Public Health Bulletin
South Africa

Epidemiological trends of animal bites and human rabies cases in Limpopo, South Africa, 2011–2023: A retrospective review

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Summary

Rabies continues to be a public health problem in the province of Limpopo, with human cases reported every year. The disease is caused by the rabies virus, which spreads to humans and other animals through contact with the saliva of infected animals. We conducted a descriptive analysis of animal bites and human rabies cases between 2011 and 2023 in Limpopo. Data on animal bites were sourced from the Limpopo Department of Health (Public Health Directorate), and human rabies data were sourced from the Centre for Emerging Zoonotic and Parasitic Diseases within the National Institute for Communicable Diseases, (Centre for Emerging Zoonotic and Parasitic Diseases), a division of the National Health Laboratory Service. We calculated the incidence rate of animal bites, analysed overall trends, and described the demographic and clinical characteristics of human rabies cases. A total of 98 743 animal bite cases were reported between 2011 and 2023, with an overall incidence of 131 per 100 000 population. Sixty per cent of animal bites were reported from Vhembe District, with an average of 4 857 annual incidents. Thirty-two human rabies cases with a median age of eight years (interquartile range: 6–19 years) were reported, and the 0–9-year age group accounted for 34% (n=11) of the cases. Domestic dogs were the source of infection in 81% (n=26) of cases, and 67% (n=18) sustained category 3 wounds. Twenty-seven per cent (n=8) of cases received post-exposure prophylaxis (PEP), but none completed the course of treatment or vaccination, and the fatality rate was 100% for all 32 cases. This study highlights the need for a comprehensive public health strategy to address the ongoing rabies challenge in the Vhembe and Mopani districts. Our findings emphasise the urgent need for in-service training on the administration of PEP for dog bites through skills training, including stock management. Ongoing surveillance is important to monitor the number of animal bites and human rabies cases and identify high-risk areas for targeted interventions. Adopting a coordinated One Health approach that integrates reporting of both animal bites and human incidents can lead to more effective control measures at municipality, district, provincial, and national levels.

Introduction

Rabies is a viral zoonotic disease caused by the rabies virus, and it is typically transmitted to humans via the saliva of infected animals, most commonly dogs, from bites, scratches, open wounds, or mucous membranes.[1] The disease is characterised by severe neurological signs and symptoms, with death resulting within an average of 5–7 days from clinical onset for furious rabies and 11 days for paralytic rabies.[2] In many parts of the world, domestic dogs are responsible for most rabies infections in humans. Rabies can be prevented in dogs through vaccination, and humans have the option of rabies post-exposure prophylaxis (PEP) should exposure occur.[3]

According to estimates, rabies is responsible for approximately 59 000 human deaths globally each year, mostly in Africa and Asia, which together account for 95% of deaths.[2] India has the highest incidence of human rabies, with an estimated 20 000 deaths annually, primarily resulting from bites by stray dogs.[4] Sub-Saharan Africa faces challenges with rabies risks resulting from the large number of unvaccinated dogs and limited availability of rabies PEP within public health systems.

International initiatives aimed at the global elimination of rabies have increased support for the commitment to the 'zero dog-mediated rabies deaths by 2030' campaign initiated by the World Organization for Animal Health, the Food and Agriculture Organization, the United Nations Environmental Programme, and the World Health Organization (WHO).[5]

This campaign comprises three key pillars: operational capacity-building, community awareness, and monitoring and evaluation to guide decision-making action on rabies elimination.[5,6]

Efforts on the African continent have demonstrated good progress in disease control through community education and vaccination. Nonetheless, challenges remain, especially funding and coordination between the health and agricultural sectors and the use of unreliable surveillance data that is not informative in the efforts to combat the disease effectively.[7] South Africa has the Department of Agriculture, National Veterinary Directorates, provincial state veterinary services, the National Department of Health (NDoH), the National Institute for Communicable Diseases (NICD), a division of the National Health Laboratory Service, and other non-governmental organisations that have collaborated through a One Health approach to combat rabies. This is achieved by following the rabies control policy recommendations of the National Rabies Advisory Group, of which all departments and stakeholders are members.[3] Rabies is endemic in domestic dogs and in certain in-country wildlife reserves, reporting an average of 10 laboratory-confirmed cases per annum between 2008 and 2018.[8–10]

Most human cases in South Africa have been attributed to rabid domestic dogs.[11] Veterinary health is central to South Africa's One Health approach to rabies prevention and control, focusing on mass dog vaccination, especially in high-risk provinces such as KwaZulu-Natal, Eastern Cape, and Limpopo.[12] A coordinated collaboration between the veterinary and human health sectors is key to enhancing surveillance, improving access to PEP, and raising public awareness for rabies elimination.

The rabies outbreak in dogs that occurred in Vhembe District from 2005–2006 resulted in 21 confirmed and five probable human deaths. The outbreak prompted collaboration between public health professionals and veterinary personnel, resulting in interventions such as vaccination campaigns of domestic animals, community awareness programmes, and improved availability of PEP, which resulted in a decline in the incidence of rabies.[11]

Although providing rabies vaccine to the general population might not be cost-effective, rabies pre-exposure prophylaxis is given to high-risk populations (e.g., veterinary staff, those handling wildlife, laboratory personnel, or animal welfare staff) through their employers. In South Africa, rabies PEP is provided free of charge in the public sector, and a human death from rabies is regarded as a failure of the health system.[3] The NDoH has guidelines to advise healthcare workers on how to manage potential rabies exposures. The management begins with a thorough risk assessment. Management of exposure is determined by the category of the wound: Category 1 requires no action; Category 2, which involves contact with an animal but no breach of the skin, requires a full course of rabies vaccination. Category 3 involves a breach of the skin or contact with mucous membranes, and requires wound management (flushing the wound with soap and water for 5 to 10 minutes, and then disinfection, antibiotics, and tetanus administration, where necessary), rabies immunoglobulin (RIG), and a full vaccination course. The rabies vaccination schedule consists of four doses administered on days 0, 3, 7, and between days 14 and 28.[3]

Limpopo was one of the provinces that reported the highest number of rabies cases in the 2005–2006 outbreak. Since this outbreak, there has been a reduction in the burden of human rabies; however, rabies still causes human

fatalities every year. In this study, we focused on animal bite injuries and human rabies cases that were treated in public health facilities in Limpopo between 1 January 2011 and 31 December 2023. Understanding the incidence of animal bites and human rabies cases will assist policymakers in acquiring an evidence-based review of rabies prevention strategies and, therefore, engage in evidence-based allocation of public health resources. This integrated analysis can also identify localities that may need better access to PEP, increased information and education campaigns, dog vaccination campaigns, and training for healthcare workers.

Methods

Study setting and population

The study was conducted in Limpopo, South Africa, a province with diverse landscapes, including the Kruger National Park, which borders Zimbabwe and Mozambique. The province is home to various wildlife species that are implicated in rabies virus cycles. Limpopo's landscape is characterised by woodlands, hot temperatures, and high precipitation, providing favourable conditions for the spread of canine rabies through black-backed jackals.[13]

Limpopo has a population of approximately 6.6 million and is subdivided into five districts: Capricorn, Greater Sekhukhune, Mopani, Vhembe, and Waterberg.[14] It shares borders with the Gauteng, North-West, and Mpumalanga provinces, as well as with Zimbabwe, Mozambique, and Botswana.[13] The provincial stock census conducted in 2023 indicated a combined dog population of approximately 99 689 (unpublished source: Limpopo Veterinary Services).

Data collection and analysis

Animal bites

We obtained data on animal bites from the Limpopo Department of Health's Public Health Programmes Directorate, which compiles weekly aggregated data on priority health conditions received via email from district health offices. The district office reports incidents from all public health facilities. These data are consolidated into a provincial dataset, which is reviewed and validated by the surveillance manager to ensure accuracy. For this study, the research team conducted additional validation by checking for inconsistencies against the original district workbooks, ensuring reliable monthly and annual counts. The number of animal bites was extracted from 1 January 2011 to 31 December 2023, using Microsoft Excel 2016 (Microsoft Corp., Mountain View, California). The analysis summarises frequencies and percentages, calculated annual and district-specific incidence rates per 100 000 individuals (using Stats SA mid-year population), and applies a non-parametric trend test in Stata Corp version 15 (PROVENANCE) to determine changes in the incidence trends of animal bites over the study period.[14]

Human rabies

Human rabies is categorised as a notifiable medical condition (NMC) in South Africa, requiring notification to the NMC surveillance system within 24 hours of diagnosis. We sourced data for confirmed, probable, and suspected human rabies cases from the Centre for Emerging Zoonotic and Parasitic Diseases (CEZPD) of the NICD. The CEZPD conducts laboratory investigations of suspected cases. Data are generated when a suspected rabies case is reported by a clinician who collects specimens for laboratory testing, accompanied by a case investigation form. Supplementary data sources include notifications from clinicians on the NMC surveillance system, information

from the NICD hotline, and field investigation reports from the Department of Health.
Data validation involved reviewing clinical documentation alongside laboratory results to ensure that both were consistent and accurate.

Data received from CEZPD contact information included demographic characteristics, clinical features, exposure history, prophylaxis, and pathological findings. We applied simple descriptive statistics, including frequency tables, to summarise the demographic and clinical characteristics of confirmed and probable human rabies cases. We used the following standard case definitions for human rabies cases as per the NMC case definition flip chart:[15]

- Suspected case: A person presenting with an acute neurological syndrome (encephalitis) dominated by forms of hyperactivity (furious rabies) or paralytic syndromes (dumb rabies) progressing towards coma and death, usually by respiratory failure, within 7–10 days after the first symptom if no intensive care is instituted.
- Probable case: A suspected case with a likely exposure to a suspected rabid animal.
- Confirmed case: A case with laboratory confirmation of rabies virus infection by detection of viral antigens or nucleic acid in a clinical specimen (e.g., saliva, skin biopsy, cerebrospinal fluid) using techniques such as direct fluorescent antibody testing, reverse transcription-polymerase chain reaction, or virus isolation.

We included probable and confirmed human rabies cases, as per the above case definitions, in the analysis.

Results

Incidence of animal bites

During the study period, 98 743 animal bite cases were reported in Limpopo, resulting in an overall incidence of 131 per 100 000 population. Over the 13 years, the median number of animal bites was 7 179, with an interquartile range of 6 518–9 607. The highest provincial incidence rates occurred in 2018 at 181 per 100 000 population; in 2014 it was at 171 per 100 000 population, followed by 2019 at 162 per 100 000 population (Figure 1).

Vhembe District reported the most cases, representing 64% (n=63 153) of all reported animal bite incidents. This district consistently reported more animal bites than the other districts, with an average of 4 857 annual incidents, peaking at 6 639 in 2014. However, there was no significant change in the observed trend over the study period (p=0.28) (Figure 2). Mopani District recorded the second highest number of animal bite incidents, accounting for 15% (n=15 218) of incidents reported during the study period. The incidence of animal bites in Mopani District steadily increased from 80 per 100 000 population in 2011 to a peak of 131 per 100 000 population in 2014, followed by slight declines in 2021 and 2022. However, there was no significant change in the observed trend over the study period (p=0.71). Waterberg District recorded the lowest number of animal bites at 4% (n=3 607). However, the annual incidence of animal bites in Waterberg District during 2019–2023 was twice as high as that recorded during 2011–2018 (p<0.01) (Figure 2).

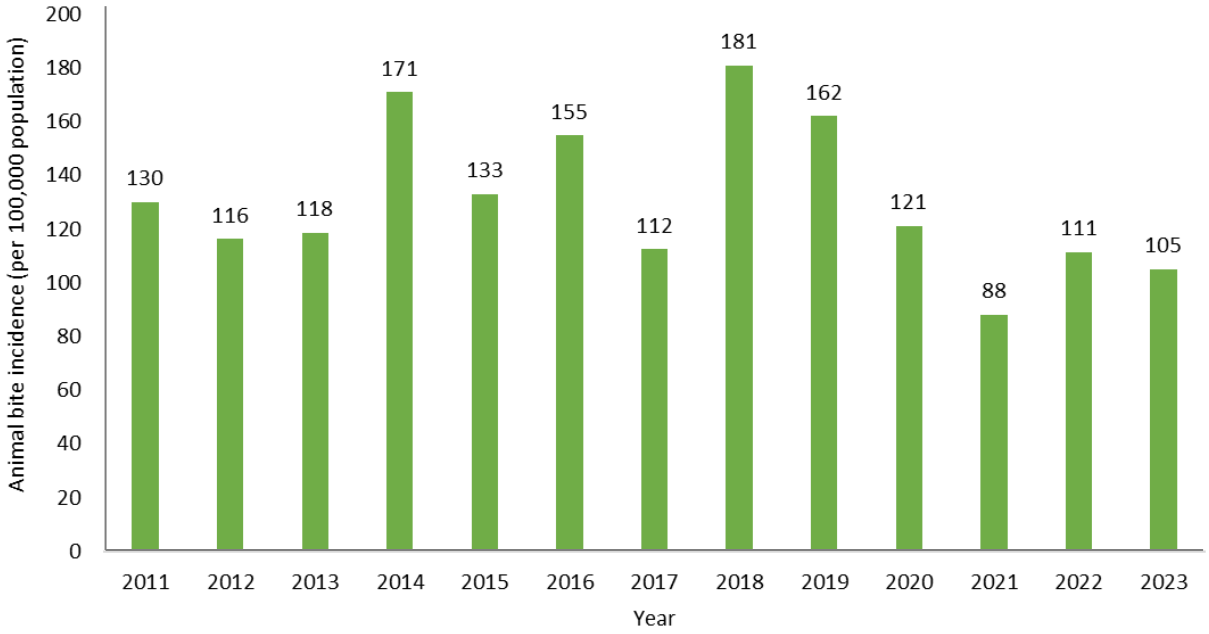

Figure 1. Incidence rate of animal bites reported at healthcare facilities by year, Limpopo, South Africa, 2011–2023, n=98 743.

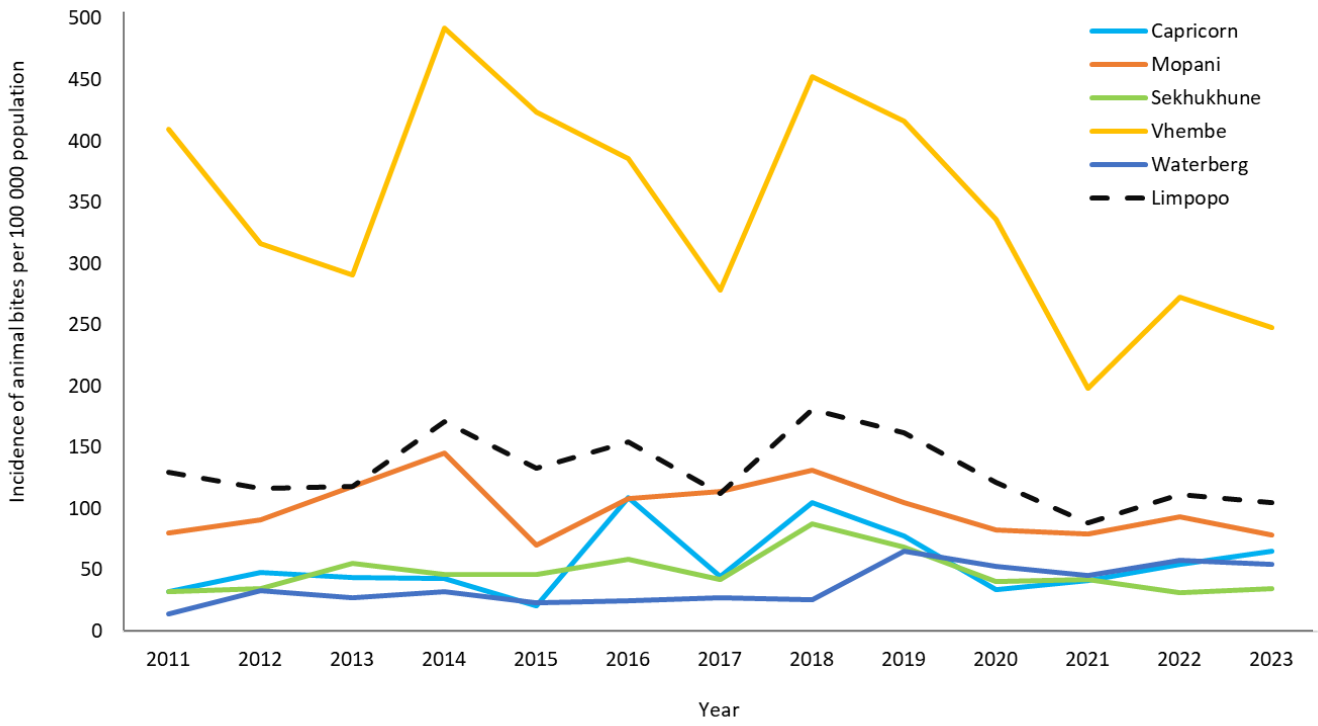

Figure 2. Incidence of animal bite cases by district and year of bite incident, Limpopo, South Africa, 2011–2023, n=98 743.

Demographic characteristics of human rabies cases, Limpopo, 2011–2023

Thirty-two human rabies cases were analysed, including 27 (84%) laboratory-confirmed cases and five probable cases, with a 100% case fatality rate. The overall median age of the cases was eight years (IQR range: 6–19 years), with the 5–9-year age group being most affected (n=11, 34%). Seventy-five per cent (n=24) of cases were male (Table 1). The highest number of cases, 16% (n=5), was reported in 2013, followed by 13% (n=4) in 2021, with no cases reported in 2016 and 2018 (Figure 3). Cases were reported in three out of five districts, with 75% (n=24) of cases reported in Vhembe District (Table 1).

Dog-mediated rabies was identified as the source of infection in 81% (n=26) of patients, with 56% (n=18) sustaining category 3 wounds. Post-exposure prophylaxis was not administered in 56% (n=18) of cases, and 25% (n=8) did not complete the PEP course (Table 2).

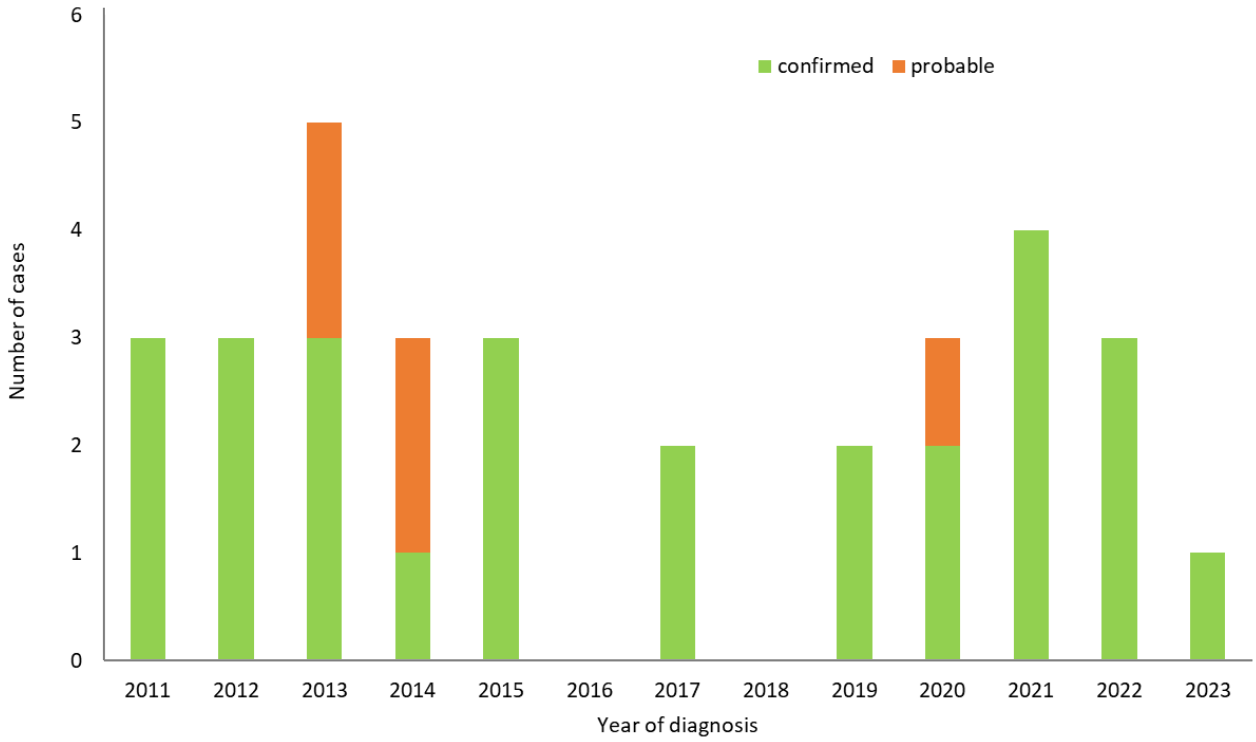

Figure 3. Number of human rabies cases by year, Limpopo, South Africa, 2011–2023, n=32.

Table 1. Demographic characteristics of human rabies cases, Limpopo, South Africa, 2011–2023, n=32.

Characteristics	Category	Number	Percentage (%)
Age category (years)	0–4	6	19
	5–9	11	34
	10–14	4	13
	15–19	2	6
	20+	9	28
Sex	Male	24	75
	Female	8	25
District of exposure	Capricorn	2	6
	Vhembe	24	75
	Mopani	6	19

Table 2. Clinical characteristics of human rabies cases, Limpopo, South Africa, 2011–2023, (n=32).

Characteristics	Category	Number	Percentage (%)
Animals involved in exposure	Dog	26	81
	Not specified	6	19
Wound category	2	3	9
	3	18	56
	Not specified	11	34
Received PEP	*Partial	8	25
	None	18	56
	Not specified	6	19

*Partial: The patient did not complete the post-exposure prophylaxis schedule.

Discussion

This study provides a useful understanding of the epidemiology of animal bites and human rabies cases. While there are no global estimates on incidence for animal bites, existing studies illustrate that animal bites and related injuries remain a public health challenge. The WHO reported that dog bites account for tens of millions of injuries annually, with varying incidences across countries.[16] Among African nations, Kenya has the highest recorded animal bite incidence at 289 bites per 100 000 population, followed by Ghana with 248 per 100 000 population.[17]

There is limited published surveillance data on the incidence of dog bite injuries in South Africa. Research conducted in rural and urban health facilities demonstrates that animal bites occur frequently among children and young adolescents.[18–20] Our study reports an overall incidence of 131 per 100 000 population from 2011 to 2023 in Limpopo. The animal bite incidence rate in Vhembe District reached 348 per 100 000 population, which exceeded the provincial rate and rates reported in Kenya and Ghana. The identified high rates of rabies cases require management and messaging concerning dog bites at the community level, which should be implemented through joint One Health efforts. The Vhembe District, along with other rural areas, shows distinct spatial rabies distribution patterns. The social inequalities that affect healthcare services for rabies PEP treatment, combined with non-compliance to follow-up care and unemployment, along with reduced healthcare usage and animal vaccination coverage and an increased stray dog population, result in elevated rabies transmission and mortality rates.[21,22] The study reveals that dog-mediated rabies accounts for 81% of human rabies cases in Limpopo, highlighting the importance of canine vaccination in controlling the disease.[23] Dogs serve as the primary source of human rabies in developing African regions.[4,10,11] These findings demonstrate the necessity of enhanced animal bite surveillance to improve prevention and control activities.

Our study included 98 743 animal bites and 32 human rabies deaths. A human death due to rabies reflects the failure of the healthcare system because, in principle, PEP is freely available at public health facilities. Primary healthcare facilities maintain stocks of the rabies vaccine in the province, and category 2 and 3 cases need to be referred to hospitals for rabies immunoglobulin (RIG). This referral practice may limit PEP accessibility, especially when referrals do not reach the hospital due to patient- and health-system-related factors. The reported number of category 3 wounds (56%) highlights the danger posed by rabid dog bites.[26] The high proportions of patients who did not receive (56%) or did not complete (25%) PEP reveal gaps in public health response and community awareness. Similar findings were reported in a study conducted in South Africa using national data.[11,23] These findings demonstrate that although PEP may be available in public health facilities, many patients do not receive it, primarily due to a lack of healthcare providers' knowledge and awareness, accessibility issues, logistic challenges, limited access to rabies immunoglobulin, and poor wound management. A study on human rabies cases in South Africa between 2008 and 2018 demonstrated that almost a third of reported rabies cases did not seek medical intervention.[11]

This study has strengths and limitations. It provides a comprehensive analysis of animal bites and human rabies cases in Limpopo over 13 years, enhancing our understanding of temporal and demographic patterns while highlighting high-risk districts. However, the geographic focus on Limpopo may limit the generalisability of findings to other settings with different epidemiological patterns. In addition, due to the aggregated nature of the information, our study could not assess the demographic characteristics of animal bite cases, the type of animal,

location, the circumstances surrounding the bite incidents, and post-exposure practices. Some human rabies cases may remain unreported if they are managed outside of healthcare facilities or because the clinician did not consider rabies in the differential diagnosis.

Although healthcare facilities continue to report sporadic human cases, the lack of large outbreaks of rabies since 2006 emphasises the benefits of ongoing surveillance and progress in the effectiveness of public health interventions, limited as they are, in mitigating the spread of the disease.

Conclusion

This study highlights the need for a comprehensive public health strategy to address the ongoing challenge of rabies in the Vhembe and Mopani districts of Limpopo. Our findings emphasise the urgent need for in-service training on the administration of PEP for dog bites through skills training, as well as for stock management. Ongoing surveillance is important to monitor the number of animal bites and human rabies cases to identify high-risk areas and groups for targeted interventions. Adopting a coordinated One Health approach that integrates reporting of both animal bites and human incidents can lead to more effective control measures at the municipality, district, provincial, and national levels. Sustained dog rabies vaccination campaigns by the provincial veterinary services are essential for eliminating human rabies.

Recommendations

- The Department of Health should continue efforts to increase community awareness about the risks of rabies, the importance of PEP, and how to seek care after exposure using platforms such as radio, posters, clinics, schools, and social media.
- The Department of Health should provide ongoing training for healthcare workers on managing animal bites, including wound cleaning, indications for rabies PEP, and guidelines for administering PEP.
- The Department of Health is to introduce an electronic case-based surveillance system for animal bites to enhance accurate detection, reporting, and management of rabies cases, and to monitor the effectiveness of intervention strategies between partners.
- Wound washing is an effective first-aid treatment against rabies. Wash all wounds and scratches immediately with soap or detergent and rinse them thoroughly for 15 minutes under running water. Seek immediate medical treatment for PEP, based on the category of exposure. Contact veterinary services or your animal health technician to assess the suspected rabid animal. Do not attempt to approach or capture the animal yourself.
- Limpopo health authorities should assess community knowledge, attitudes, and practices regarding rabies and PEP to guide interventions.
- Veterinary services need to provide sustained and effective dog vaccination programmes.

Acknowledgements

- Public Health Directorate (Limpopo Department of Health)
- Capricorn Department of Health
- Mopani Department of Health
- Sekhukhune Department of Health
- Vhembe Department of Health
- Waterberg Department of Health
- Centre for Emerging Zoonotic and Parasitic Diseases, National Institute for Communicable Diseases
- Division of Public Health Surveillance and Response, National Institute for Communicable Diseases

Funding

The study was funded by the National Institute for Communicable Diseases, a Division of the National Health Laboratory Service.

Ethical considerations

Ethics clearance for the study was obtained from the Polokwane Mankweng Research Ethics Committee (Reference number: PMREC 30 October UL 2024/A).

Conflict of interest

The authors declare no conflicts of interest.

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