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One Health surveillance report for rabies, South Africa, 2021–2023

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Summary

Rabies – endemic in South Africa – is a deadly viral infection that affects livestock, wildlife, domestic pets, and humans by direct zoonotic contact. Most human cases are associated with contact with infected domestic dogs. This report uses a One Health approach by combining human and animal surveillance data from South Africa for the period 2021–2023 to describe national trends and support rabies prevention and control efforts. During this period, 54 human cases (both confirmed and probable) and 1 856 confirmed animal rabies cases were reported. Domestic dogs accounted for 83% (n=1 548) of animal cases and were the most common source of human exposure. Over 75% (n=41) of human cases were caused by dog bites and scratches, with 83% (n=45) occurring in children under the age of 16 years. Exclusively human cases from the provinces of KwaZulu-Natal (KZN) (n=18), Limpopo (n=9), and the Eastern Cape (EC) (n=27) were reported; in 2021–2022, nine cases originated in Nelson Mandela Bay (NMB). Compared to other more rural municipalities in the EC that had previously reported cases on a regular basis, these were the first cases in the NMB metro municipality. In addition, 88% of dog cases were reported in these provinces. When compared to other municipalities, the eThekwini (KZN) and NMB metros had the most cases. Two cat-mediated human cases were reported from KZN, while the majority (n=27) of the 47 cat cases were from the EC and eight were from KZN. An uncommon outbreak involving two honey badgers and a domestic dog in Gauteng's West Rand District was linked to an outbreak in jackals (n=11) during that period, as was an entirely novel seal outbreak in the Western Cape province. None of these outbreaks were associated with human cases. Variations in case numbers between municipalities likely reflect differences in outbreak frequency, awareness, and reporting capacity. A positive correlation between animal and human case reporting highlights the value of integrated surveillance. This One Health analysis highlights the importance of co-ordinated, cross-sectoral reporting to enhance surveillance, identify hotspots, facilitate risk communication, and advance progress towards eliminating dog-mediated rabies in South Africa by 2030, in line with the global 'Zero-by-30' goal.

Introduction

Rabies is a fatal viral infection of the central nervous system caused by viruses in the *Lyssavirus* genus.[1] Although rabies has been reported in numerous mammalian species globally, most human cases are linked to exposure to rabid domestic dogs.[2,3] Annually, rabies causes an estimated 59 000 human deaths worldwide.[4] Beyond its high case fatality rate, the disease imposes a considerable burden, with an estimated 3.7 million Disability-Adjusted Life Years (DALYs) lost each year in dog-rabies-endemic countries.[4] Africa accounts for over one-third of all human rabies deaths worldwide, with an estimated 21 476 dog-mediated deaths and 1.34 million DALYs lost each year.[4] Furthermore, the African region bears the highest economic cost of rabies-associated mortality while investing the least in rabies post-exposure prophylaxis (PEP).[5]

In South Africa (SA), rabies is endemic and has been reported in various animal species, with periodic human cases. In addition to rabies virus (RABV), several other lyssavirus species have been detected in the country, including *Lyssavirus Duvenhage*, *Lyssavirus Lagos*, *Lyssavirus caucasicus*, *Matlo bat lyssavirus*, *Phala bat lyssavirus*, and *Lyssavirus mokola*.[6,7] Historically, Duvenhage virus infection has been associated with two human rabies cases in SA.[8] Two biotypes of RABV – the canid and mongoose variants – are recognised in SA.[9,10] The canid biotype circulates mainly among domestic dogs, black-backed jackals, bat-eared foxes, and aardwolves, while the mongoose biotype is maintained within various *Herpestidae* species.[11-17] In 2024, rabies was confirmed in Cape fur seals along the Western Cape and Northern Cape (WC and NC) coasts, marking an unusual host emergence.[18] Although rabies is occasionally reported in other domestic and wild species, these typically represent dead-end hosts for the virus.[19]

Rabies control in SA is governed under the Animal Diseases Regulations (R.2026 of 1986) of the Animal Diseases Act, 1984 (Act No. 35 of 1984), which designates rabies as a controlled animal disease.[20] State and private veterinarians, as well as animal welfare organisations, submit specimens from suspected cases for laboratory confirmation and must report confirmed or suspected rabies cases to local state veterinary offices. The Act also mandates vaccination of all domestic dogs and cats against rabies.[20] Animal rabies surveillance data are compiled by the Department of Agriculture (DoA), based on reports from state veterinarians submitted through Provincial Veterinary Services (PVS). Laboratory confirmation of animal rabies is conducted at the Agricultural Research Council-Onderstepoort Veterinary Research (ARC-OVR) in Pretoria and the Allerton Provincial Veterinary Laboratory in Pietermaritzburg, KwaZulu-Natal (KZN).

Human rabies has been documented in SA since 1983, with 458 cases reported between 1983 and 2018.[21,22] The majority of human infections were the result of dog exposures, a small number (n=13) were associated with cat exposures, and rare cases were linked to mongooses and other wildlife.[21-23] Human rabies has been notifiable in SA since 1977,[24,25] under the Health Act of 1977, which provides for communicable disease control.[24] In SA, human rabies is classified as a Category 1 Notifiable Medical Condition (NMC), necessitating immediate public health action. The National Institute for Communicable Diseases (NICD), a division of the National Health Laboratory Service (NHLS) in Johannesburg, serves as the national reference laboratory for human rabies and provides comprehensive diagnostic services for both ante-mortem and post-mortem investigations.

In 2015, the World Health Organization (WHO) issued a global call to action for rabies elimination.[26] Since 2018, the WHO, the World Organisation for Animal Health (WOAH), the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Environment Programme (UNEP) have collaborated under the United Against Rabies initiative to achieve zero dog-mediated human rabies deaths by 2030.[3] SA's National Strategy for the Elimination of Canine-Mediated Human Rabies (2019–2030)[27] aligns with this global initiative, supported by the Pan-African Rabies Control Network and the Global Alliance for Rabies Control (GARC). The National Rabies Advisory Group (RAG), comprising representatives from the agriculture, health, and environment sectors, NICD, ARC-OVR, GARC, academia, and other stakeholders,

co-ordinates national efforts towards this goal. These efforts are underpinned by relevant legislation, including the Animal Diseases Act, 1984 (Act No. 35 of 1984) and the Health Act of 1977, [20,24] as well as the National Guidelines for the Prevention of Rabies in Humans (2021), which detail PEP measures and are publicly accessible through the NICD website (www.nicd.ac.za). In 2014, SA established the One Health Forum as a collaborative initiative for detecting, responding to, and preventing zoonotic events in the country. In 2023, SA adopted a One Health Strategy and updated its Joint Plan of Action.[28] All the aforementioned strategies aim to replace fragmented approaches with an integrated, cross-sectoral framework for rabies prevention and control.

This report presents an integrated One Health surveillance overview of rabies in SA for the period 01 January 2021 to 31 December 2023, combining data from human and animal health sectors to inform progress towards national and global rabies elimination goals.

Methods

Study design

A retrospective review of documents was carried out using data collected during routine rabies surveillance in SA (as described below). Descriptive epidemiology was applied to characterise the occurrence of rabies in humans and animals in SA during the study period.

Data sources

For human rabies cases, data were extracted from the Notifiable Medical Conditions Surveillance System (NMCSS) and compared with data available from a database curated at the NICD. The latter database was compiled through data collected from test requests and submission forms, case investigation forms, and field investigation reports by provincial Department of Health (DoH) Communicable Disease Clusters (CDC) and SA Field Epidemiology Training Programme (FETP). It also incorporated emails and electronic messages from referring hospitals, as well as notes from the NICD hotline calls received for medical advice, where available for each case. The DoA provides aggregated official counts of rabid animals (including municipality and month of reporting) reported through PVS in a centralised, verified, and publicly accessible database using WOAH standards and requirements for disease reporting according to the Terrestrial Animal Health Code,[29] available via the following webpage link: http://webapps1.daff.gov.za/VetWeb/dieaseDatabase.do (accessed on 24 April 2024).

Inclusion and exclusion criteria

This report was based on human and animal rabies data from 01 January 2021 to 31 December 2023, obtained from the sources as detailed above and accessed on 17 May and 24 April 2024, respectively. For human rabies, both probable and laboratory-confirmed cases were reported. The NMCSS case definition of a suspected human rabies case, as stipulated by the WHO, is 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. Suspected patients who tested positive for the RABV by reverse transcriptase polymerase chain reaction (RT-PCR) or by the direct fluorescent antibody (DFA) test for rabies antigen detection were classified as confirmed cases. Probable cases were those with a clinical history and outcome and an epidemiological history consistent with a rabies diagnosis, but laboratory confirmation was not possible. Key characteristics of human rabies cases were described in this report, including age and sex, the animal species involved in exposure if known, the year and municipality of exposure, and administration of rabies PEP.

Only laboratory-confirmed animal rabies cases that had been officially reported to the DoA through PVS were included in this study. The case definition for animal rabies from 1997[30] was satisfied by a positive DFA on brain tissue or central nervous system tissue collected from a suspected animal rabies case, which is defined as an animal displaying sudden behaviour change, excessive salivation, and neurological symptoms that do not improve with time. The year, species, and municipal location of the animal case were among the variables analysed in this study.

Data extraction, management, and analysis

Human case data were extracted from Microsoft (MS) Excel 2016 using the filter function. Data cleaning was performed in MS Excel using built-in features to correct spelling errors and format text, dates, and geographic co-ordinates. Animal data for rabies for the study period were downloaded as an MS Excel spreadsheet from the DoA database webpage. Municipal names were added where they were missing and corrected in cases involving humans and animals. Additional corrections were made to the data extraction to join municipal names in the spreadsheet and the attributes table of the QGIS (Quantum GIS Development Team, Grüt, Switzerland) shapefile based on the most recent Municipal Boundary Administration Demarcation Process by the Municipal Demarcation Act (MDA) 27 of 1998.

Data analysis was performed in MS Excel using the PivotTable feature, which presented tables summarising human case counts per province and municipality and provided a list of animal species detected as rabid. Choropleth maps per animal group corresponding with an aggregated summary of provincial counts of rabid cases were created using QGIS. Bar charts were used to compare the frequency and relative frequency (percentage) of rabies cases in humans and animals by year and province during the reporting period. An age-sex pyramid graph was created. A layer displaying the distribution of human rabies cases was added to a map with a choropleth layer background with the aggregated summary of municipal counts of combined canine and feline rabid cases. This map was also created using QGIS. The map and the municipal numbers of domestic animals (dogs and cats) and human rabies cases were used to describe differences and shortcomings, as well as similarities and conformities in surveillance.

Results

Human rabies

A total of 54 human rabies cases was reported, comprising 44 laboratory-confirmed cases and 10 probable cases. These cases were reported from 17 municipalities in three provinces, namely the Eastern Cape (EC, n=27), KZN (n=18), and Limpopo (LP, n=9) (Table 1). Eighty-three per cent (n=45) of the cases were aged under 16 years, and 64.8% (n=35) were male (Figure 1). Dog-mediated rabies was identified in 75.9% (n=41) of the cases, while 3.7% (n=2) of cases were exposed to domestic cats, and 3.7% (n=2) cases were exposed to wildlife (a wild dog and a wild cat species). During this period, there were reports of rabies infection in farm animals (Table 2), but no human cases were documented as a result of rabid livestock bites or rabies exposure during handling or slaughter. For 16.7% (n=9) of the cases, no exposure history was known.

Table 1. Laboratory-confirmed and probable human rabies cases reported by municipality and province for 01 January 2021–31 December 2023, South Africa.

Districts and Municipalities	Eastern Cape	KwaZulu-Natal	Limpopo
Nelson Mandela Bay	**9**	**-**	**-**
Buffalo City	**7**	**-**	**-**
O.R. Tambo	**6**	**-**	**-**
Nyandeni	3	**-**	**-**
King Sabata Dalindyebo	3	**-**	**-**
Amathole	**5**	**-**	**-**
Mbhashe	3	-	-
Great Kei	2	-	-
eThekwini	**-**	**11**	**-**
King Cetshwayo	**-**	**3**	**-**
uMhlathuze	-	3	-
Zululand	**-**	**2**	**-**
Nongoma	-	1	-
Ulundi	-	1	-
iLembe	**-**	**1**	**-**
Maphumulo	-	1	-
Ugu	**-**	**1**	**-**
Umzumbe	-	1	-
Vhembe	**-**	**-**	**6**
Thulamela	-	-	5
Makhado	-	-	1
Mopani	**-**	**-**	**3**
Greater Giyani	-	-	1
Letaba	-	-	1
Maruleng	-	-	1
Total	**27**	**18**	**9**

Provinces and districts are indicated in boldface and local municipalities in regular font. Nelson Mandela Bay, Buffalo City, and eThekwini are all districts and metro municipalities.

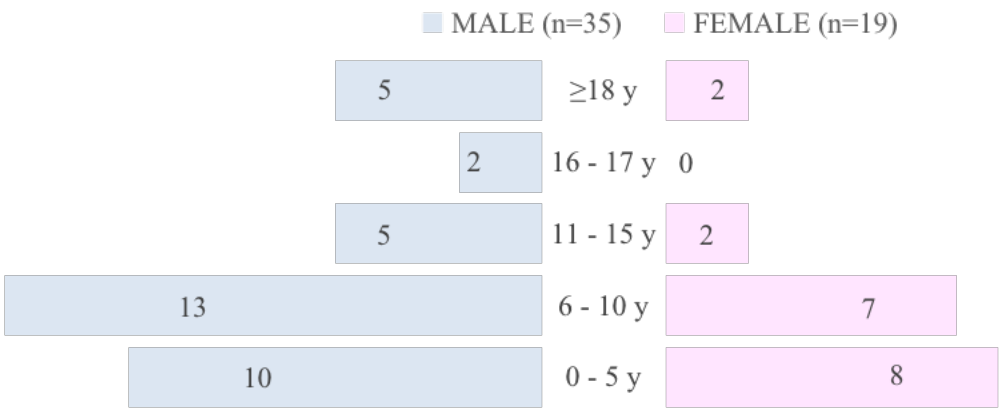

Figure 1. The age-sex pyramid of laboratory-confirmed and probable human rabies cases, 01 January 2021–31 December 2023, South Africa.

Of the 54 human cases, 44.4% (n=24) involved bites or scratches or licks to the head, face (including mucous areas), ears, or neck; six involved the hand or wrist, eight involved the leg, six involved the arm, and three involved the trunk. In eight of the incidents, wound injuries or abrasions to two (n=7) or multiple body parts (n=1) were reported. In 25.9% (n=14) of the cases, the body part that was harmed was not identified; five involved bite cases, one involved a cat scratch, four had no report of a specific bite incident, and four had no information available.

All of these individuals required rabies vaccination as they progressed into rabies cases. In addition, 74.1% (n=40) of the patients had category 3 bites with bleeding wounds, which also required rabies immunoglobulin (RIG). It was frequently unclear whether the 54 patients who did not receive the necessary rabies PEP were affected by patient-related factors, health system factors, or both.

Based on the available information, it is roughly estimated that 64.8% (n=35) did not seek medical care or, in the case of children, were not taken to a nearby healthcare facility to receive rabies PEP, with the majority of these being children. This may have been reasonable in some cases where only abrasions or scratches (n=4) or mucous membrane licks (n=1) occurred, and certainly in cases where no specific animal bite was reported (n=5). In four cases, no information was provided about the exposure at all. Of those who did seek treatment at a nearby healthcare facility, an additional 11.1% (n=6) of cases received the necessary RIG and vaccine on the first visit, but four missed follow-up visits to complete the rabies vaccination schedule, including one case that did not receive further vaccinations due to a stock-out. Two cases completed the full rabies regimen, but it is possible that the RIG was not applied properly to all wounds, and one case may not have had enough time to develop immunity because of a very short incubation period of 16 days. In 24.1% (n=13 cases), no RIG was given on the first visit, likely because RIG was unavailable (only provincial hospitals stock RIG) or due to an incorrect categorisation of the exposure as less than category 3 by the healthcare professional.

Animal rabies

A total of 1 856 animal rabies cases was confirmed and reported through PVS to the DoA (Table 2). These cases were reported from 119 municipalities across all nine provinces of SA. Of the animal rabies cases, 83.4% (n=1,548) involved domestic dogs and 2.5% (n=47) involved domestic cats. Rabies in livestock (8.8%, n=164) was reported in cattle, goats, sheep, horses, and a pig. Rabies in wildlife (4.7%, n=88) was reported in canine species and felids. Rabies was also confirmed in one Cape ground squirrel, two kudus, and two honey badgers.

Table 2. Confirmed and reported animal rabies cases by species, 01 January 2021–31 December 2023, South Africa.

Animal species	Scientific name	Total
Domesticated animals and livestock		
Dogs	*Canis familiaris*	1 548
Cattle	*Bos species*	100
Cats	*Felis domesticus*	47
Goats	*Capra hirsutus*	29
Sheep	*Aries ovis*	22
Horses	*Equus calabus*	12
Pigs	*Suis scrofula*	1
Wildlife		
Canid species		
Bat-eared fox	*Otocyon megalotis*	25
Black-backed jackal	*Canis mesomelas*	16
Aardwolf	*Proteles cristatus*	10
Side-striped jackal	*Canis adustus*	3
Spotted hyena	*Crocuta crocuta*	2
Cape fox	*Vulpes chama*	1
Mongoose species		
Yellow mongoose	*Cynictis penicillata*	13
Suricate	*Suricata suricatta*	5
Water mongoose	*Atilax paludinosus*	3
Slender Mongoose	*Galerella sanguinea*	2
Large grey mongoose	*Herpestes ichneumon*	1
Small grey mongoose	*Galerella pulverulenta*	1
White-tailed mongoose	*Ichneumia albicauda*	1
Felid species		
Lion	*Panthera leo*	4
Striped polecat	*Ictonyx striatus*	2
Caracal	*Felis caracal*	1
Serval	*Felis serval*	1
Small spotted cat	*Felis nigripes*	1
Herbivore species		
Kudu	*Tragelaphus strepsiceros*	2
***Mellivora* species**		
Honey badger	*Mellivora capensis*	2
Rodent species		
Cape ground squirrel	*Xerus inauris*	1

The geographic distribution of animal rabies cases by species group is presented in Figure 2.

For the period 2021–2023, all provinces reported rabies in domestic dogs, with the largest number in KZN, followed by the EC. The highest percentage of rabies in dogs (compared to other species groups: domestic cats, livestock, and wildlife) was in LP (96.5%) and the provinces along the east coast: KZN (93.8%), Mpumalanga (MP) (90.0%), and the EC (87.6%). Rabies in domestic cats (feline) was detected in five provinces, albeit in much lower numbers than in dogs, with the highest incidence in the EC (Figures 2 and 3b).

KZN reported the highest percentages of dog rabies cases in each year during the reporting period, with the EC following it closely. The associated human cases in the KZN province were second after the EC province, which had the highest numbers of human cases for 2021 and 2022 (Figures 3a and 3b). The highest number of cat rabies cases for both 2021 and 2023 was reported in EC. However, in 2022, the data showed a relative reduction in the reporting of animal cases, which is in contrast to the human rabies cases, which were the highest of all provinces that year. Illustrated in Figures 3a and 3b, LP ranked fourth for the number of dog (or cat) rabies cases but third for the number of human rabies cases amongst the provinces. Six of the nine cases were known to be from dog bites, whereas in three cases, the animal source was not known. The Free State (FS) reported the third-highest percentage of dog (or cat) rabies for the three years and no human cases. The other provinces all reported dog (or cat) rabies in very low numbers and no human cases (Figures 3a and 3b). Rabies in livestock was mostly detected in the EC (n=44) and KZN (n=42), followed by the FS (n=36) and North West (NW) (n=33) provinces. The Gauteng (GP) and MP provinces did not report rabies in livestock cases during this period (Figure 2).

Rabies in canine wildlife was most prevalent in the WC (n=22), followed by the NW (n=15) and GP (n=13) provinces. Other provinces, with the exception of LP, also reported cases. The WC reported mainly rabies in bat-eared foxes and one in a Cape fox (n=17), whereas the NW and GP reported rabies mainly in black-backed and side-striped jackals (n=18). The FS reported the most mongoose cases (including yellow mongoose, suricates, and other species) (n=17) compared to the other provinces. Rabies in aardwolves (Table 1) was reported from the FS (n=5), WC (n=4), and NC (n=1). Gauteng experienced an outbreak in the West Rand District, including Mogale City, Merafong, and Randfontein, with rabies cases in black-backed jackals, side-striped jackals, honey badgers, and domestic dogs (n=14) (Figure 2).

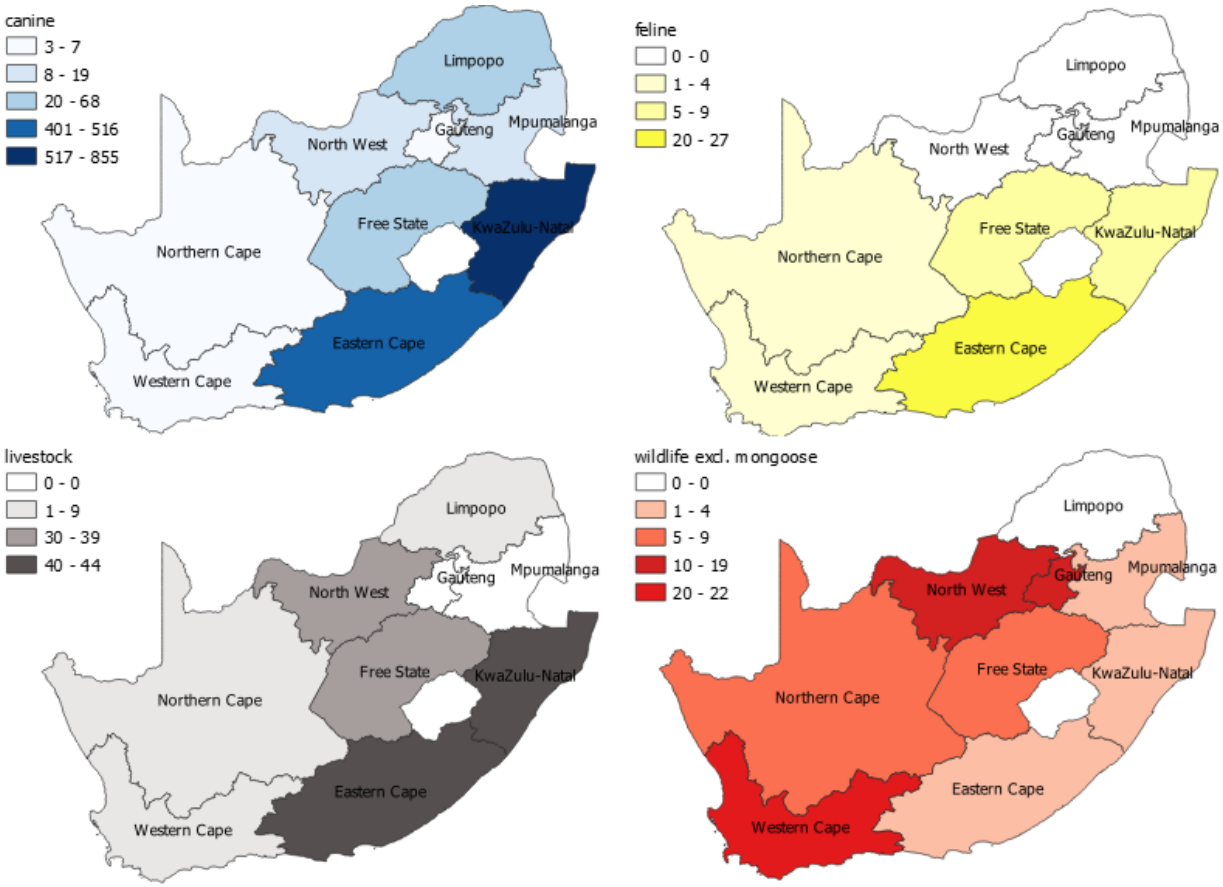

Figure 2. Density maps of animal rabies cases by species and province, South Africa, 2021–2023. Clockwise from top left to bottom left is the density map of canine (domestic dog), feline (domestic cat), wildlife (excluding mongoose), and livestock cases.

Spatial-temporal trends of domestic dog and human rabies

On a municipal level, the areas with the highest reported burden of animal (dog and cat) and human rabies cases related to these animals from 2021–2023 were eThekwini metro in KZN and Nelson Mandela Bay metro in the EC (Figure 4). Buffalo City metro municipality in the EC reported significantly fewer animal rabies cases, nearly 10 times less than Nelson Mandela Bay metro, but despite that, the number of human deaths associated with rabies in Buffalo City was exceptionally high during 2021–2023. The conflicting figures for animal and human cases in the EC for 2022 are shown in Figures 3a and 3b. Besides the three above municipalities, King Sabata Dalindyebo, Mbhashe, Nyandeni, and Great Kei in EC, Maphumulo and Ulundi in KZN, and Greater Giyani, Maruleng, and Greater Letaba in LP, showed positive links between animal and human rabies cases. However, Nyandeni municipality in the EC reported more human cases than animal cases, and Nongoma municipality in KZN reported a human case without any animal cases. As shown in Figures 3a and 3b, there is a connection between animal and human rabies cases in KZN and the EC.

Other municipalities in the EC and KZN provinces reported solely animal rabies cases, and only a few did not contribute to reporting (Figure 4). Of note, the Enoch Mgijima and Mhlontlo municipalities in the EC reported the highest numbers of rabies in cats, which were much higher than reported in dogs. In KZN, the reporting from the eThekwini metro municipality far outweighed that of other municipalities in the province. uMhlathuze, KwaDukuza, uMlalazi, and Ray Nkonyeni municipalities reported a fair number of animal cases, but their numbers were still much lower by at least tenfold in comparison to eThekwini municipality. The same applies to the EC, where reporting of positive cases from the other municipalities was only a fraction of those reported from the Nelson Mandela Bay metro municipality (Figure 4). In contrast, Figure 4 also shows that a few municipalities (Greater Giyani, Maruleng, Molemole, Blouberg, and Greater Letaba) in LP contributed to the reporting of animal cases, with Maruleng municipality recording the most. Whereas Greater Giyani, Maruleng, and Greater Letaba each reported a human case, the Makhado and Thulamela municipalities of Vhembe district in northern LP surprisingly did not report rabid animal cases despite reporting six human cases during the three years, as indicated in Figures 3a and 3b. In MP, where no human cases had been reported, dog cases were reported from mainly the Bushbuckridge municipality in the north-east and a few other municipalities. The Mangaung metro municipality (Bloemfontein) in the FS reported a modest number of animal (dog, cat, and unknown) cases. Some other municipalities reported animal cases in these species. No human cases were reported in the FS during 2021–2023. In the other provinces, municipalities reported animal (dog, cat, and unknown) cases at very low levels compared to the provinces in the east of the country and the FS province. In GP, a rabies case in dogs was reported in 2022 in both the Mogale City local municipality and Johannesburg, and in 2023 in the Tshwane (Pretoria) metro municipality. In the WC, the city of Cape Town reported cases of rabies in dogs (n=5) in 2021 and in 2022. Two other municipalities in the WC, Hessequa and Swellendam, each reported a dog rabies case in 2022 and a cat case in Beaufort West in 2021.

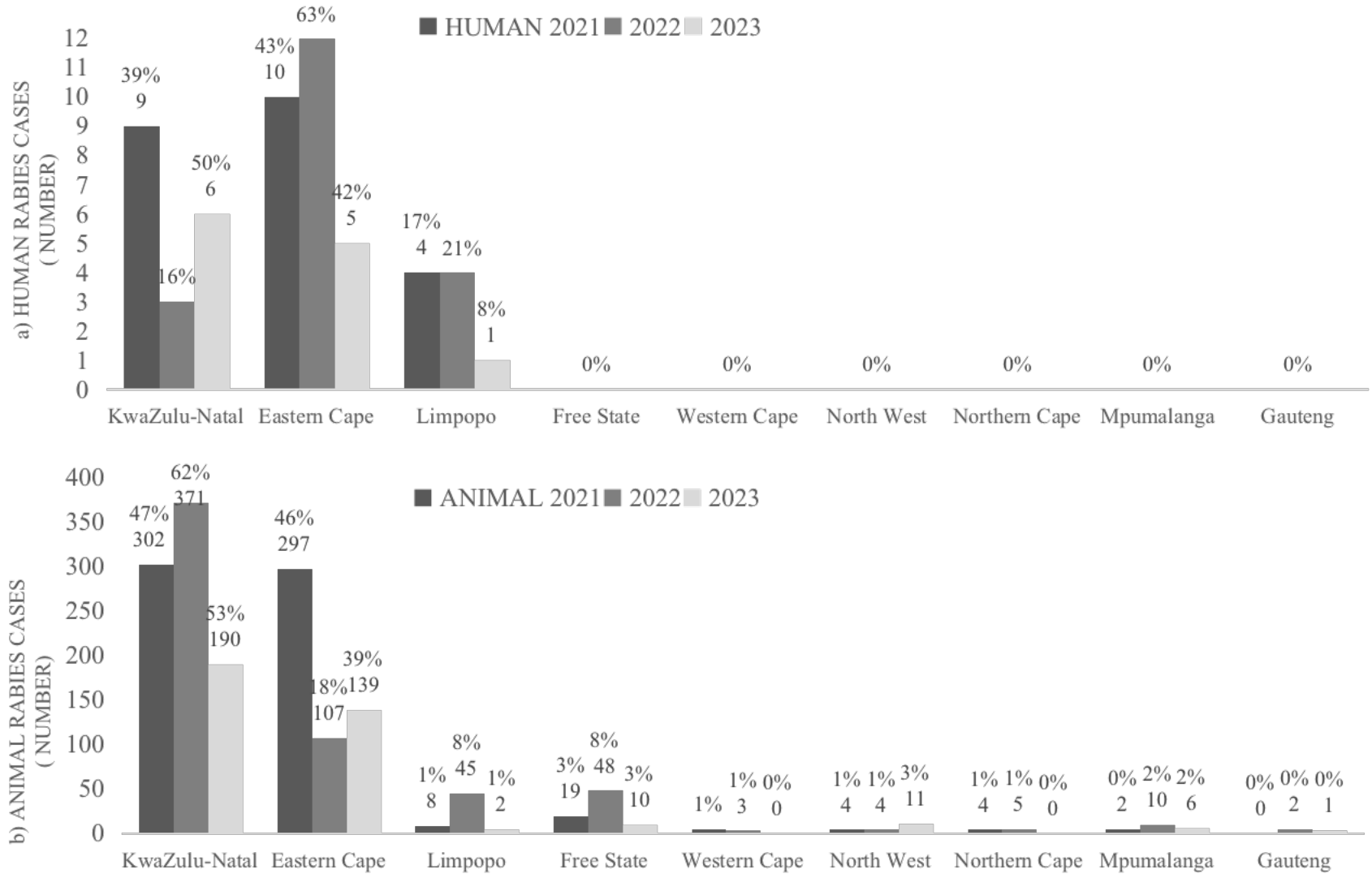

Figure 3. Comparison of a) human and b) animal (dog or cat) rabies cases by province, South Africa, 2021–2023.

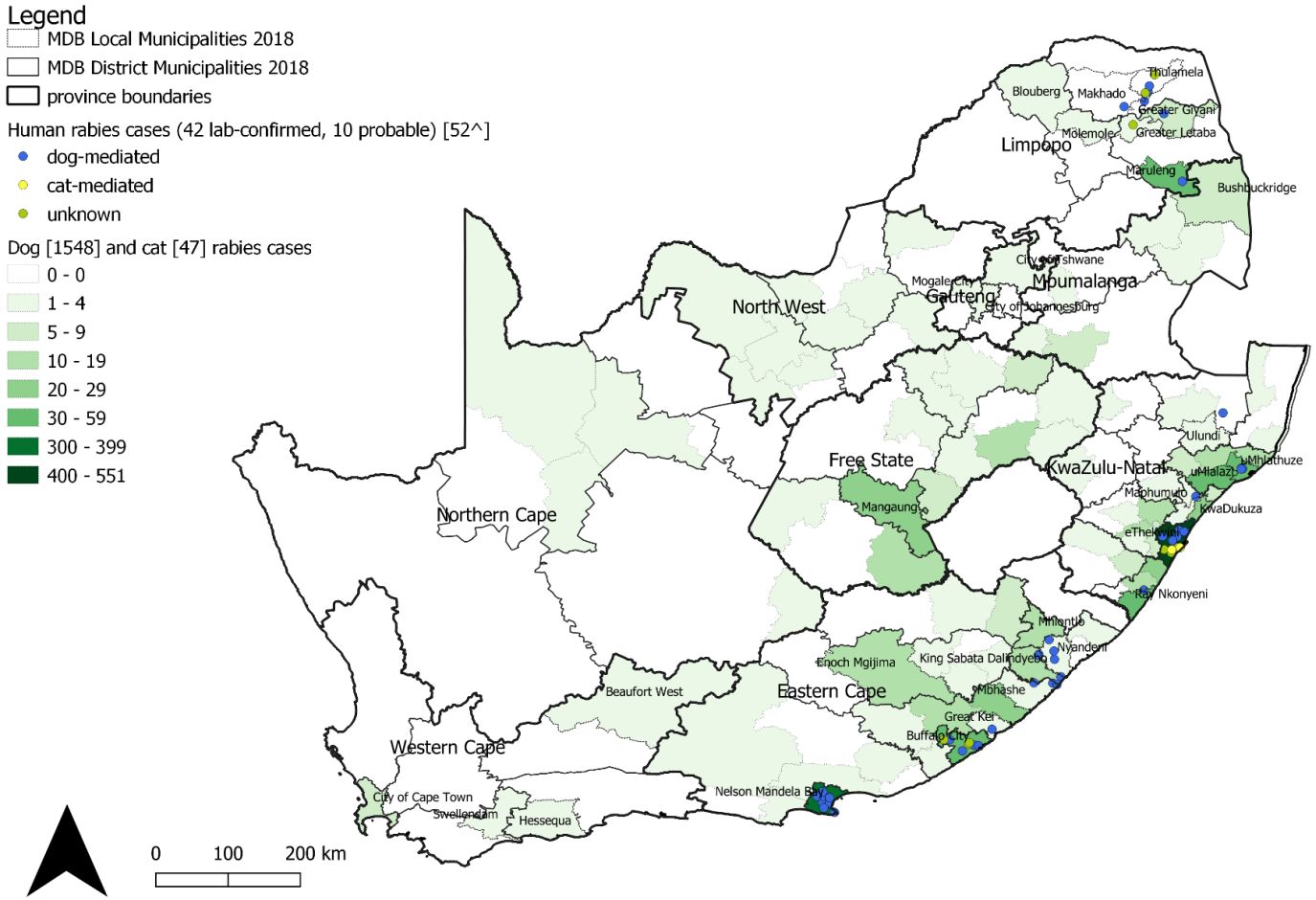

Figure 4. Choropleth of combined dog and cat cases (green multicolours) and distribution of human rabies cases (dog-mediated by green dots and cat-mediated by yellow dots; unknown animal source in grey dots) by municipality, South Africa, 2021–2023 (https://dataportal-mdb-sa.opendata.arcgis.com/ Date created: 02/10/2019; Date updated: 22/06/2022).

^animal-mediated human rabies cases, excluding the two wildlife-mediated human rabies cases; no livestock-mediated human rabies cases were detected during 2021–2023.

Discussion

This report integrates official surveillance data on rabies in SA from 01 January 2021 to 31 December 2023, combining laboratory-confirmed animal cases reported through the PVS to the DoA with confirmed and probable human rabies cases reported by NICD to the NMCSS. It provides a comprehensive One Health overview of rabies at municipal, provincial, and national levels and identifies areas for improvement based on observed limitations in reporting and surveillance.

Human rabies

The surveillance data indicate a high number of human rabies cases during 2021–2023. Notably, metropolitan municipalities in the EC have historically reported few cases, but NMB experienced an unprecedented outbreak in 2021 and 2022.[31] In the same province, Buffalo City Metro recorded seven human cases across the surveillance period (2021 n=2, 2022 n=2, and 2023 n=3), with only 40 dog cases officially reported to the DoA, highlighting likely under-reporting of animal cases. The EC province recorded nearly double the human rabies incidence recorded in previous decades (1997–2007 vs. 2008–2018).[22]

Previously, human cases were primarily reported from rural municipalities, but in 2021–2022, urban municipalities such as NMB and Buffalo City began reporting cases. No dog rabies cases had been confirmed in NMB in the eight years prior to this outbreak.[31] Following awareness campaigns, public education, and dog vaccination interventions, the outbreak in NMB was contained by 2023, with no human cases reported thereafter.[31] In contrast, Buffalo City continues to report sporadic human cases.[32] Factors contributing to these urban outbreaks likely include low awareness of rabies, limited knowledge of responsible dog ownership, socioeconomic disparities, poverty, crime, and insufficient municipal and veterinary services.

The COVID-19 pandemic further disrupted access to PEP and animal rabies control measures, likely exacerbating the risk.[33] In KZN, human rabies cases persisted primarily in eThekwini Metro, particularly in the Umlazi township, reflecting the ongoing challenge of rabies control in established enzootic areas.[32] Historical interventions in KZN (2008–2013), including awareness campaigns, dog vaccination, and expanded PEP access, previously reduced outbreaks.[34] Gaps identified through knowledge, attitude, and practice (KAP) studies (2017–2018, 2022) highlighted continuing challenges, including limited awareness of rabies, inadequate dog vaccination, and inconsistent access to PEP.[35,36] Children under 16 years-of-age remained the most affected group, accounting for 71% (45/54) of reported cases, reflecting both behavioural vulnerability and dependence on guardians for accessing healthcare.[37] While PEP is effective, access challenges and awareness gaps persist.[38] Pre-exposure prophylaxis (PrEP) is recommended for high-risk individuals, but widespread paediatric PrEP remains limited, although initiatives such as the Global Alliance for Vaccines and Immunisation's (GAVI) conditional funding aim to improve access in endemic regions.[39-41]

Animal rabies

Domestic dogs were the most frequently affected species (n=1 548) and were linked to 75% of human cases, consistent with historical epidemiology in SA and global trends.[21,22,42] Dogs remain the principal source of human rabies transmission worldwide.[2,3] Preventing human rabies is therefore most effectively achieved through control of rabies in dog populations.[2,3] Mass dog vaccination, combined with PEP, offers cost-effective and equitable prevention, with modelling estimating welfare gains of USD 9.5 billion across Africa over 30 years if dog vaccination is scaled.[43] Vaccination coverage of at least 60–70% of the dog population is required to interrupt transmission sustainably.[44]

Other domestic animals and wildlife were occasionally affected, including cats, goats, cattle and honey badgers, but these are generally considered dead-end hosts.[19] Notably, the WC documented the usual outbreaks in terrestrial wildlife, including bat-eared foxes, and rare cases in dogs and unusual rabies in Cape fur seals, which was first detected in 2024 but is thought to have emerged in 2022.[18] In GP, an outbreak mainly in Mogale City, which primarily occurred in 2021, involved eight wildlife cases (jackals and honey badgers) and one dog case (2022). Except for a single fatality resulting from severe injuries from an attack by a rabid honey badger, following timely PEP and awareness interventions, no human deaths from rabies infection occurred there.

The cost disparity between human PEP and dog vaccination underscores the public health value of canine rabies control. While dog and cat vaccination is inexpensive (~20 ZAR per dog), human PEP costs approximately 250 ZAR per vaccine dose plus rabies immunoglobulin for severe exposures, highlighting the economic efficiency of preventive animal vaccination.[42,45,46]

Spatio-temporal features of human and dog rabies

The distribution of human and dog rabies cases varied markedly across municipalities and over time. Urban municipalities, including eThekwini and NMB, reported disproportionately high numbers of human and domestic dog cases, reflecting both true transmission foci and better access to diagnostic facilities. Rural municipalities continued to report cases, but some areas, such as Vhembe District (LP) and parts of KZN, recorded human cases without corresponding animal reports, suggesting gaps in animal surveillance and under-reporting. Conversely, eThekwini's high case counts likely reflect both endemic transmission and proximity to diagnostic laboratories.

Spatio-temporal patterns also highlighted the emergence of rabies in previously unaffected areas, including metropolitan municipalities in the EC and GP, while traditional hotspots in rural areas continued to persist. Outbreak timing and clustering indicate that human cases generally follow peaks in dog rabies, consistent with the known transmission dynamics.[47] Cross-sectoral linkage mapping confirms that human exposures occur predominantly in localities with high dog rabies incidence, reinforcing the critical role of integrated One Health surveillance for timely outbreak detection and targeted interventions.

Across the three years, reported animal cases declined between 2021 (n=743) and 2023 (n=444), reflecting both containment efforts and improved municipal reporting coverage. The number of municipalities reporting cases also increased annually (n=71 in 2021, n=78 in 2022 and n=82 in 2023), reflecting enhanced surveillance capacity alongside disease spread. Nevertheless, discrepancies in reporting, particularly in the EC and Buffalo City, emphasise the need for continued strengthening of both human and animal rabies surveillance systems.

Laboratory-confirmed human cases (n=44) were supplemented by probable cases (n=10) based on clinical and exposure history. Probable cases often originated from rural municipalities, whereas confirmed cases were more concentrated in metro areas with better infrastructure. This pattern highlights persistent under-detection of rabies, with true incidence likely substantially higher than reported, in line with global estimates suggesting under-reporting by 20–160 fold in Africa and Asia.[48]

Conclusion

Rabies prevention and control remain ongoing challenges in SA. Key to reducing dog-mediated human rabies deaths is the establishment of integrated surveillance systems supported by robust laboratory capacity, timely cross-reporting between sectors, and heightened awareness among healthcare professionals and the general public. Strengthening general service delivery – including accessible veterinary services and reliable provision of PEP – is also critical to preventing fatalities. Enhanced integration, including systematic bite case tracking, ensures that individuals exposed to suspect rabid animals receive timely and complete PEP. SA is effectively progressing towards integrated disease surveillance and response (IDSR) systems using a One Health approach, with human and veterinary sectors, along with public and private stakeholders, reporting cases collaboratively.

This cross-sectoral report of human and animal rabies cases highlights correlations in geographic distribution and emphasises the value of integrated surveillance. We advocate formalising these systems with standard operating procedures, leveraging the current manual cross-reporting efforts as an initial step towards a comprehensive, sustainable One Health rabies surveillance and response framework.

Recommendations

- The DoA and PVS to improve dog vaccination coverage in KZN, EC, and LP. The largest number of dog and human rabies cases were reported from these provinces. Targeted dog vaccination campaigns in municipalities to achieve sustained herd immunity and interrupt RABV transmission in dogs in these locations are critical for rabies control and prevention of future outbreaks of the disease.
- The DoA, DoH, the Department of Education, municipalities, the NICD, and non-governmental organisations to enhance rabies awareness and bite prevention in children. Eighty-three per cent of human rabies cases occurred in children under the age of 16 years. School-based rabies education and dog-bite

prevention targeting primary school learners, particularly in KZN, EC, and LP, may reduce the number of rabies exposures, improve health-seeking behaviour for rabies PEP, and improve responsible pet care and uptake of rabies vaccination in dogs.

- DoH and healthcare facilities to manage improved access and adherence to rabies PEP. Sixty-five per cent of human rabies cases did not receive PEP because they did not seek medical care, and the remainder received incomplete PEP treatment. Improve stock availability at primary healthcare clinics and hospitals in KZN, EC, and LP, particularly at facilities in municipalities or districts where dog rabies is reported. Provide regular healthcare worker training to improve capacity for appropriate PEP delivery and ensure that national guidelines for rabies prevention in humans are easily accessible at these facilities and by the healthcare workers.

Ethical considerations

The collection and reporting of data related to human rabies cases in SA were provided for in the protocol entitled 'Essential communicable disease surveillance and outbreak investigation activities of the NICD' (reference number M210752, the Human Research Ethics Committee of the University of the Witwatersrand). The data for animal rabies cases were collected from routine diagnosis and surveillance activities, which were not subject to ethics approval. The webpage link for animal rabies data was publicly available.

Conflicts of interest

The authors declare no conflict of interest.

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References

1. Walker PJ, Freitas-Astúa J, Bejerman N, et al. ICTV virus taxonomy profile: Rhabdoviridae 2022. *Journal of General Virology*. 2022; 103(6):001689

2. Fooks AR, Banyard AC, Horton DL, et al. Current status of rabies and prospects for elimination. *The Lancet*. 2014; 384(9951):1389-99

3. World Health Organization WHO expert consultation on rabies: Third report. World Health Organization; 2018 . Available from: https://iris.who.int/handle/10665/272364

4. Hampson K, Coudeville L, Lembo T, et al. Estimating the global burden of endemic canine rabies. *PLOS Neglected Tropical Diseases*. 2015; 9(4):e0003709. doi:10.1371/journal.pntd.0003709

5. Anderson A, Shwiff S. The cost of canine rabies on four continents. *Transboundary and emerging diseases*. 2015; 62(4):446-52

6. Viljoen N, Weyer J, Coertse J, et al. Evaluation of taxonomic characteristics of matlo and phala bat rabies-related Lyssaviruses identified in South Africa. *Viruses*. 2023; 15(10):2047

7. Coertse J, Grobler CS, Sabeta CT, et al. Lyssaviruses in insectivorous bats, South Africa, 2003–2018. *Emerging infectious diseases*. 2020; 26(12):3056

8. Van Eeden C, Markotter W, Nel LH. Molecular phylogeny of Duvenhage virus. *South African Journal of Science*. 2011; 107(11):1-5

9. King A, Meredith C, Thomson G. The biology of southern African lyssavirus variants. *Current topics in microbiology and immunology*. 1994; 187:267-95

10. von Teichman BF, Thomson GR, Meredith CD, et al. Molecular epidemiology of rabies virus in South Africa: evidence for two distinct virus groups. *The Journal of General Virology*. 1995; 76 (Pt 1):73-82. doi:10.1099/0022-1317-76-1-73

11. Sabeta C, Bingham J, Nel L. Molecular epidemiology of canid rabies in Zimbabwe and South Africa. *Virus Research*. 2003; 91(2):203-11

12. Sabeta C, Mansfield K, McElhinney L, et al. Molecular epidemiology of rabies in bat-eared foxes (Otocyon megalotis) in South Africa. *Virus Research*. 2007; 129(1):1-10

13. Sabeta C, Mkhize G, Ngoepe E. An evaluation of dog rabies control in Limpopo province (South Africa). *Epidemiology & Infection*. 2011; 139(10):1470-5

14. Coetzee P, Nel LH. Emerging epidemic dog rabies in coastal South Africa: a molecular epidemiological analysis. *Virus research*. 2007; 126(1-2):186-95

15. Koeppel KN, Schalkwyk OL, Thompson PN. Patterns of rabies cases in South Africa between 1993 and 2019, including the role of wildlife. *Transboundary and Emerging Diseases*. 2021; 00:1-13. doi:10.1111/tbed.14080

16. Ngoepe C, Shumba W, Sabeta C. Evidence for a host switching in the maintenance of canid rabies variant in two wild carnivore species in the Northern Cape province, South Africa. *Journal of the South African Veterinary Association*. 2024; 95(1):16-25

17. Zulu G, Sabeta C, Nel L. Molecular epidemiology of rabies: focus on domestic dogs (Canis familiaris) and black-backed jackals (Canis mesomelas) from northern South Africa. *Virus Research*. 2009; 140(1-2):71-8

18. Winkler MP, Parker S. Rabies in seals: visitors to Cape Town marine areas urged to be alert. *Journal of Travel Medicine*. 2024:taae106

19. Müller T, Freuling CM. Chapter 6 - Rabies in terrestrial animals. In: Fooks AR, Jackson AC, editors. Rabies (Fourth Edition). Boston: Academic Press; 2020. p. 195-230

20. Department of Agriculture Forestry and Fisheries Republic of South Africa. Animal Diseases Act, 1984 (ACT No 35 OF 1984). Government Gazette South Africa. 1984 4 April;Sect. 9152

21. Weyer J, Szmyd-Potapczuk AV, Blumberg LH, et al. Epidemiology of human rabies in South Africa, 1983-2007. *Virus Research*. 2011; 155(1):283-90. doi:10.1016/j.virusres.2010.10.023

22. Weyer J, Dermaux-Msimang V, Grobbelaar AA, et al. Epidemiology of human rabies in South Africa, 2008 - 2018. *South African Medical Journal*. 2020; 110(9):877-81-81. doi:10.7196/SAMJ.2020.v110i9.14324

23. Grobbelaar AA, Blumberg L, Msimang V, et al. Human rabies associated with domestic cat exposures in South Africa, 1983–2018. *Journal of the South African Veterinary Association*. 2020; 91(0):a2036. doi:10.4102/jsava.v91i0.2036

24. Forman L, Pillay Y, Sait L. Health legislation: 1994-2003. *South African Health Review*. 2003; 2003(1):13-28

25. Government Republic of South Africa. The Government Gazette - Staatskoerant 15 December 2017. Vol. 630. No. 41330. In: Government Printing Works Republic of South Africa, editor. Pretoria2017. p. 1-32

26. World Health Organization. Ending the neglect to attain the sustainable development goals: a road map for neglected tropical diseases 2021–2030: World Health Organization; 2020.Available from: https://www.who.int/publications/i/item/9789240010352

27. Department of Agriculture Land Reform and Rural Development and Department of Health Republic of South Africa [Internet]. National strategy for the elimination of canine mediated human rabies in South Africa (2019-2030) Pretoria2024 [updated June 2024]. Available from: https://www.dalrrd.gov.za/index.php/publication/425-animal-health-information

28. World Health Organization. A guide to implementing the one health joint plan of action at national level: Food & Agriculture Org.; 2023. Available from: https://www.who.int/publications/i/item/9789240082069

29. World Organisation for Animal Health. Terrestrial Animal Health Code - General provisions (32nd Edition, Vol. 1). 2024. p. 501

30. Center for Disease Control. Case definitions for infectious conditions under public health surveillance. *Morbidity and mortality weekly report : MMWR*. 1997; 46((RR-10)):1-55. doi:https://www.cdc.gov/mmwr/preview/mmwrhtml/00047449.htm

31. Ravensberg MF, Fanoy EB, Whelan J, et al. Ongoing rabies outbreak in dogs of unprecedented scale and human cases in Nelson Mandela Bay Municipality, South Africa, up to 13 February 2022. *Eurosurveillance*. 2022; 27(16):2200252.

32. National Institute for Communicable Diseases . Increase in human rabies cases in South Africa (24 Nov 2024). Johannesburg2024. Available from: https://www.nicd.ac.za/increase-in-human-rabies-cases-in-south-africa-24-november-2021/

33. Goel K, Sen A, Satapathy P, et al. Human rabies control in the era of post-COVID-19: a call for action. *Journal of Travel Medicine*. 2023; doi:10.1093/jtm/taad009

34. le Roux K, Stewart D, Perrett K, et al. Rabies control in KwaZulu-Natal, South Africa. *Bulletin of the World Health Organization*. 2018; 96(5):360-5. doi:10.2471/BLT.17.194886

35. Hadebe JM, Sibiya MN. Experiences of people affected by rabies in Ethekwini district in the province of Kwazulu-Natal, South Africa. *African Health Sciences*. 2020; 20(1):150-7

36. Mabona M, Zwane T, Mhlongo B, et al. Knowledge, attitudes, and referral practices regarding animal bites and prevention of human rabies among traditional health practitioners in the eThekwini district in KwaZulu-Natal province, South Africa, 2022. *Frontiers in Tropical Diseases*. 2025; 6:1542614

37. Aldridge GL, Rose SE. Young children's interpretation of dogs' emotions and their intentions to approach happy, angry, and frightened dogs. *Anthrozoös*. 2019; 32(3):361-74

38. Warrell MJ. Time to revise the strategy for Gavi funding of rabies vaccine? *The Lancet*. 2021; 397(10273):471-2

39. Gavi The Vaccine Alliance. Gavi board starts framing Alliance's approach to 2021–2025 period. Gavi board approves in principle a set of new and expanded vaccine programmes. 2018 . Available from: https://www.gavi.org/news/mediaroom/gavi-board-starts-framing-alliancesapproach-2021-2025-period

40. World Health Organization. Zero by 30: the global strategic plan to end human deaths from dog-mediated rabies by 2030: United Against Rabies Collaboration: first annual progress report: Global strategic plan to end human deaths from dog-mediated rabies by 2030 World Health Organization technical report series. 2019; (No.WHO/CDS/NTD/NZD/2019.04).

41. Soentjens P, Berens-Riha N, Van Herrewege Y, et al. Vaccinating children in high-endemic rabies regions: what are we waiting for? *BMJ global health*. 2021; 6(2):e004074.

42. World Health Organisation . WHO | Rabies. 2023 [updated 2019-09-09 10:11:07]. Available from: https://www.who.int/news-room/fact-sheets/detail/rabies.

43. Bucher A, Dimov A, Fink G, et al. Benefit-cost analysis of coordinated strategies for control of rabies in Africa. *Nature Communications*. 2023; 14(1):5370.

44. World Health Organization. Rabies vaccines: WHO position paper, April 2018–Recommendations. *Vaccine*. 2018; 36(37):5500-3.

45. Borse RH, Atkins CY, Gambhir M, et al. Cost-effectiveness of dog rabies vaccination programs in East Africa. *PLoS neglected tropical diseases*. 2018; 12(5):e0006490.

46. Kent SJ, Naicker B, Wood DR. Demographics and management of dog-bite victims at a level two hospital in KwaZulu-Natal. *South African Medical Journal.* 2012; 102(11):845-7.

47. Malan AJ, Coetzer A, Bosch C, et al. A perspective of the epidemiology of rabies in South Africa, 1998–2019. *Tropical Medicine and Infectious Disease*. 2024; 9(6):122.

48. Knobel DL, Cleaveland S, Coleman PG, et al. Re-evaluating the burden of rabies in Africa and Asia. *Bull World Health Organ*. 2005; 83(5):360-8.