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Original Article

Epidemiological characteristics of rabies in Zambia: A retrospective study (2004–2013)

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ABSTRACT

Background: Human and animal rabies have been known to be present in Zambia since the early 1900s. However, systematic reporting, analysis, and dissemination have remained limited. This study aims to quantify trends and patterns in confirmed rabies cases and human dog bites based on reported hospital and laboratory data in Zambia, for the period 2004–2013. We further explore the space–time evolution of risk of confirmed rabies cases and dog bites.

Method: Data on human dog bites, confirmed rabies cases by province for the period 2004–2013, and on rabid dogs in the period 2005–2012 were analyzed. We calculated the incidence rates, by year and province, and modeled the spatial variability in risk at province level using Poisson spatial regression.

Results: A total of 14,818 dog bites occurred in all provinces for 2004–2013. The rate of dog bites ranged from 0.01 to 9.18 per 10,000 population. The incidence rate of rabid dogs varied from 2.4 to 17.5 per 10,000 dog population. Over the years, the risk of dog bites varied. The highest risks were at Western province (RR = 14.91, 95% CI: 9.08–34.09) in 2004 and Lusaka province from 2009 to 2013. The risk of rabies in dogs increased in Central province (RR = 1.79, 95% CI: 1.11–2.74).

Conclusion: This study reveals increasing trends in reported dog bites and rabies. The increase could be a case of improved reporting due to change in health policies or indeed high incidence necessitated by change in ecosystem. Moreover, the risk of dog bites and confirmed rabies seem to be established in selected provinces. A more detailed epidemiological design is warranted to establish such increases in risk.

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1. Introduction

Rabies virus is responsible for encephalitis in humans.^{1–3} Human infection usually occurs following a bite or scratch by an infected animal.^{4,5} Other forms of transmission include direct contact with the victim's mucosa or with fresh skin wounds by infectious material, usually saliva.

Rabies causes almost 100% mortality in patients, who have developed symptoms.¹ Most of these deaths, estimated to be 55,000 per year, occur in remote rural areas of Africa and Asia.^{2–6} Unfortunately, these deaths are either under-reported or never reported at all. About 4 per 100,000 population are at risk of dying from rabies each year in Africa.⁴ Official data on human rabies deaths submitted to WHO from Africa greatly under-estimate the true incidence of the disease,⁷ primarily due to challenges with diagnostic capacities particularly in humans and poor reporting system.

Human and animal rabies have been known to be present in Zambia since the early 1900s.^{2–4} The first case was recorded in 1913 at the Central Veterinary Laboratory (renamed Zambia Institute for Animal Husbandry) in Mazabuka. Rabies is a notifiable disease in Zambia, however, confirmed cases in humans, through fluorescent antibody testing, have been rare. Nevertheless, the total number of people bitten by dogs, and who both received post-exposure prophylaxis is increasing. Particularly, the main source of exposure to rabies for humans in Zambia is the domestic dogs, although incidences of attacks by wild foxes too have been documented.^{3,4}

This study aims to quantify trends and patterns in confirmed rabies cases and human dog bites based on reported hospital and laboratory data in Zambia, for the

period 2004–2013. We further explore the space–time evolution of risk of confirmed rabies cases and dog bites.

2. Methods

2.1. Source of data

Data on human dog bites and confirmed rabies cases for the period 2004–2013, disaggregated by province, were obtained from the Health Management and Information System (HMIS) of the Ministry of Health in Zambia. Fig. 1 shows the map of Zambian provinces under consideration. Of the years under review, incomplete data of dog bite cases were recorded in most provinces in 2012, except for Lusaka, Northern and Muchinga provinces. Data on rabid dogs per 10,000 in the period 2005–2012 were obtained from the Central Veterinary Research Institute (CVRI) of the Department of Veterinary and Livestock Development under the Ministry of Agriculture and Cooperatives in Zambia. For rabies diagnosis, CVRI used the fluorescent antibody test using FITC anti-rabies monoclonal immunoglobulin (CENTOCOR Inc., Malvern, PA, USA).

2.2. Statistical analysis

We calculated incidence rate, per 10,000 persons, for each year and province. We fitted a space–time model on reported dog-bites, using a Poisson regression that accounted for space–time correlation.⁸ For the confirmed rabies cases, we pooled the data and fit a spatial model of reported cases for the entire period. For spatial analysis, we used the provinces as the spatial units. There were 9 provinces (Central, Copperbelt,

Fig. 1 – Map of Zambia showing its provinces.
Source: Google.

Eastern, Luapula, Lusaka, Northern, North-Western, Southern, Western).

Data entry was done in Microsoft Office Excel and analysis for rates of human cases and rabid dogs was done using Epi Info 3.5.4. The spatial and space-time models were fitted in BayesX⁸ in R statistical software.⁹

3. Results

There were a total of 14,818 reported cases of dog bites from all the 10 provinces in the country for the period January 2004 to December 2013 (Table 1). The lowest number of cases (351, 2.37%) was recorded from Muchinga province and the highest from Lusaka province with 5440 (36.7%) cases. The number of total reported cases of dog bites shows an increasing trend from 0.20 per 10,000 in 2004 to 4.24 per 10,000 population in 2013 (Table 2). The rate of dog bites ranged from 0.01 per 10,000 populations, in Copperbelt province in 2012, to a high of 9.18 per 10,000 in Lusaka in 2011, followed by 8.72 per 10,000 population in Central province in 2013 (Table 2). The small number of cases in Muchinga might be due to missing recording systems, which were not yet in place being a newly created province. Subsequent analyses, therefore, only uses the original 9 provinces.

Over the years, the risk of dog bites varied (Fig. 2). In 2004, the highest risk area was the Western province (RR = 14.91, 95% CI: 9.08–34.09), and the lowest risk was in Luapula (RR = 0.03, 95% CI: 0.0008, 0.24). The risk of the dog bites

Fig. 2 – Estimated relative risk of dog bites for the 9 provinces from 2004 to 2013. Note that no estimates were obtained in 2012 due to missing data in 7 provinces.

remained somewhat stable for the years 2005–2007, in which the central and north-western provinces were at highest risk of dog bites (Fig. 2). From 2009 to 2013, Lusaka province had the highest risk. For example in 2009, RR = 7.52; 95% CI: 4.12–12.57,

Table 1 – Dog bites cases by province and year, Zambia.

Dog bites per province	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Central	35	51	71	107	66	211	356	397	0	1231	2525
Copperbelt	12	25	61	36	16	8	0	8	2	911	1079
Eastern	10	32	9	66	47	187	326	73	0	778	1528
Luapula	44	0	0	2	4	63	122	101	0	358	694
Lusaka	–	6	0	1	105	631	1157	2064	42	1434	5440
Muchinga	–	–	–	–	–	–	–	20	6	325	351
Northern	0	4	14	53	13	24	35	125	11	235	514
North-Western	59	48	54	50	62	46	29	38	0	0	386
Southern	5	7	3	23	15	62	108	243	0	0	466
Western	61	143	21	40	368	220	71	167	0	746	1837
Zambia	226	316	233	378	696	1450	2204	3236	61	6018	14,818

Table 2 – Dog bites per 10,000 human population by province, Zambia, 2004–2013.

Rate per 10,000	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Central	0.31	0.45	0.6	0.89	0.53	1.63	2.72	2.96	–	8.72
Copperbelt	0.07	0.14	0.34	0.2	0.08	0.04	–	0.04	0.01	4.31
Eastern	0.07	0.23	0.06	0.45	0.31	1.18	2.05	0.45	–	4.52
Luapula	0.52	–	–	0.02	0.04	0.64	1.23	0.99	–	3.35
Lusaka	–	0.03	–	0.01	0.53	2.9	5.28	9.18	0.18	5.83
Muchinga	–	–	–	–	–	–	–	0.27	0.08	4.19
Northern	–	0.04	0.14	0.53	0.13	0.22	0.32	1.1	0.09	1.94
North-Western	0.93	0.74	0.81	0.74	0.89	0.65	0.4	0.51	–	–
Southern	0.04	0.05	0.02	0.16	0.1	0.39	0.68	1.49	–	–
Western	0.75	1.73	0.25	0.47	4.22	2.5	0.79	1.8	–	7.79
Zambia	0.2	0.28	0.2	0.31	0.56	1.12	1.68	2.41	0.04	4.24

Table 3 – Rabid dogs per 10,000 population, Lusaka Province, Zambia, 2005–2012.

	2005	2006	2007	2008	2009	2010	2011	2012
Rabid dogs	4	1	2	8	4	2	2	2
Estimated registered dogs	2938	3405	3945	4572	5297	6138	7113	8242
Rabid dogs per 10,000	13.6	2.9	5.1	17.5	7.6	3.3	2.8	2.4
	2005	2006	2007	2008	2009	2010	2011	2012
Estimated rabid dogs per 10,000	13.6	2.9	5.1	17.5	7.6	3.3	2.8	2.4
Estimated dog bites per 10,000	0.03	0	0.01	0.53	2.9	5.28	9.18	0.18

Table 4 – Confirmed rabies cases in dogs by province and year, Zambia.

Province	2005	2006	2007	2008	2009	2010	2011	2012	Total	%
Central	14	7	4	5	5	3	3	2	43	28.1
Copperbelt	–	5	1	5	1	3	2	–	17	11.1
Eastern	–	–	–	4	–	1	1	2	8	5.2
Luapula	–	2	–	3	1	–	–	1	7	4.6
Lusaka	4	1	2	8	4	2	2	2	25	16.3
Northern	1	–	2	1	–	1	–	1	6	3.9
North-Western	2	2	–	2	–	–	2	3	11	7.2
Southern	5	3	3	2	2	6	5	2	28	18.3
Western	1	–	–	3	1	2	1	–	8	5.2
Zambia	27	20	12	33	14	18	16	13	153	100

and in 2013 the risk was estimated at $RR = 6.35$; 95% CI: 4.96–10.11. In 2010 and 2011, Lusaka region was estimated to have the highest risk ($RR = 15.49$; 95% CI: 8.42–32.55 in 2011 and $RR = 16.160$, 95% CI: 10.87–25.21 in 2010).

The incidence rate of rabid dogs in Lusaka province was estimated to vary from 2.4 per 10,000 dog population in 2012 from a high of 17.5 per 10,000 dog population in 2008 (Table 3). The estimated prevalence rate of dog bites in Lusaka province ranged from zero per 10,000 in 2006 to 9.18 dog bites per 10,000 population in 2011 (Table 3).

A total of 153 positive samples from suspected rabid dogs were confirmed to have rabies virus at CVRI from January 2005

to December 2012 (Table 4). The Central province recorded the highest proportion of confirmed rabies cases in dogs at 28.1%, while the Northern province reported the lowest at 3.9% between 2005 and 2012 (Table 4). Fig. 3 shows the estimated geographical variation in risk of rabies in dogs. The risk of rabies in dogs was highest in the Central province ($RR = 1.79$, 95% CI: 1.11–2.74), but lowest in Luapula province ($RR = 0.62$, 95% CI: 0.33–0.98) and Northern province ($RR = 0.77$, 95% CI: 0.42–0.99). Both Lusaka and Southern provinces showed increased risk, but the effects were marginally significant ($RR = 1.36$, 95% CI: 0.96–1.98, $p < 0.07$ and 1.27, 95% CI: 0.89–1.85, $p < 0.10$, respectively).

Fig. 3 – Spatial extent of confirmed rabies in dogs by province in Zambia: (a) percentage and (b) relative risk for the period 2005–2012.

4. Discussion

Our results confirm that rabies remains a public health concern in Zambia. The disease, although rare, is endemic in all provinces. Compared to the period 1984–2004,⁴ this study indicates increasing reported human rabies cases in Zambia. The increasing trend from 0.20 per 10,000 in 2004 to 4.24 per 10,000 in 2013, can be attributed to probably an increase in the dog population,^{4,14–16} but can also be a reflection of better reporting following the revision of the HMIS. It may also be a result of improved health communication, in that the populace is aware of the need to go to health facilities following an attack by a dog.

In comparison with other countries in Africa, the incidence of dog-bites in Zambia is relatively low. In N'djamena, Chad, the incidence of human dog-bites was estimated at 12.9 cases per 100,000 people¹⁷ with an estimated 7 human deaths per 100,000 per year.¹⁵ In Ethiopia, rabies incidence was found to be 2.33 cases per 100,000.¹⁸ However, a study in Zimbabwe reported a much lower the risk.¹⁹

This study extends a previous study,⁴ which considered rabies status in Zambia between 1985 and 2003. Compared to the previous decades, the number of reported cases has also increased tremendously, especially after 2009. We again attribute this change to the revision of HMIS, which has resulted in rabies cases being identified and recorded separately, when initially these were grouped among general zoonotic diseases. Moreover, there has been an increased reporting because of the joint surveillance efforts by veterinarians in both private and public sectors since 2010, hence resulted such a stark jump in recorded cases of rabies (Tables 1 and 3).

This study offers some insights in the dynamics of rabies in Zambia. It is the first approach, to the best of our understanding, to present the spatial and space-time dynamics of the disease in the country.

There could be a number of potential factors that need to be considered when interpreting the estimated spatial distribution of risk of rabies in the country. First, dog density and human density are risk factors, with an increase in both densities intensifying the transmission of rabies.^{10,12,13} Second, issues related to environmental change and transformation of ecosystems, namely land use type, presence of major roads, and forest encroachment may increase or decrease transmission.^{11,12} Identifying covariates that are associated with rabies spatial distribution will be an important step to guide surveillance and control of the disease. A more appropriate analysis is planned at district level, to capture within province variation and clusters of risk of rabies.

The provinces, which have been estimated to have a moderate-to-high risk of dog-bites, should be prioritized for prevention and control programs. An important finding in this study is that, where the risk of human dog bites is high, the same provinces have high risk of confirmed rabies in dogs (Figs. 1 and 2). This correlation, although not quantified, maybe worthwhile to study further. Be as it may, the control of rabies in Zambia has been mainly through vaccination of dogs. Since 1984, the objective has been to cover over 80% of dogs.

However, the target has not been met due to various limitations, including poor vaccine coverage in certain parts of the country and insufficient vaccine supply at times.³ However, there has been a shift in policy direction in that the mandate for vaccination of dogs has been given to the private sector in Zambia.

While this is a good move in the spirit of private–public partnerships, it has some challenges. These include a cost as most people cannot afford to pay for services provided by private-for-profit practitioners. Moreover, most private practitioners are along major roads and rail lines, thus creating shortage of such services to provinces/districts located away from the major routes. The other challenge is related to reporting system. The reporting system linkage between the public–private sector disease surveillance system is non-existence despite discussions on how the collaboration between public–private partnership, resulting to some extent relevant data on vaccines and dog bites not being reported to the HMIS. Furthermore, data on the number of dogs in the country are not exactly known, although it has been estimated to be about 1–2 million dogs. This has implications on the current rabies control and eradication efforts in terms of estimation of commodities and medical supplies needed for the dog immunization.

We focused on dog-bite cases, as the vast majority of human rabies cases are due to bites by domestic dogs.^{4,5,7,14,15} Indeed, earlier literature in Zambia confirms that this is the case.⁴ This phenomenon is to be patterned in many other countries in Africa and Asia. For example, the prevalence of dog bites is, similarly, as high as observed in Malawi, where prevalence is 83%.¹⁴ Other studies in Delhi, India, found out that dog bites were in the ratio of 4:1 with human males being more affected than females. Most of the bites (90.7%) were due to stray dogs. This was probably due to higher exposure to outdoor activities to field work as a contributing factor.^{5,16} Although, this analysis was restricted to human and dog rabies, other forms of rabies such as bovine and wildlife rabies have been recorded in Zambia.^{2–4} However, dog rabies cases remain the highest among all groups.

Our analysis used secondary administrative data from HMIS. The increase in the number of human cases should be interpreted with caution, because most cases reported in HMIS might not be subjected to laboratory diagnosis due to poor compliance to post-exposure treatment.⁴ In additional, only highly urbanized provinces of Lusaka, Copperbelt, Central and Southern, tend to have more medical and veterinary facilities, which have strengthened the public health services by carrying out surveillances, dog vaccinations, and post-exposure treatment of patients.^{2–4} This may explain an increase in reported cases in Lusaka province, which has diagnostic laboratories than distant rural provinces (Tables 3 and 4). Moreover, being a capital province, collection of data might be consistent and complete most of the time than other areas, hence posting as high risk province.

Furthermore, the data used lacked segregation into sex–age groups. An analysis of the male–female-ratio of incidence would have offered a better insight into the epidemiology of rabies in the country. Studies elsewhere report that most dog bite victims were children or adolescents, and males were the most affected.^{20–22}

5. Conclusion

Prioritizing high risk provinces is critical for rabies control in Zambia. This entails strengthening provincial capacities for prevention and control through improving surveillance, and rabies prevention and awareness programs, in collaboration with different government line Ministries such as health, veterinary, education, and legal and linkages with local communities to reduce burden of rabies in the country. It necessitates that provinces immediately enacting on the policy direction, which points to the need to bring information on prevention of rabies to a wider community through dissemination of information using school children. Furthermore, detailed epidemiological study to identifying risk factors to guide interventions is crucial to stem the increasing risk of rabies in Zambia.

Author contributions

OB conceived the study.

BM collected data and constructed the tables plus initial analysis.

LK conducted in-depth data analysis including spatial maps.

FM, PS and LK drafted the manuscript.

All authors reviewed and provided comments to the manuscript.

All authors read and approved the final version of the manuscript.

Conflicts of interest

The authors have none to declare.

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