Veterinary and Animal Science 24 (2024) 100347

Contents lists available at ScienceDirect

Veterinary and Animal Science

journal homepage: www.elsevier.com/locate/vas

Rabies incidence and burden in three cities of Cameroon (2004–2013)

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A R T I C L E I N F O

Keywords:
Rabies
Incidence
Dogs
Humans
Burden
DALY
Cameroon

A B S T R A C T

Rabies is a fatal disease occurring worldwide and especially in almost all the countries in Asia and Africa including Cameroon. Though animal and human rabies is prevalent in Cameroon, the epidemiology and socio-economic burden of the disease in the country is not known. Therefore, a 10-year (October 2004–April 2013) retrospective study on the incidence of animal and human rabies and its burden in Garoua, Ngaoundéré and Yaoundé in Cameroon was carried out. Records of human cases were extracted from the database of the regional hospitals, and animal cases from the databases of Centre Pasteur and National Veterinary Laboratory. The burden of the disease was assessed through the estimation of costs linked to preventive measures (vaccination), corrective procedures (Post Exposure Treatment), Disability-Adjusted Life Year (DALY) and overall societal cost of the disease. Overall, 56 rabies-suspected human deaths, corresponding to an incidence of 0.02 ± 0.00 ‱ and Animal Rabies Incidence (ARI) of 0.37 ± 0.00 % among 1844 suspected animal cases were recorded. The economic loss due to preventive measures of 326,046 ± 28,130.85 USD, related to corrective procedures of 806,741.25 ± 2,466.08 USD, and DALY of 1690.28 ± 4.76 years were estimated. This is the first study that highlights the enormous socio-economic burden associated with animal and human rabies in endemic parts of Cameroon and emphasizes on enhancing rabies eradication strategy focusing on the One Health approach.

Introduction

Rabies is a fatal disease with almost half of the global annual deaths occurring in Africa (Lodha et al., 2023). The impact of the disease is grossly underestimated due to the scarcity of reliable data which hampers its control and eradication (Rupprecht et al., 2022) and scanty studies on its socio-economic burden (Lodha et al., 2023; Nel, 2013). Rabies is neglected in many countries, even where it is endemic and the evaluation of its impacts has often focused on mortality where vital indicators such as time, disability and socio-economic impacts of the Disease are overlooked (Hampson et al., 2015). Therefore, a better understanding of the burden of rabies entails the association of deaths to other indicators such as Disability-Adjusted Life Year (DALY) due to the disease (Hampson et al., 2015; Knobel et al., 2005; Lembo et al., 2010).

Despite the fact that animal and human rabies are endemic and some epidemiological data and control measures of animal and human rabies (Awah-Ndukum et al., 2002, 2004; Dah et al., 2023; Wobessi et al., 2023) and dog ecology in relation to rabies (Awah-Ndukum, 2003; Ngah Osoe et al., 2018) have been described in Cameroon, there is a dearth in information on the socio-economic impact of the disease in the country. The years of life lost to due to premature mortality and years lived with disabilities due to rabies in Cameroon are not known. Therefore, it is essential to determine the burden and economics of rabies management, such as the cost of prevention through vaccination versus post-exposure treatment of suspected cases. Also, it is essential to estimate the loss of years due to rabies and its societal cost through the evaluation of Disability Adjusted Life-Year (DALY) for better understanding of the trend and impact of the disease, which was done for the first time in the country. In this context, this study was carried out to assess the incidence, socio-economic impact and Disability Adjusted Life-Year (DALY) of human and animal rabies over a period of ten years (2004–2013) in Cameroon.

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https://doi.org/10.1016/j.vas.2024.100347

Available online 24 March 2024

Materials and method

Study area and period

The retrospective study (2004–2013) was carried out during the period of October 2013–April 2014 in the cities of Garoua, Ngaoundéré and Yaoundé of the North, Adamaoua and Centre regions of Cameroon, respectively (Fig. 1) and are located in the Sahelian, Sudanian and tropical agroecological zones of the country. These areas were selected based on previous confirmation of endemic animal and human rabies in them (Awah-Ndukum et al., 2002). Three teams of two people each were responsible for collecting information including incidence of animal and human rabies and its burden from relevant sites in the cities of Garoua, Ngaoundéré and Yaoundé. Overall, 12 veterinary services including 3 public veterinary clinics (1 in each city) and 09 private veterinary clinics (1 in Ngaoundéré and 8 in Yaoundé) and 03 laboratories namely the National Veterinary Laboratory (LANAVET) and its annex (Garoua and Yaoundé) and the Centre Pasteur and its annex (Yaoundé and Garoua) were used in the study.

Data collection and analysis

Animal rabies incidence (ARI)

Data related to animal rabies was collected from the databases of public and private veterinary services for suspected rabies cases, while the confirmed cases was obtained from databases of the National Veterinary Laboratory (LANAVET Garoua and Yaoundé) and the Centre Pasteur (Garoua and Yaoundé) after analysis via the direct Fluorescent Antibodies Test (dFAT). The Annual Rabies Incidence at a 95 % confidence interval was then calculated through the following formula as described by Thrusfield (2007).

$$ARI = \sum_{i=x}^{y} \frac{Laboratory\ confirmed\ positive\ cases}{Suspected\ cases\ x\ T} x\ 100$$

Where: i = years from x = 2004 and y = 2013; T = number of years of observation

Clinically suspected human positive rabies incidence

Though laboratory diagnosis of human rabies cases is not routinely done in Cameroon, records of human cases were extracted from the database of the regional hospitals (Garoua, Ngaoundéré and Yaoundé). Therefore, the study used clinically suspected Positive Rabies Incidence (CSHPRI) which was established based on the (i) history of the person bitten mainly by dog(s) within a period of less than two months; (ii) death of the concerned dog(s) with clinical rabies symptoms; and (iv) death of the concerned patient with hydrophobia symptom.

The estimated annual Incidence was assessed by the following formula:

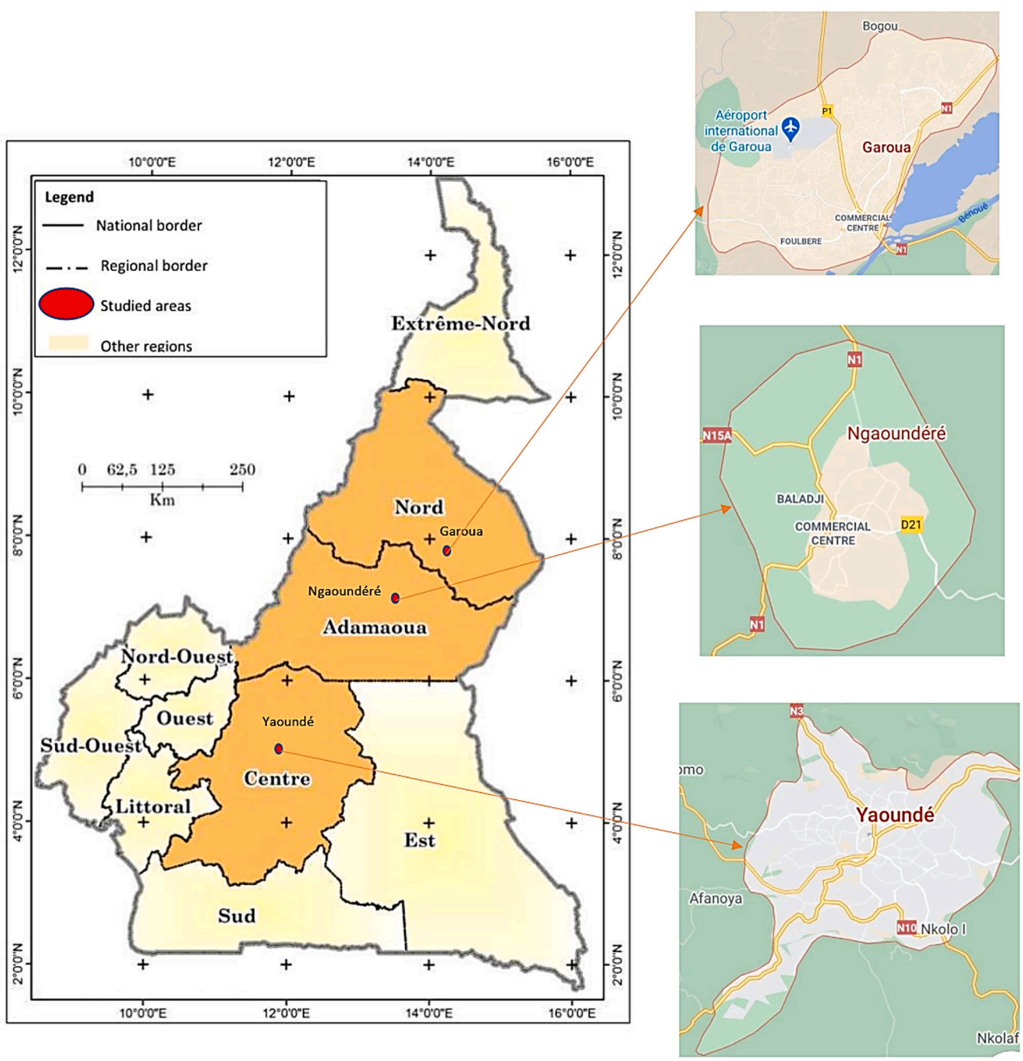

Fig. 1. Map of Cameroon showing study areas in the North (Garoua), Adamaoua (Ngaoundéré) and Centre (Yaoundé) regions.

$$CSHPRI = \sum_{i=x}^{y} \frac{Clinically\ suspected\ cases}{Nx\ T} x\ 100$$

Where : i = years from x = 2004 and y = 2013; N = Population size of the studied areas; T = number of years of observation.

Financial cost

Preventive measures

The number of vaccinated animals was obtained from databases of public and private veterinary services (MINEPIA Regional Delegations and private Veterinary clinics in Garoua, Ngaoundéré and Yaoundé) in the study cities. The evaluation of the cost of preventive measures was calculated based on the overall cost of antirabies vaccination of animals as previously described by Knobel et al. (2005) as follows: $CRP = NVA\ x\ CRV$ with $CRV = CV + CDVA$ where CRP = Cost of rabies prevention, NVA = Number of vaccinated animals; CRV = Cost of rabies vaccination; CV = Cost of vaccine, CDVA = average cost of displacement to vaccinate animal(s).

Corrective procedures

The assessment of the financial cost for corrective procedures was linked to the evaluation of the Post Exposure Treatment (PET) following human exposure to rabies and HCSPRI. Only complete corrective procedures of PET were considered for estimation of the associated financial cost which included cost of the different tools and products (e.g. rabies, vaccines, syringes, antiseptic and others), lost work time and labour cost for the technician per treatment and human patient (Mindekem et al., 2017). The national guaranteed mean minimum wage for the technician for the period of 2004–2013 (approximately 50 USD) divided by the monthly working time (140 h) was used to estimate the lost work time. While the cost of labour for a technician equated to fixed consultation and follow-up charged to persons on PET during the study period.

Estimation of the burden of rabies

The evaluation of DALY of rabies was done using standard comparative measures of the burden of the disease in terms of lost life time and life lived in disability due to the disease through determination of the DALY score and financial cost of death as previously described (Hampson et al., 2015; Knobel et al., 2005). The direct DALY score was based on Years of Life Lost (YLL) because of premature deaths caused by rabies and indirect DALY score was based on the Years of Life Lived with Disability (YLD) due to the disease (WHO, 2013a). Associated financial cost due to the impacts of adverse or side effects of antirabies vaccination and PET during the study period were not considered because there was no available data related to such effects. However, estimates of subsequent financial cost of deaths due to rabies also considered the human capital approach based on productivity losses and mean country-specific GDP per capita without discounting (Hampson et al., 2015). The estimation of DALY of rabies in the study was done using the following formula (Fox-Rushby & Hanson, 2001):

$$\begin{aligned} \mathrm{DALY}[\mathrm{r},\mathrm{K},\beta] &= \mathrm{YLD}[\mathrm{r},\mathrm{K},\beta] + \mathrm{YLL}[\mathrm{r},\mathrm{K},\beta] \\ &= \frac{\mathrm{KCe^{ra}}}{(\mathrm{r}+\beta)}\left[\mathrm{e}^{-(\mathrm{r}+\beta)(\mathrm{L+a})}[-\mathrm{r}+\beta)(L+a)-1\right] \\ &\quad - \mathrm{e}^{-(\mathrm{r}+\beta)\mathrm{a}}[-\mathrm{r}+\beta)\mathrm{a}-1]] + \frac{1-\mathrm{k}}{\mathrm{r}}(1-\mathrm{e}^{-\mathrm{rL}}) \text{ with YLD} \\ &= 0 \end{aligned}$$

Where:

K = Age weighting modulation factor; C = Constant; r = Discount rate; a = Age at death, β = Parameter from the age weighting function; L = Standard expectation of life at age a, with YLD = 0.

K, c, r, β, and *L* were obtained from WHO guidelines for DALY calculations (WHO, 2013a)

Data analysis

The data were saved in Epidata™ version 2.0 then exported and analysed using the Microsoft Excel™ software 2010. Two main statistical tests were used to test the independence of indicators in this study. The logistic regression was used to test the significance of the relation between ARI and location, HCSPRI and DALY scores between locations. While a one-way Analysis of Variance (ANOVA) was used to compare the effects of location on rabies vaccination of animals and PET. The results were expressed with their 95 % confidence intervals and statistical significance set at $P < 0.05$.

Results

Animal rabies incidence (ARI)

A total of 1844 animals (1839 dogs (99.73 %), 3 monkeys (0.16 %) and 2 cats (0.11 %)) were suspected and observed for clinical rabies during the period 2004–2013 in the study cities. Overall, 68 animals (67 dogs (98.53 %); 1 cat (1.47 %)) were confirmed positive for rabies following laboratory analysis corresponding to an Annual ARI of 0.37 ± 0.00 %. The area specific incidence was 0.18 ± 0.01 % in Garoua, 0.07 ± 0.01 % in Ngaoundéré and 0.52 % in Yaoundé (Table 1). The study showed continuous and increasing trend over the years of the reporting of rabies cases (suspected and confirmed cases) in the Garoua, Ngaoundéré and Yaoundé (Fig. 2). However, location significantly influences the probability of rabies occurring (Cox and Snell R square (R2CS): 0.48, $\chi 2 = 44.70$, p-value = 2.0e-^{10}). For example, the highest proportion of rabies cases was recorded in Yaoundé followed by Garoua and Ngaoundéré.

Clinically suspected human rabies incidence (CSHRI)

Though doctors acknowledged human rabies cases in hospitals in Yaoundé (personal communication), cases were not recorded in the database used in the present study. Data on Clinically Human Suspected Rabies Incidence were obtained only in the cities of Ngaoundéré and Garoua. Overall, 56 human rabies victims were observed among the 3,500,988 persons in the databases in Ngaoundéré and Garoua, corresponding to a CHSRI of 0.02 ‰ with many victims being less than 15 years old (33.93 %) and males (55.36 %) (Table 2).

Logistic regression showed that there was no correlation between location and rabies incidence (Cox and Snell R square (R^2_{CS}): 0.0047; $\chi 2 = 0.26$, p-value = 0.61) though there was a significant difference in the proportions of cases between locations ($p < 0.05$). Furthermore, the likelihood of occurrence of a suspected rabies case was higher among females aged more than 15 years old in Garoua than elsewhere (Odds Ratio = 4.6 exp^{-86}).

Financial cost

Preventive measures

During the period 2004 to 2013, a total of 3150.10 ± 1891.21 animals were vaccinated against rabies, corresponding to 208.60 ± 84.67 in Garoua; 683; ±; 45.15 in Ngaoundéré and 2873.2 ± 1893.70 in Yaoundé (Fig. 3). However, the price of a rabies vaccine has varied from 6 USD in 2004, to 14 USD in 2009, and the cost of displacement to a vaccination site varied from 0 to 6 USD. Therefore, the estimated labour cost of vaccination was 9.2 ± 3.92 USD (5.28–13.12) USD, and cost of preventive measures was 326,046 ± 28,130.85 (297,915.15–354,176.85) USD. Though there was a significant difference between location and number of animals vaccinated against rabies ($p < 0.0001$), the rate of vaccination was highest in Yaoundé (92.21 %) followed by Garoua (6.62 %) and Ngaoundéré (2.17 %).

Table 1
Animal rabies incidence and geographic distribution of suspected and confirmed animal cases (2004–2013).

Year	Garoua			Ngaoundéré			Yaoundé			Total		
	Suspected cases	Confirmed cases		Suspected cases	Confirmed cases		Suspected cases	Confirmed cases		Suspected cases	Confirmed cases	
	n	*n*	%	*n*	*n*	%	*n*	*n*	%	*n*	*n*	%
2004	74	2	2.70	14	0	0	65	0	0	153	2	1.31
2005	78	1	1.28	14	1	7.14	17	0	0	109	2	1.83
2006	52	1	1.92	18	0	0	98	0	0	168	1	0.60
2007	51	4	7.84	11	0	0	127	1	0.79	189	5	2.65
2008	63	2	3.17	15	0	0	118	0	0	196	2	1.02
2009	111	1	0.90	2	0	0	79	10	12.66	192	11	5.73
2010	76	1	1.32	17	0	0	145	13	8.97	238	14	5.88
2011	49	0	0	25	0	0	249	8	3.21	323	8	2.48
2012	60	0	0	11	0	0	86	12	13.95	157	12	7.64
2013	46	0	0	2	0	0	71	11	15.49	119	11	9.24
Total	**660**	**12**	**1.82**	**129**	**1**	**0.78**	**1055**	**55**	**5.21**	**1844**	**68**	**3.69**
95% CI of%		**0.99–3.25**			**0.04–4.89**			**3.98–6.77**		**–**	**2.9–4.68**	

n = number; % = proportion; 95 % CI of % = 95 % Confidence Interval of the proportion.

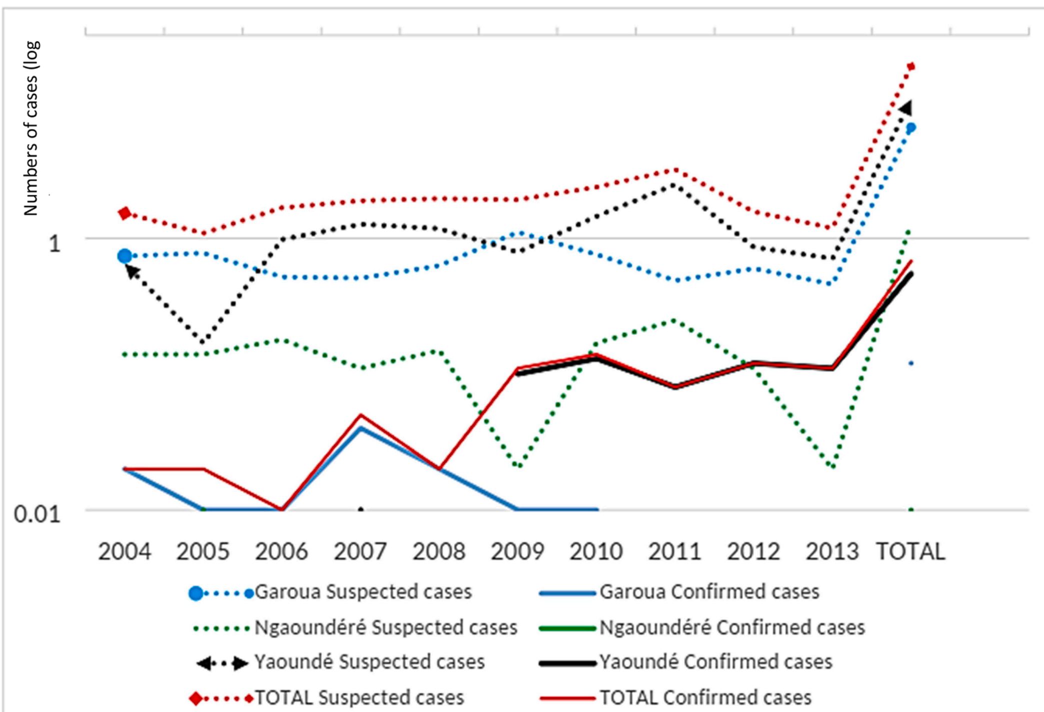

Fig. 2. Suspected and confirmed animal rabies profile in Garoua, Ngaoundéré and Yaoundé (2004–2013).

Table 2
Human suspected rabies cases geographic and age distribution.

Years	*Ngaoundéré n(%)*			*Garoua n(%)*			*Total (a + b)*
	]0–15]	]15-+[	*Total a*	]0–15]	]15-+[	*Total b*	
2004	0	1	*1*	2	4	*6*	**7 *(12.5)*[a]**
2005	1	1	*2*	3	1	*4*	**6 *(10.71)*[a]**
2006	0	2	*2*	2	4	*6*	**8 *(14.28)*[b]**
2007	0	2	*2*	1	2	*3*	**5 *(8.93)*[c]**
2008	0	1	*1*	2	5	*7*	**8 *(14.28)*[a]**
2009	0	1	*1*	4	3	*7*	**8 *(14.28)*[a]**
2010	0	1	*1*	2	0	*2*	**3 *(5.36)*[d]**
2011	0	2	*2*	2	3	*5*	**7 *(12.5)*[a]**
2012	0	0	*0*	1	1	*2*	**2 *(3.57)*[d]**
2013	0	0	*0*	0	2	*2*	**2 *(3.57)*[d]**
Total	**1[a]**	**11[b] *(91.67)***	**12**	**20[a] (45.45)**	**24[b] (54.55)**	**44**	**56**
N(%)	***(0.08)***		***(100)***			**(100)**	***(100)***

Value in a line with different letters in the same area are significantly different ($p < 0.05$).
Value in a column with different letters are significantly different ($p < 0.05$).

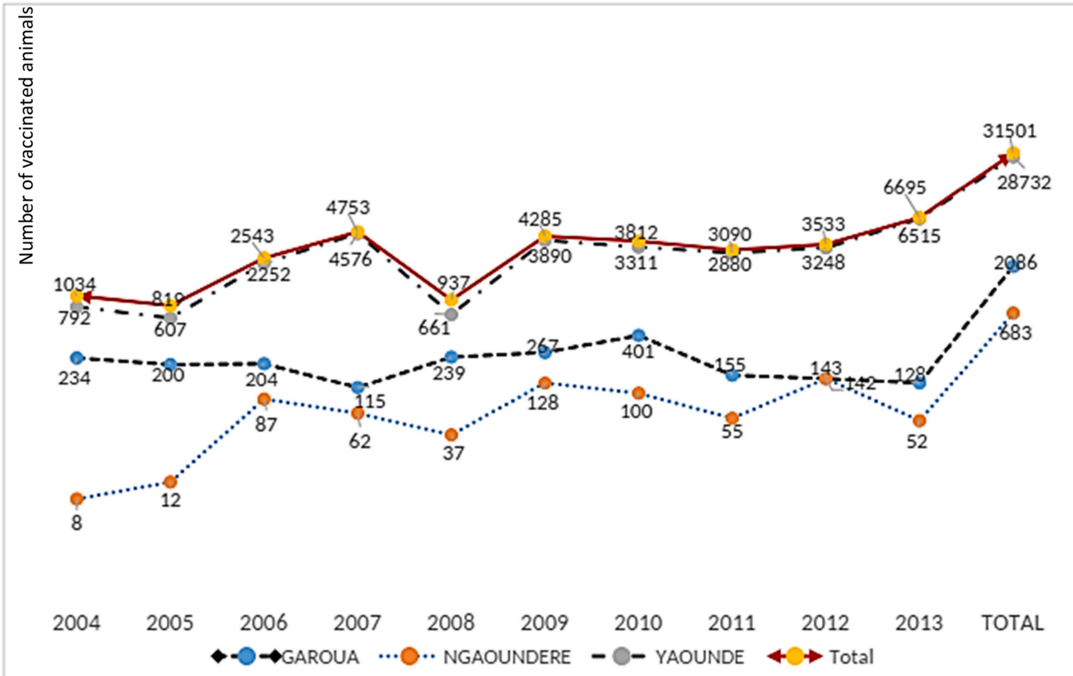

Fig. 3. Evolution of canine vaccination in Garoua, Ngaoundéré and Yaoundé (2004–2013).

Corrective procedures

The records showed that a total of 10,950 persons had a complete Post Exposure Treatment (PET) against rabies (Zagreb protocol) corresponding to 9.07 % in Garoua and 90.93 % in Yaoundé (Fig. 4). However, considering that 50 % of victims followed the WHO recommended procedure WHO (2013b), which states that exposed persons should be administered antibiotics and anti-inflammatories products; an estimated cost for a complete PET of 70.85 USD was obtained.

The study showed a significant difference between the number of persons according to location ($p < 0.001$), and an estimated total financial cost for PET of 806 741.25 ± 2 466.08 USD (Table 3).

Burden of the disease

The study showed that the estimated Disability-Adjusted Life based on CHSRI was 1690.28 ± 4.76 Years of Life Lost (YLL) ($K = 1$; $r = 0.03$, $\beta = 0.1658$) corresponding to 1303.59 ± 6.72 and 303.68 ± 1.89 YLL for Garoua and Ngaoundéré ($p < 0.05$), respectively. The subsequent direct financial lost due to productivity losses associated to premature deaths in the study cities was estimated at 2178,973.92 ± 61,218.88 USD.

Thus, the estimated overall total direct financial lost due to the disease (cost of PET + financial cost of DALY's) for the ten years period (2004–2013) was 2985,715.17 ± 31,842.48 USD, corresponding to an average loss of 298,571,52 ± 3184.40 USD per annum.

Table 3
Post Exposure Treatment Cost evaluation from 2004 to 2013 in Garoua and Yaoundé cities of Cameroon.

Cost items	Unit basis	Cost in USD[c]
Vaccine cost for one PET	Per dose	15
Cost for technician	Per person	0.37
Cost for syringe and needles	Per treatment	0.8
Tetanus vaccine (1 dose)	Per person	6
Antibiotics and Anti-inflammatories	Per treatment	10
Water	Per person	0.07
Antiseptic	Per person	0.47
Lost work time[a]	Per treatment	2.14
Transport cost[b]	Per treatment	6
Total	Per treatment	70.85
Number of PET	10,950	
Total Cost of PET	806,741.25 ± 2466.08	

[a] . 50 % of patients are accompanied.
[b] . Expenses for accommodation not included.
[c] . with 1 USD = 500 FCFA.

Discussion

The areas used in this study (Garoua, Ngaoundéré and Yaoundé) are highly metropolitan and have infrastructures for the benefits animal and human welfare and wellbeing including health centres and laboratories. These observations are similar to the characteristics of urban areas worldwide irrespective of the region people including the location of more health centers in these areas compared to rural areas (BUCREP, 2010a; 2010b; Leyland et al., 2014).

The Animal Rabies Incidence obtained in our study for the three regions (Garoua, Ngaoundéré and Yaoundé) was less than the half of the value obtained ten years ago (0.85 %) for a similar study done by Awah-Ndukum et al. (2002). This shows that even if the disease is still endemic, an improvement has been done in the fight of the disease explained by a better knowledge of the disease, and by the increase of the number of veterinary clinics (publics and private) in the country between the two studies (Awah-Ndukum et al., 2002, 2003, 2004; Dah et al., 2023). In this study 98.53 % of rabies cases were lined to dogs, showing that they are the principal reservoirs and victims of the disease in domestic animals. Dogs have been described as the main reservoir and transmitter of the disease of rabies (Dah et al., 2023; Sofeu et al., 2018; Wobessi et al., 2023). This finding agrees with reports that dogs are the main reservoir and source of rabies in parts of Asia and Africa (Lin et al., 2023; N'Guessan et al., 2022). In agreement with reports done by Ngah Osoe et al. (2018) and Wobessi et al. (2023), the incidences of animal rabies were higher in Yaoundé, where there is a higher level of awareness about the disease and access to veterinary structures compared to other cities.

As for Human clinically Suspected Rabies Positive Incidence (HCSPRI), the study showed an average of 5.6 ± 2.4 persons were affected annually contrary to Lembo et al. (2010) who reported about 162 human deaths per annum in 37 African countries. Many factors,

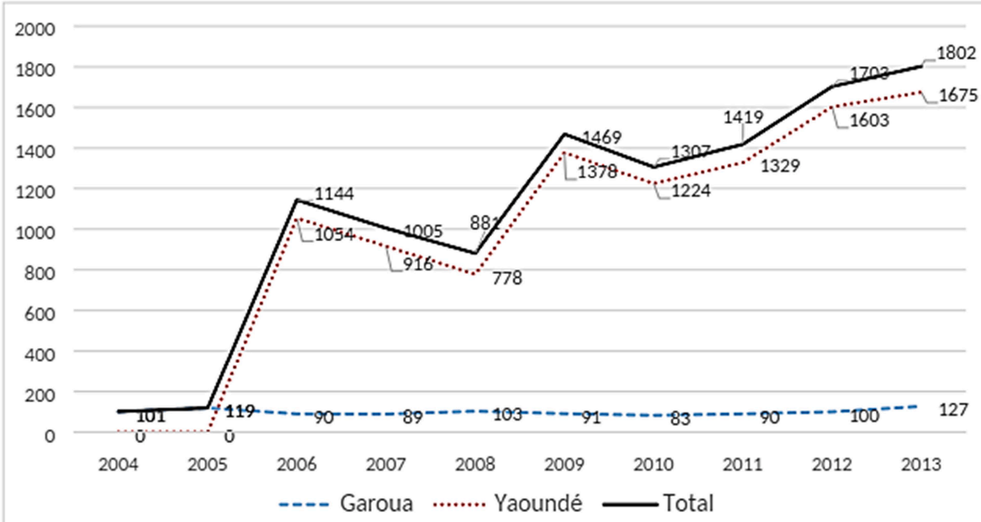

Fig. 4. Evolution of post exposure treatment profile in Garoua and Yaoundé (2004–2013).

including uneven distribution between countries and lack of systematic investigation and laboratory analysis in many countries (Knobel et al., 2005; Nel, 2013; WHO, 2013b), among others, explained the difference. However, the findings of the present study agree with those of Hikufe et al. (2019) and Lin et al. (2023) who reported human rabies incidence of 0.1–0.3 per 100 000 and 0.8–2.6 per 100 000, respectively, and similar levels of knowledge and attitudes and practices about rabies. The regression analysis showed that the likelihood of occurrence of human rabies cases was higher in Garoua compared to the other cities. It is worth noting that the worse management and most unsatisfactory practices against the disease in the country have been described in Garoua, where unorthodox traditional treatment of humans related dog bites are preferred instead of following the recommended standard hospital procedures (Ngah Osoe et al., 2019). The majority of HCSPRI cases were among relatively young persons (about 15 years) in the present study, similar to the observation of Sofeu et al. (2018) who reported over 40 % rabies cases among persons less than 15 years. Children usually hide and do not report dog-bite wounds and are more susceptible being bitten by stray dogs than adults (WHO, 2005).

The societal and financial costs of rabies in this study was over seven times higher than the invested cost to prevent the disease in animals due mainly to productivity losses from premature deaths. Hampson et al. (2015) reported a similar estimation for the global burden of rabies. Similarly, the expenditure on corrective procedures (PET) was three times compared to the cost for preventive measures linked to vaccination of animals. This suggests that the potential risk of rabies is not understood by communities with dogs and dog owners (Awah-Ndukum et al., 2003, 2004; Ngah Osoe et al., 2019). Similar observations have been recorded among communities where sociocultural and economic factors hinder effective control against rabies including irresponsible dog ownership and poor attitudes towards handling their animals (Awah-Ndukum et al., 2004; Bucher et al., 2023). Lower expenditure for corrective procedures (PET) associated with free rabies vaccination of animals has been recorded in Ivory Coast (N'guessan et al., 2023). However, in the present study a reactive management strategy against rabies was frequently used and the cost of Post-Exposure Prophylaxis or Treatment was significantly higher than the cost of mass animal vaccination campaigns. The high PET cases highlight the fact that many suspected and unvaccinated dogs are in the studied areas.

The estimation of the burden of rabies in the present study is the first in the country. The high DALY value obtained in the study was due mostly to deaths that among affected children which induced more loss of life years (Hampson et al., 2015; Knobel et al., 2005; Lembo et al., 2010). This finding highlights a huge burden of animal and human rabies from societal cost and DALY's evaluations in the study areas and Cameroon in general through the loss of potentially productive labour populations and economic resources.

Conclusion

The study reports animal and human rabies incidence and burden in Garoua, Ngaoundéré and Yaoundé cities of Cameroon over a ten-year period (2004–2013). It presents the first estimate of associated societal costs and DALY's of rabies in an endemic part of Cameroon. Animal and human rabies were recorded throughout the study period and in all the study cities, with an overall incidence rate of 0.02 ‱ in humans and 0.37 % in animals. Economic losses due to preventive measures of 326,046 ± 28,130.85 USD and related to corrective procedures of 806,741.25 ± 2466.08 USD, as well as DALY of 1690.28 ± 4.76 years were estimated. The study revealed an enormous socio-economic burden associated with animal and human rabies in endemic parts of Cameroon. The significantly higher cost of Post Exposure Prophylaxis or Treatment compared to the cost of preventive measures including mass vaccination of animals highlights the fact that large numbers of suspected and unvaccinated dogs exist in the study areas. Further focus on the awareness and management of zoonotic rabies cases using a coordinated one-health approach in urban and rural areas of the country cannot be overemphasized.

Ethics approval and consent to participate

Ethical approval was sought from the ethics committee of the School of Veterinary Medicine and Science of the University of Ngaoundéré. An administrative authorization was obtained from the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA) and from all the private veterinary clinics of the studied areas, so as the regional health delegate.

Animal rights

No action was done during in order to harm animals.

Funding

No specific funding was received for this study.

Data transparency

The datasets used for this study are available from the corresponding author upon a reasonable request.

CRediT authorship contribution statement

Ngah Osoe Bouli Freddy Patrick: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Awah-Ndukum Julius:** Validation, Supervision, Project administration, Methodology, Data curation. **Mingoas Kilekoung Jean-Pierre:** Writing – review & editing, Validation. **Mouiche Mouliom Mohamed Moctar:** Writing – review & editing, Visualization, Software, Formal analysis.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Acknowledgments

The authors are grateful to Centre Pasteur institution, Ministry of Livestock, Fisheries and Animal Industries (MINEPIA), and Ministry of Public Health for technical support and granting access to their database.

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