanda.com, accessed on 29 November 2005).

Cost per dog vaccinated

To vaccinate 3000 dogs, the average cost per dog vaccinated are 1110 FCFA (1.69 €) to the public, and the marginal cost for every additional dog is 536 FCFA (0.82 €). The average cost to the society is 1610 FCFA (2.45 €) per dog, while the marginal cost for one additional dog is 1036 FCFA (1.58 €). For the extrapolation of the vaccination cost, the given confidence limits of costs refer to the confidence limits of the dog population estimate (Mindekem *et al.* 2005). To vaccinate 23 600 dogs (95% confidence limits: 14 600; 38 000 dogs), the extrapolated (public) average cost per dog vaccinated is 763 FCFA (1.16 €) (95% confidence limits: 746 FCFA (1.14 €); 790 FCFA (1.21 €) while the marginal cost is 425 (0.64 €) for all dog numbers. The full societal average costs 1263 FCFA (1.93 €) (95% confidence limits: 1246 FCFA (1.90 €); 1290 FCFA (1.97 €), with a marginal cost of 925 FCFA (1.41 €).

Components of cost

The relative contributions (%) of different cost items towards societal cost are given in Table 3.

Discussion

There were not many studies performed on the cost per vaccinated dog in a parenteral mass vaccination campaign. Bögel and Meslin (1990) suggest that one vaccinated dog costs 1.30US$ (1.11 €, 1US$ = 0.853 €, http://www.oanda.com, accessed on 29 November 2005), based on data for vaccine administration cost from a national program against rabies in Tunisia, and WHO data on prices

Table 1 Cost of a pilot mass vaccination campaign for 3000 dogs in N'Djaména

Cost item	Units	Work days	Price/unit (FCFA*)	Total cost (FCFA*)
Public sector				
Marginal cost				
Vaccine†	3000	N.A.	425	1 275 000
Syringes with needles	3000	N.A.	61	184 440
Vaccination certificates	3000	N.A.	50	149 978
Equipment of VPs				
Chairs and tables	8	5	Free	0
Seko	8	N.A.	1250	10 000
Wood to fix seko	24	N.A.	750	18 000
Registers	8	N.A.	1750	14 000
Writing material	N.A.	N.A.	N.A.	15 000
Cool-boxes	9	5	Free	0
Ice bars	27	N.A.	1000	27 000
Muzzles	8	N.A.	613	4900
First aid material‡	1	N.A.	4400	4400
Per diem				
Supervisor (training)	2	1	5000	10 000
Supervisor (information§)	2	3	10 000	60 000
Supervisor (vaccination)	2	5	10 000	100 000
Technician (training)	16	1	2500	40 000
Technician (information¶)	3	3	2500	22 500
Technician (information**)	2	3	5000	30 000
Technician (vaccination)	16	5	5000	400 000
Local chief (vaccination)	8	5	2500	100 000
Lunch sandwich (vaccination)	30	5	900	135 000
Transportation				
Pick up (including gasoline)	1	5	25 000	125 000
Car	1	5	50 000	250 000
Gasoline (car)	10	5	500	25 000
Information				
Megaphone	1	3	free	0
Posters	150	N.A.	free	0
Car	1	6	50 000	300 000
Gasoline (car)	10	6	500	30 000
Total public sector			3 330 218	
Average per dog vaccinated			1110	
Private sector				
Lost work time for vaccination	3000	1	500	1 500 000
Transportation to VP	3000	Negligible	0	0
Total private sector			1 500 000	
Total campaign			4 830 218	
Per dog vaccinated			1610	

N.A., Not Applicable; VPs, vaccination points.
*1 Euro = 655 FCFA (13).
†With collars and information-posters.
‡In the car circulating between VPs.
§Meetings with the district administration.
¶With megaphone.
**Poster distribution.

for dog vaccine. These costs are public sector costs and do not take into account any income loss of dog owners during the campaign. However, they are comparable to our extrapolated public add on cost per dog vaccinated in a mass vaccination campaign for the whole town of N'Djaména. In future costing studies the proportion of children and adults presenting their dogs should be assessed to stratify opportunity cost of labour accordingly.

Table 2 Extrapolated costs of vaccinating the entire estimated dog population of N'Djamena (9)

	Lower 95% confidence limit (14 600 dogs)				Average of dog population estimate (23 600 dogs)				Upper 95% confidence limit (38 000 dogs)			
Cost item	Units	Work days	Price/unit (Euro*)	Total cost (Euro*)	Units	Work days	Price/unit (Euro*)	Total cost (Euro*)	Units	Work days	Price/unit (Euro*)	Total cost (Euro*)
Public sector												
Marginal cost												
Vaccine†	14 600	N.A.	0.48	6999.08	23 600	N.A.	0.48	11 313.59	38 000	N.A.	0.48	18 216.79
Syringes with needles	14 600	N.A.	0.09	1359.69	23 600	N.A.	0.09	2197.86	38 000	N.A.	0.09	3538.93
Vaccination certificates	14 600	N.A.	0.08	1114.50	23 600	N.A.	0.08	1801.53	38 000	N.A.	0.08	2900.76
Fixed cost												
Equipment of VPs												
Chairs	48	9			48	24			48	24		
Tables	16	9			16	24			16	24		
Seko	16	N.A.	1.91	30.53	16	N.A.	1.91	30.53	16	N.A.	1.91	30.53
Wood to fix seko	48	N.A.	1.15	54.96	48	N.A.	1.15	54.96	48	N.A.	1.15	54.96
Registers	15	N.A.	2.67	40.08	24	N.A.	2.67	64.12	38	N.A.	2.67	101.53
Writing material	N.A.	N.A.			N.A.	N.A.			N.A.	N.A.		
Cool-boxes	18	9	0.31	5.50	18	15	0.31	5.50	18	24	0.31	5.50
Ice bars	90	N.A.	1.53	137.40	144	N.A.	1.53	219.85	216	N.A.	1.53	329.77
Muzzles	16	N.A.	0.70	11.14	16	N.A.	0.70	11.14	16	N.A.	0.70	11.14
First aid material‡	2	N.A.	6.72	13.44	2	N.A.	6.72	13.44	2	N.A.	6.72	13.44
Per diem												
Supervisor (training)	2	1	7.63	15.27	2	1	7.63	15.27	2	1	7.63	15.27
Supervisor (information‡)	2	8	15.27	30.53	2	8	15.27	30.53	2	8	15.27	30.53
Supervisor (vaccination)	2	9	15.27	30.53	2	15	15.27	30.53	2	24	15.27	30.53
Technician (training)	32	1	3.82	122.14	32	1	3.82	122.14	32	1	3.82	122.14
Technician (information§)	2	8	3.82	7.63	2	8	3.82	7.63	2	12	3.82	7.63
Technician (information¶)	2	8	7.63	15.27	2	8	7.63	15.27	2	12	7.63	15.27
Technician (vaccination)	32	9	7.63	244.27	32	15	7.63	244.27	32	24	7.63	244.27
Local chief (vaccination)	16	9	3.82	61.07	16	15	3.82	61.07	16	24	3.82	61.07
Lunch sandwich (vaccination)	50	9	1.37	68.70	50	15	1.37	68.70	50	24	1.37	68.70
Transportation												
Pick up (including gasoline)	2	9	38.17	76.34	2	15	38.17	76.34	2	24	38.17	76.34
Car	2	9	76.34	152.67	2	15	76.34	152.67	2	24	76.34	152.67
Gasoline (car)	20	9	0.76	15.27	20	15	0.76	15.27	20	24	0.76	15.27
Information												
Megaphone	1	8			1	8			1	12		
Posters	730	N.A.			1180	N.A.			1900	N.A.		
Car	1	16	76.34	76.34	1	16	76.34	76.34	1	20	76.34	76.34
Gasoline (car)	10	16	0.76	7.63	10	16	0.76	7.63	10	20	0.76	7.63
Total public sector				17 604.20				27 476.49				43 283.97
Average per dog vaccinated				1.21				1.16				1.14

Table 2 (Continued)

Cost item	Lower 95% confidence limit (14 600 dogs)				Average of dog population estimate (23 600 dogs)				Upper 95% confidence limit (38 000 dogs)			
	Units	Work days	Price/unit (Euro*)	Total cost (Euro*)	Units	Work days	Price/unit (Euro*)	Total cost (Euro*)	Units	Work days	Price/unit (Euro*)	Total cost (Euro*)
Private sector												
Lost worktime for vaccination	14 600	1	0.76	11 145.04	23 600	1	0.76	18 015.27	38 000	1	0.76	29 007.63
Transportation to VP	14 600	Negligible	0.00	0.00	23 600	Negligible	0.00	0.00	38 000	Negligible	0.00	0.00
Total private sector				11 145.04				18 015.27				29 007.63
Total campaign				28 749.24				45 491.76				72 291.60
Average per dog vaccinated				1.97				1.93				1.90

N.A., Not Applicable; VPs, vaccination points.
*1 Euro = 655 FCFA (fixed parity).
†With collars and information-posters.
‡In the car circulating between VPs.
§Meetings with the district administration.
¶With megaphone.
**Poster distribution.

For a large campaign covering all dogs in N'Djaména, cost per dog vaccinated are substantially lower compared with a small-scale campaign for 3000 dogs. In our pilot campaign we did not account for wastage of vaccines. However, we do not expect wastage to affect cost per vaccinated dog significantly, as we find very little variation between substantially different numbers of dogs to be vaccinated in Table 2. A comparison of the proportional cost shows that among public sector cost the salary component and the information cost decrease substantially when a high number of dogs are vaccinated. Private sector costs for lost income, however, increase when more dogs are vaccinated. The cost distribution in our study (Table 3) is comparable to (Miranda & Miranda 1997), but these authors did not include an estimate of private cost. While the dog population estimate is highly dispersed Mindekem *et al.* (2005) the average cost for the different numbers of dogs used show a surprisingly low variation. Hence, also if vaccination coverage would very likely reach only 70–80% we do not expect the cost per vaccinated dog to increase significantly.

Post-exposure treatment cost is estimated at 55US$ (47 €) with vaccine only, and at 215US$ (183 €) combining vaccine and human immunoglobulines (Bögel & Meslin 1990). In addition to these monetary costs, the fear and anxiety of the patient, which can last for many months are difficult to measure, but are a severe burden. While the aim of this paper was not to present a cost-effectiveness analysis of dog vaccination compared with the treatment of people, the results show that dogs can be vaccinated at low cost in N'Djaména, and the effectiveness and feasibility of dog vaccination was documented elsewhere (Kayali *et al.* 2003b). Based on these results dog rabies transmission could probably be interrupted after a two to three annual campaigns. The incurred costs should be compared with continuous needs for PEP in humans and the duration to break even between dog vaccination and PEP established in analogy to Bögel and Meslin (1990). The vaccination of dogs controls the disease in dogs, and protects human beings from exposure. We suggest that the parenteral mass vaccination of dogs is a comparatively cheap and ethical way to prevent human rabies, especially when full-course treatment for victims of dog bites is not assured, as it is very often the case in developing countries. More research is needed to assess the comparative cost-effectiveness of parenteral dog mass vaccination and PEP against PEP alone, as was performed, for example by Roth et al. for brucellosis (Roth *et al.* 2003). Such an assessment should use a dynamic animal-human transmission model to consider the force of infection during the vaccination campaign (Edmunds *et al.* 2000). In addition it is recommended that DALY estimates are developed for rabies

Table 3 Components of vaccination campaign costs the extrapolation with its lower (LCL) and upper (UCL) 95% confidence limits

		Extrapolated		
	Campaign	Average	LCL	UCL
Number of dogs vaccinated	3000	23 600	14 600	38 000
Public sector cost (%)				
Marginal cost	33.3	33.7	33	34.1
Equipment of VPs	1.9	1.1	1.3	1
Per diem	18.6	14.6	14.6	14.3
Transportation	8.3	8.1	7.6	8.1
Information	6.8	2.9	4.7	2.3
Total public sector cost	68.9	60.4	61.2	59.8
Private sector cost (%)	31.1	39.6	38.8	40.2

VPs, vaccination points.

(Coleman *et al.* 2004) and other zoonotic diseases (Budke *et al.* 2004), as they receive very limited attention in the current burden of disease literature. It is important to present such comparative results to policy makers and funding agencies, to increase the spending on this easily preventable disease that severely affects millions of people in poor developing countries.

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Coûts d'une campagne pilot de vaccination parentérale contre la rage du chien à N'Djamena au Tchad

Dans les discussions sur les politiques et stratégies de la prévention de la rage dans les pays en développement, les coûts des interventions apparaissent comme étant un problème majeur. Dans une campagne pilot de vaccination contre la rage à N'Djamena au Tchad, 3000 chiens ont été vaccinés. Nous avons évalué la couverture et le coût de la vaccination et donnons le coût par chien vaccinée pour le secteur public et pour la société. Une extrapolation à l'échelle de la ville a permis une approximation du coût de vaccination des 23600 chiens de N'Djamena. Dans la campagne pilote sur les 3000 chiens, le coût moyen par chien était de 1,69 Euros pour le publique et de 2,45 Euros pour le coût total a la société. Si tous les 23600 chiens de N'Djamena étaient vaccines, le coût moyen tomberait à 1,16 euros pour le publique et 1,93 Euros pour la société. Le coût dans le secteur privé correspond à 31% du coût total pour la vaccination de 3000 chiens et à 40% du coût pour celle de 23600 chiens. La vaccination en masse de chiens pourrait être un moyen comparativement moins cher et éthique pour le contrôle de la maladie à la fois chez les chiens et pour la prévention des cas et expositions humaines, spécialement dans les pays en voie de développement. Le rapport coût/efficacité de la vaccination des chiens, comparée au traitement des victimes de morsures de chiens pour la prévention de la rage humaine reste encore à être évalué et documenté.

mots clés rage du chien, N'Djamena, villes Africaines, vaccination parentérale, coûts

Costo de una campaña de vacunación parenteral piloto contra la rabia en perros en N'Djaména, Chad

en la discusión sobre políticas y estrategias para la prevención de la rabia en países en vías de desarrollo, los costos suelen surgir como un problema mayor. en una campaña piloto de vacunación masiva contra la rabia en n'djaména, chad, se vacunaron 3,000 perros. hemos evaluado la cobertura vacunal y el costo para el sector público y la sociedad, mostrando el costo por perro vacunado. una extrapolación al nivel de ciudad, calculó el costo aproximado de vacunar los 23,600 perros que hay en n'djaména. en la campaña piloto de 3,000 perros, el coste promedio por perro fue de 1.69 eur para el público y el coste total a la sociedad fue de 2.45 eur. si se vacunasen los 23,600 perros que hay en n'djaména, el costo promedio caería a 1.16 eur para el público y 1.93 eur para la sociedad. los costos del sector privado explican el 31% del coste de vacunar 3,000 perros, y 40% del coste de vacunar 23,600 perros. la vacunación masiva de perros podría ser comparativamente más barata y una forma ética para controlar la enfermedad en los animales y prevenir los casos y la exposición en humanos, especialmente en países en vías de desarrollo. se debería evaluar y documentar más a fondo la costo-efectividad de la vacunación de perros, comparada con el tratamiento de las víctimas de mordeduras de perros, en la prevención de la rabia en humanos.

palabras clave rabia canina, N'Djaména, ciudades Africanas, vacunación parenteral, costos

