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Review Article

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Viral zoonoses at the human-animal interface in southern Africa: A systematic review

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ABSTRACT

Objective: To collate and summarize reports of viral zoonoses occurring at the human-animal interface in Southern Africa, along with their associated risk factors.

Methods: A comprehensive search was implemented in PubMed, Web of Science, Scopus and ProQuest databases for English language publications. The search used a combination of keywords for viral zoonoses, human-animal interface*, risk factor*, and countries in Southern Africa. The search covered the period from 1 January 2000 to 18 April 2024.

Results: A total of 893 records were retrieved from the database, with 17 articles included after screening. An additional 6 articles were identified through reference list tracking, yielding a total of 23 included articles. Domestic dog bites were identified as the primary source of rabies transmission across southern Africa, with only few cases linked to jackals, mongooses, and cats. Reported exposures for Rift Valley fever, Crimean-Congo hemorrhagic fever, influenza, hantavirus and Wesselsbron virus were all associated with occupational activities.

Conclusions: Preventive and mitigative strategies, such as dog rabies vaccination, post-exposure prophylaxis, and the use of personal protective equipment among animal workers - should be intensified across the region.

KEYWORDS: Viral zoonoses; Human-animal interface; Spillover; Southern Africa

1. Introduction

The human-animal interface is a critical pathway for the spillover of zoonotic pathogens from animals to humans. Zoonotic diseases are infectious diseases that can transmit between vertebrate animals and humans[1]. In the last century, around two-thirds of emerging infectious disease events have been zoonotic, and the majority of these zoonoses (71%) have been of wildlife origin[2]. Viral zoonoses continue to pose serious public health challenges with devastating consequences[3], especially the recent Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic[4,5]. Outbreaks from a range of these zoonotic pathogens have been reported across Africa[6]. Rabies, Rift Valley fever, avian influenza, and Crimean-Congo haemorrhagic fever were identified among the top research priorities for control of zoonoses in South Africa[7]. In Southern Africa, animal surveillance has revealed widespread circulation of zoonotic viruses, including the rabies virus, Rift Valley fever virus, filoviruses, influenza viruses, paramyxoviruses, and coronaviruses, even in the absence of recorded outbreaks[8–23].

Given their origin, inter-species interaction has been identified as an important factor in the spillover, amplification, and spread of pathogens from wildlife to humans[24]. Humans have always lived close to animals, and contact points and frequency have changed as populations and interactions with nature have grown[25]. The human-animal interface refers to these points of interaction between humans and animals, which encompasses both direct and indirect contact with animals, including direct physical, indirect environmental/ecological, and social/behavioural relationships and interactions[26,27]. The occurrence of these interfaces is often linked to human behaviour, cultural forces, and anthropogenic activities[28–30]. Therefore, specific human-animal interfaces may

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vary by locations as a factor of the surrounding demographic, cultural, and environmental context. This review aims to collate and synthesize available evidence on viral zoonotic diseases affecting humans at the human-animal interface and their associated risk factors in Southern Africa., Given the critical need for surveillance systems to focus on key interfaces and prioritize early detection and response[31], this study will generate valuable insights into the major and unique pathways of zoonotic spillovers in the region, thereby informing targeted prevention strategies and strengthening public health preparedness.

2. Methods

This review was registered in the international prospective register of systematic reviews (PROSPERO) under the registration number CRD42024537728, and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[32].

2.1. Information sources and search strategy

A comprehensive search strategy was employed in PubMed, Web of Science, Scopus and ProQuest databases for publications, conference abstracts, and other data reports using a combination of medical subheading (MeSH) terms and keywords for viral zoonoses, human-animal interface*, risk factor* and the Southern African countries. The search strategy was developed in PubMed and then adapted for the other databases. The search in PubMed was last executed on 18 April 2024 and on 25 April 2024 for the other databases.

2.2. Eligibility criteria

For a record to be eligible for inclusion, it had to assess at least one viral zoonotic disease among adults and/or children anywhere in southern Africa. The record also needed to have mentioned the human-animal interface implicated in the disease. The reference lists of all included studies were also reviewed to identify other eligible studies. Review articles, systematic reviews, as well as studies not published in the English language were excluded. Considering the recent advent of relevant surveillance technologies and availability of high-quality data/sources, only articles published from the year 2000 onwards were considered. Grey literature like government reports were not included in the study.

2.3. Screening process

Rayyan software was used to aid in tracking the literature screening process[33]. Articles identified from the database search were first screened for any duplicates, and duplicates with the same titles and abstracts were removed. This was followed by screening for relevant articles, which was conducted independently by two reviewers (ADB and SM). First, titles and abstracts were screened based on the eligibility criteria. Short-listed articles were then retrieved for full-text review.

2.4. Data extraction

A pre-designed Google sheet data extraction form was used to extract data on the article details, study details, and results/findings

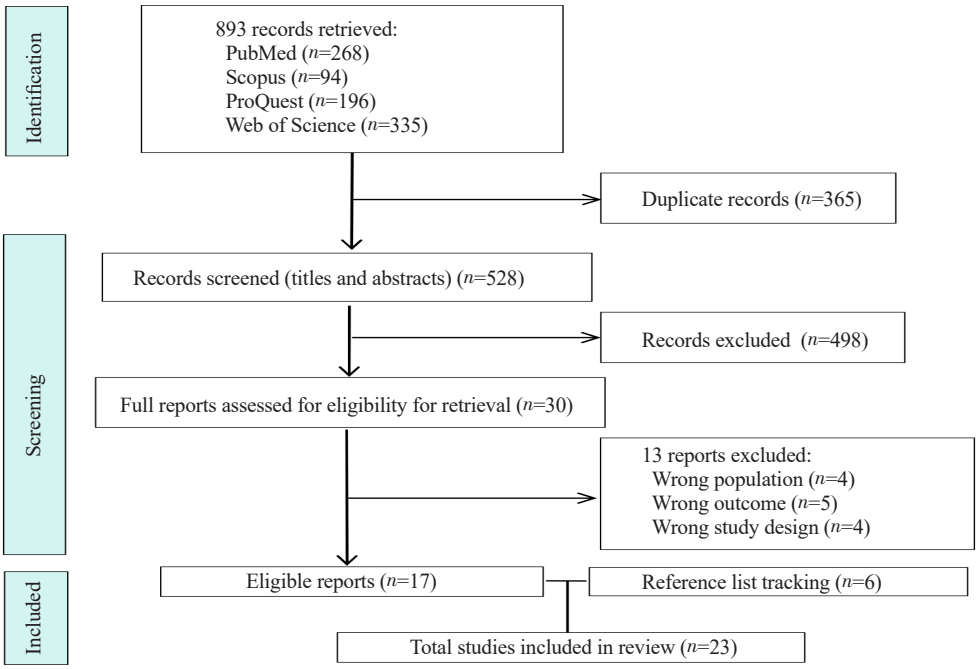


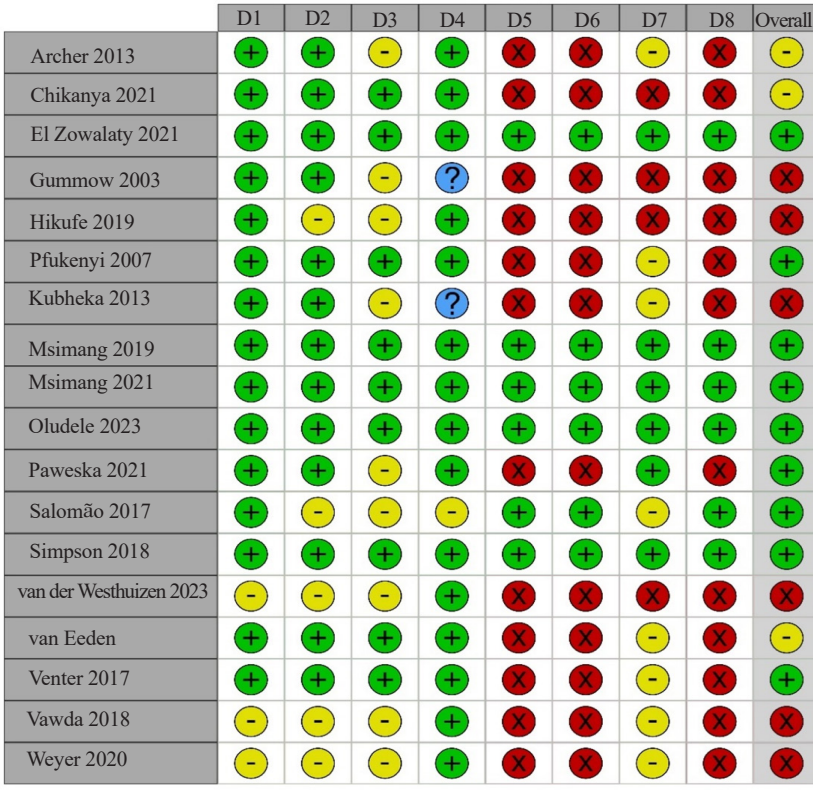
Figure 1. PRISMA flow diagram for the identification, screening, eligibility and inclusion of studies.

from the included articles. Data extraction was performed by ADB and cross-checked for accuracy by two other reviewers (SM and SB). Although it was important for articles to specify the screening and/or diagnostic test used for the virus, studies were not excluded if the viral disease was named without mention of the specific test. Data on Quality Assurance/Quality Control (QA/QC) and validation procedures of the screening and/or diagnostic tests used were extracted from each study, where available. These included adherence to manufacturer protocols, use of internal controls and participation in external quality assurance programs. Articles were also not excluded for not reporting disease prevalence/incidence or risk factors. Additionally, articles were included if the implicated animal was mentioned, regardless of whether the specific human-animal interface was described.

2.5. Risk of bias assessment

All included articles with quantitative study designs were assessed for risk of bias using the Joanna Briggs Institute (JBI) critical appraisal checklist comprising 8 items[34]. Each of the assessment criteria were scored qualitatively as 'low', 'some concerns', or 'high' risk of bias. To generate each article's overall-risk-of-bias score, qualitative ratings were converted to numerical values (low = 3, some concerns = 2, high = 1) and summed. The total was expressed as a percentage of the maximum possible score (24). Each article was categorised based on its checklist score as low risk (>70%), unclear risk (60–69%), high risk (<50-59%) or critical risk (<50%)[35]. The robvis visualisation tool was used to plot the assessment results.

A



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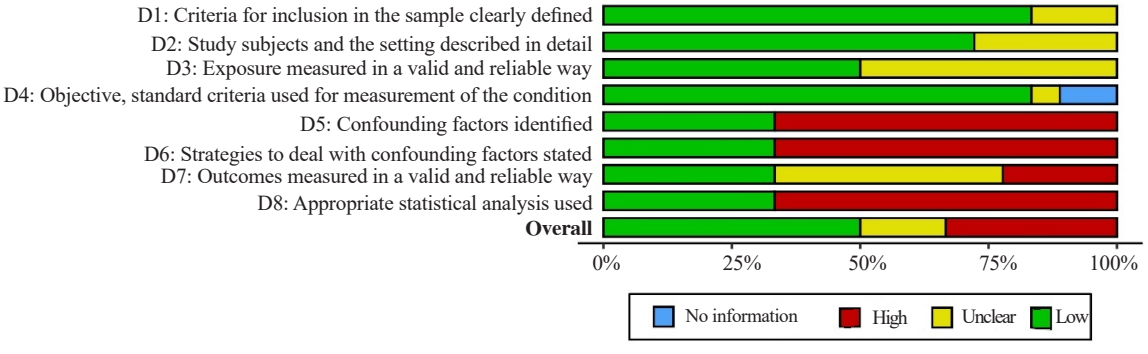

Figure 2. Assessment of bias traffic-light plot (A) and bias summary plot (B) of the included quantitative studies.

2.6. Synthesis methods

Extracted data were analysed qualitatively to identify patterns, themes, and concepts related to human-animal interfaces and exposure to viral zoonoses across the studies. Gaps in research and practice were also identified.

3. Results

The search process is presented in Figure 1. A total of 893 records were retrieved from the four databases, of which 365 exact duplicates were removed. Thirty articles were selected for full-text review, from which 13 were then excluded. An additional six articles were identified through reference list tracking, resulting in 23 included articles. Figure 2 depicts the risk-of-bias assessment for the quantitative studies included. Six studies (26%) were rated as having an overall high risk of bias. More than half of the included studies did not adequately address confounding and failed to apply appropriate statistical analyses.

A summary of the findings from the included studies is presented in Table 1. Eighteen (78%) of the included studies were conducted in South Africa, two each in Zimbabwe and Mozambique, and one in Namibia. Only three of the included papers were published before the year 2010. The publications on rabies primarily comprised secondary data analysis and case reports. Despite the varying trends in different parts of the country, rabies epidemiology at the country level remained essentially the same in South Africa between the periods 1983-2007 and 2008-2017. Domestic dog bites were the main source of rabies transmission across southern Africa, with fewer cases linked to jackals, mongooses, and cats. Dog bites were more frequently reported among males, younger individuals, and residents of suburban areas. Data on post-exposure prophylaxis were largely unavailable; however, available records indicate that compliance was generally poor across the region. The reported exposures for Rift Valley fever, Crimean-Congo hemorrhagic fever, influenza, hantavirus and Wesselsbron virus were all related to occupational activities. More than half of the included studies lacked a reporting of the validation methods used for primary screening/diagnosis of the viral disease.

4. Discussion

This review provides a comprehensive synthesis of viral zoonoses at the human-animal interface specifically within southern Africa, covering studies conducted over two decades (2003–2023). Unlike prior work that often focused on individual pathogens, single countries, or veterinary contexts, our review integrates diverse viral diseases affecting humans and multiple animal reservoirs across the region. By combining epidemiological, molecular, and serological evidence from a wide array of studies, this review offers updated and region-specific insights into the prevalence, transmission dynamics, and risk factors of zoonotic viruses. These findings fill a critical gap in the literature by elucidating the complex interplay between humans, animals, and viral pathogens in southern Africa, thereby informing more targeted and effective public health strategies and research priorities in this high-risk and understudied setting.

Despite the well-recognised role of wildlife in zoonotic transmission[2], the identified studies predominantly focused on dogs and livestock, with minimal representation of wildlife species. Dog bites – the primary human-animal interface for rabies transmission[36,37,40,51] – are highly prevalent in the southern African region[37,42,58]. Rabies control efforts should therefore prioritize eliminating or reducing this interface[59] through dog rabies vaccination programs[60–62] and improved access to post-exposure prophylaxis[63].

In the included studies, exposures to Rift Valley fever, Crimean-Congo hemorrhagic fever, West Nile fever, and hantaviruses were occupational, consistent with findings from other regions[64–68]. Only one study[51] assessed the effectiveness of personal protective equipment (PPE) in preventing zoonotic disease transmission. In Malawi[69] and Zambia[13], poor occupational practices related to Rift Valley fever, such as handling live animals, animal carcasses, abortable materials, and neonatal deaths without PPE, were frequently reported. Considering these risk factors, the use of PPEs and disinfectants will likely reduce the risks of transmission[64]. Additionally, further research is required to explore behaviours associated with wildlife contact like wildlife hunting, trading, and consumption. Some exposures occurred in the context of animal outbreaks[44,46,47,52], underscoring the need for clinicians to maintain a high index of suspicion for specific zoonotic pathogens when patients present from areas experiencing epizootics. Notably, seropositivity for Chikungunya, Dengue, West Nile, and Rift Valley fever viruses was detected among febrile patients in Mozambique who were initially presumed to have malaria[65]. Similarly, a SARS-CoV-2 survey in Zambia revealed higher prevalence among clinic attendees compared to community members[70], highlighting the critical role of health facilities in the surveillance of viral zoonoses.

Rabies was the most frequently cited virus, while important viral families with known zoonotic potential, such as filoviruses, coronaviruses and paramyxoviruses, were underrepresented. Expanding the scope of One Health surveillance studies in southern

Table 1. Summary of findings.

Author/ Year/ Country/	Study design	Sample size	Viral pathogen/ disease	Screening/ diagnostic method	QA/QC or Validation Methods	Results(Prevalence risk factors)	Animal-interface type
Szmyd-Potapczuk AV 2009[36] South Africa	Retrospective descriptive - secondary data analysis	Not applicable-laboratory confirmed human rabies cases for the period 1983-2007	Rabies	Direct fluorescent antibody test on brain impressions, and/or reverse transcription Polymerase Chain Reaction (RT-PCR), virus isolation in suckling mice	Not applicable (retrospective surveillance data review); no specific QA/QC procedures reported	353 lab confirmed rabies case	Domestic dog (predominantly), mongoose
Weyer J 2020[37] South Africa	Retrospective descriptive - secondary data analysis	Not applicable-laboratory confirmed human rabies cases for the period 2008-2018	Rabies	Fluorescent antibody test on postmortem-collected brain samples, RT-PCR	Not applicable (retrospective record review); no specific QA/QC procedures reported	10.5 cases per year	Dog-bite, scratch, lick on open wound
Kubheka V 2013[38] South Africa	Retrospective descriptive - secondary data analysis	5 139 dog bite cases	Rabies	Not stated	Not applicable (retrospective surveillance data review); no specific QA/QC procedures reported	7 human rabies cases; 136 rabies cases per 100 000 dog-bite injuries; Rabies post exposure prophylaxis reduces the risk of rabies	Dog-bite
Mollentze N 2013[39] South Africa	Case report	A 29-year-old canoeist and farmer	Rabies	Postmortem laboratory testing on brain and nuchal biopsy specimens	Not specified in the article; no detailed QA/QC procedures reported	Tested positive	Dog-direct contact (had rescued a puppy)
Pfukenyi DM 2007[40] Zimbabwe	Retrospective descriptive - secondary data analysis	57 rabies-suspect human samples	Rabies	Fluorescent antibody test	Not applicable (retrospective surveillance data review); no specific QA/QC procedures reported	42 (73.7%) were positive	Dog, jackal, honey badger-bite
Chikanya E 2021[41] Zimbabwe	Cross-sectional	195 dog bite cases	Rabies	Clinical	Not specified; no explicit QA/QC procedures reported	Prevalence: 1.5%; Risk factors: dog ownership, bitten in dog hotspot, unvaccinated dog	Dog, jackal-bite
Salomão C 2017[42] Mozambique	Retrospective case series, Case-control	819 animal bite cases	Rabies	Clinical	Not applicable (retrospective and case-control study); no specific QA/QC or validation procedures reported	14 rabies cases; Risk factors: bite by stray dog, bite by unimmunised dog, no post exposure prophylaxis	Dog-bite
Hikufe EH 2019[43] Namibia	Retrospective cohort	Not stated	Rabies	Clinical	Not applicable (surveillance study); no specific QA/QC or validation procedures reported	Incidence: 1.0 to 2.4/ 100 000 inhabitants/year	Kudu, jackal, cat, dog
Archer BN 2013[44] South Africa	Cross-sectional	2009 suspected RVF cases	Rift Valley fever	RT-PCR, loop-mediated isothermal amplification assays, virus isolation, hemagglutination-inhibition assays, or IgM ELISA	Not specified; the article does not detail specific QA/QC or validation procedures for laboratory testing	15% prevalence	Domestic and wild ruminants-direct contact with animal tissues, blood, or body fluid, acquiring, handling, or consuming meat directly from a farm or an informal or traditional butcher
Gummow B 2003[45] South Africa	Cross-sectional	88 veterinarians	Rift Valley fever, Orf, Pseudocowpox, Rabies, West Nile fever	Not stated	Not applicable (survey-based study); no specific QA/QC or validation procedures reported	History of at least one zoonotic disease: 63.6%; Incidence density rate for contracting a zoonotic disease: 0.06 per person year of exposure	Not stated-direct contact

Table 1. Continued.

Author/ Year/ Country/	Study design	Sample size	Viral pathogen/ disease	Screening/ diagnostic method	QA/QC or Validation Methods	Results(Prevalence risk factors)	Animal-interface type
Mismang V 2019[46] South Africa	Cross-sectional	802 farmers, farm workers, and veterinarians	Rift Valley fever	ELISA	Not specified in the article; no detailed QA/QC or validation procedures reported for laboratory testing	Seroprevalence: 9.1%; Risk factors: slaughtering animals), preparing/ consuming meat of hooved animals found dead, working on farm with one or more man-made dam structures for holding water, injection of and collection of samples from animals	Cattle, sheep, goats
Paweska 2021[16] South Africa	Cross-sectional	1 395 febrile and afebrile patients	Rift Valley fever	Inhibition ELISA, Serology	Not specified in the article; no detailed QA/QC or validation procedures reported for laboratory testing	Prevalence: Inhibition ELISA: 2.8%, IgG: 2.6%, IgM: 0.8%	Nguni chickens, cattle, goats, or ducks
van Vuren 2018[47] South Africa	Case report	6 farm workers who had experienced RVF compatible symptoms	Rift Valley fever	RT-PCR, hemagglutination inhibition assay (HAI), RVF inhibition ELISA, and RVF IgM ELISA	Standard laboratory protocols which have been previously validated for Rift Valley fever virus detection and antibody identification were followed for all the diagnostic assays	Prevalence: ELISA and HAI: 4 positive	Sheep-slaughter, disposal of infected carcasses, or aborted lambs
Vawda S 2018[48] South Africa	Cross-sectional	387	Crimean-Congo Fever	Indirect immunofluorescence assay	Not specified in the article; no detailed QA/QC or validation procedures reported for laboratory testing	Prevalence: 0.52%	Occupational activity (Abattoir workers, Informal slaughterers, Veterinarians, Horse handlers, Recreational hunters, Farmers)
Msimang V 2021[49] South Africa	Cross-sectional	1 040 livestock and game industry workers	Crimean-Congo Hemorrhagic Fever	ELISA	Validated ELISA assays were used, following standard operating procedures and biosafety protocols to ensure reliable results	Prevalence: 3.8% of farm workers, 4.2% of wildlife workers Risk factors: age, collecting samples from or giving injections to animals, rainy season	Cattle
Oludele J 2023[50] Mozambique	Cross-sectional	218 pastoralist community members	Crimean-Congo Fever	Serology	The assays followed standard operating procedures to ensure consistency and reliability	Prevalence: Caia: IgM: 5.3%, IgG: 1.0% Búzi: IgM: 3.3%, IgG: 0.8%	Cattle-farming
El Zowalaty ME 2022[51] South Africa	Cross-sectional	87 swine workers	Influenza A	PCR, Serology	Tests were conducted following standard laboratory protocols with appropriate positive and negative controls to ensure reliability. Assays were validated and performed under biosafety and QA/ QC standards	Prevalence: nasal wash: 52.38%, Serology: 29% Risk factors: male sex, age group, worn cloth gloves while working with animals in the last 30 days, working in swine farms for 5 years	Pig-farming
Venter M 2017[52] South Africa	Cross-sectional	Survey 1: 207 animal handlers involved in H5N2 outbreak Survey 2: 66 involved in H7N1 or previous H5N2 outbreaks Survey 3: 38 vets irrespective of exposure	Highly pathogenic avian influenza (HPAI)H5N2, low-pathogenic avian influenza (LPAI)H7N1	Serum hemagglutination inhibition (HAI), Microneutralization assays (MNAs)	Microneutralization titer above 40 was defined as positive	Survey 1: H5: 0.9%, H7:1.9% Survey 2: H5:1.5%, H7:12.1% Survey 3: H5:2.7%, H7:11%	Ostrich-culling, handling

Table 1. Continued.

Author/ Year/ Country/	Study design	Sample size	Viral pathogen/ disease	Screening/ diagnostic method	QA/QC or Validation Methods	Results(Prevalence risk factors)	Animal-interface type
Venter M 2010[53] South Africa	Case report	A veterinary student	West Nile virus	RT-PCR	Standard protocols to confirm specificity and sensitivity; laboratory assays included positive and negative controls for quality assurance	1 person infected	Horse-autopsy
van Eeden M 2014[54] South Africa	Cross-sectional	125 veterinarians	West Nile virus, Shuni virus	Microneutralization assay	Manufacturers' instructions; internal controls and standard quality control procedures were applied to ensure accuracy and reproducibility	Prevalence: West Nile virus-12.5%, Shuni virus- 4%	Horse-regular contact through veterinary care
Simpson GJG 2018[55] South Africa	Cross-sectional	119 non-malaria (AFP) acute febrile patients and 64 diptankers (cattle farmers, herders, and government veterinary staff)	West Nile virus, Sindbis fever virus, chikungunya virus, Rift Valley fever virus	Serology	Not specified in the article; no detailed QA/QC or validation procedures reported for laboratory testing	Prevalence: AFP: West Nile: 4.1%, Sindbis fever: 1.4%, Chikungunya: 0.0%, Rift Valley fever: 0.0%; Diptankers: West Nile: 3.1%, Sindbis fever: 3.1%, Chikungunya: 4.7%, Rift Valley fever: 0.0%	Farming
van der Westhuizen CG 2023[56] South Africa	Cross-sectional	327 farm workers	Hantavirus	ELISA	Manufacturers' instructions; internal controls and standard quality control procedures were applied to ensure accuracy and reproducibility	Prevalence: 11.6%	
Weyer J 2013[57] South Africa	Case report	2 suspected RVF cases	Wesselsbron virus	RT-PCR	ELISA - appropriate positive and negative controls; RT-PCR - standard protocols with quality assurance measures, including the use of controls and assay validation	2 cases	Goats, sheep, and cattle farming

Africa to include these important viruses could be crucial in preventing future outbreaks[71,72]. Given that these viruses have been detected among animals in the region[15,17,20–23,73], the potential for spillover events cannot be ruled out, underscoring the need for ongoing surveillance to determine whether such exposures are occurring. Angola, Botswana, Lesotho, Malawi, Eswatini, and Zambia did not contribute data, as no eligible studies from these countries were identified. The overall scarcity of eligible studies did not allow for pooled regional or sub-regional estimates to be calculated. Additionally, parallel, independent, and blind data extraction and assessment of risk of bias were not conducted, which may introduce errors and bias. Given that Angola and Mozambique are Portuguese-speaking countries, it is likely that relevant literature published in Portuguese were missed, as this review included only English-language articles.

5. Conclusions

Overall, there is a pressing need for more robust studies analysing both risk and protective factors at these human-animal interfaces, including investigations into the role of PPE in preventing zoonotic virus exposures. Better characterization of these potentially high-risk interfaces will guide the development of tailored and evidence-based interventions to reduce zoonotic spillover risk. The incomplete or absent reporting of validation and quality control procedures in the majority of studies raises concerns about potential bias, highlighting the need for standardized reporting guidelines in zoonotic disease surveillance research. Furthermore, strengthening capacity and fostering multidisciplinary collaborations within One Health research will enhance the quantity and quality of research outputs, ultimately improving policy-making, especially in the underrepresented countries.

Conflict of interest statement

The authors claim there is no conflict of interest.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon request.

Authors' contributions

Epstein JH and Balami AD conceived the study. Epstein JH, Balami AD, Munro S, Ball S, and Sullivan A participated in the study design and manuscript review. Balami AD and Munro S did the data analysis and manuscript writing. All authors read and approved the final manuscript.

References

[1] Filho WL, Ternova L, Parasnis SA, Kovaleva M, Nagy GJ. Climate change and zoonoses: A review of concepts, definitions, and bibliometrics. *Int J Environ Res Public Health* 2022; **19**(9): 5574.

[2] Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. *Nature* 2008; **21**(7181): 990-993.

[3] Reed KD. Viral Zoonoses. In: *Reference module in biomedical sciences*. Amsterdam: Elsevier; **2018**.

[4] Kadam SB, Sukhramani GS, Bishnoi P, Pable AA, Barvkar VT. SARS-CoV-2, the pandemic coronavirus: Molecular and structural insights. *J Basic Microbiol* 2021; **18**(3): 180-202.

[5] Fontanet A, Autran B, Lina B, Kieny MP, Karim SSA, Sridhar D. SARS-CoV-2 variants and ending the COVID-19 pandemic. *Lancet* 2021; 397(10278): 952-954.

[6] Chauhan RP, Dessie ZG, Noreddin A, El Zowalaty ME. Systematic review of important viral diseases in Africa in light of the 'One Health' concept. *Pathogens* 2020; **9**(4):301.

[7] Simpson G, Quesada F, Chatterjee P, Kakkar M, Chersich MF, Thys S. Research priorities for control of zoonoses in South Africa. *Trans R Soc Trop Med Hyg* 2021; **115**(5): 538-550.

[8] Munang'andu HM, Mweene AS, Siamudaala V, Muma JB, Matandiko W. Rabies status in Zambia for the period 1985-2004. *Zoonos Public Health* 2011; **58**(1): 21-27.

[9] Babaniyi O, Songolo P, Matapo B, Masaninga F, Mulenga F, Michelo C, et al. Epidemiological characteristics of rabies in Zambia: A retrospective study (2004-2013). *Clin Epidemiol Glob Health* 2016; **4**(2): 83-88.

[10]Coetzer A, Gwenhure L, Makaya P, Markotter W, Nel L. Epidemiological aspects of the persistent transmission of rabies during an outbreak (2010-2017) in Harare, Zimbabwe. *PLoS One* 2019; **14**(1): e0210018.

[11]Jori F, Alexander KA, Mokopasetso M, Munstermann S, Moagabo K, Paweska JT. Serological evidence of Rift Valley fever virus circulation in domestic cattle and African buffalo in northern Botswana (2010-2011). *Front Vet Sci* 2015; **2**: 63.

[12]Moiane B, Mapaco L, Thompson P, Berg M, Albihn A, Fafetine J. High seroprevalence of Rift Valley fever phlebovirus in domestic ruminants and African Buffaloes in Mozambique shows need for intensified surveillance. *Infect Ecol Epidemiol* 2017; **7**(1): 1416248.

[13]Lysholm S, Fischer K, Lindahl JF, Munyeme M, Wensman JJ. Seropositivity rates of zoonotic pathogens in small ruminants and associated public health risks at informal urban markets in Zambia. *Acta Trop* 2022; **225**: 106217.

[14]van den Bergh C, Venter EH, Swanepoel R, Thompson PN. High seroconversion rate to rift valley fever virus in cattle and goats in far northern Kwazulu-Natal, South Africa, in the absence of reported outbreaks. *PLoS Negl Trop Dis* 2019; **13**(5): e0007296.

[15]Pawęska JT, Msimang V, Kgaladi J, Hellferscee O, Weyer J, van Vuren PJ. Rift Valley fever virus seroprevalence among humans, Northern KwaZulu-Natal Province, South Africa, 2018-2019. *Emerg Infect Dis* 2021; **27**(12): 3159-3162.

[16]Changula K, Kajihara M, Mori-Kajihara A, Eto Y, Miyamoto H, Yoshida R, et al. Seroprevalence of filovirus infection of rousettus aegyptiacus bats in Zambia. *J Infect Dis* 2018; **218**(Suppl 5): S312-S317.

[17]Ogawa H, Miyamoto H, Nakayama E, Yoshida R, Nakamura I, Sawa H, et al. Seroepidemiological prevalence of multiple species of filoviruses in fruit bats (*Eidolon helvum*) migrating in Africa. *J Infect Dis* 2015; **212**: S101-S108.

[18]Sinclair M, Brückner GK, Kotze JJ. Avian influenza in ostriches: Epidemiological investigation in the Western Cape Province of South Africa. *Vet Ital* 2006; **42**(2): 69-76.

[19]Molini U, Yabe J, Meki IK, Ouled Ahmed Ben Ali H, Settypalli TBK, Datta S, et al. Highly pathogenic avian influenza H5N1 virus outbreak among Cape cormorants (Phalacrocorax capensis) in Namibia, 2022. *Emerg Microbes Infect* 2023; **12**(1): 2167610.

[20]Muleya W, Sasaki M, Orba Y, Ishii A, Thomas Y, Nakagawa E, et al. Molecular epidemiology of paramyxoviruses in *Frugivorous Eidolon helvum* bats in Zambia. *J Vet Med Sci* 2014; **76**(4): 611-614.

[21]Mortlock M, Geldenhuys M, Dietrich M, Epstein JH, Weyer J, Pawęska JT, et al. Seasonal shedding patterns of diverse henipavirus-related paramyxoviruses in Egyptian rousette bats. *Sci Rep* 2021; **11**(1): 24262.

[22]Geldenhuys M, Mortlock M, Weyer J, Bezuidt O, Seamark ECJ, Kearney T, et al. A metagenomic viral discovery approach identifies potential zoonotic and novel mammalian viruses in Neoromicia bats within South Africa. *PLoS One* 2018; **13**(3): e0194527.

[23]Chidoti V, De Nys H, Pinarello V, Mashura G, Missé D, Guerrini L, et al. Longitudinal survey of coronavirus circulation and diversity in insectivorous bat colonies in Zimbabwe. *Viruses* 2022; **14**(4): 781.

[24]Ellwanger JH, Chies JAB. Zoonotic spillover: Understanding basic

aspects for better prevention. *Genet Mol Biol* 2021; **44**(1 Suppl 1): e20200355.

[25]Reperant LA, Cornaglia G, Osterhaus AD. The importance of understanding the human-animal interface: From early hominins to global citizens. *Curr Top Microbiol Immunol* 2013; **365**: 49-81.

[26]Reperant LA, Osterhaus AD. The human-animal interface. In: Mackenzie JS, Jeggo M, Daszak P, Richt JA (Eds). *One Health: The human–animal–environment interfaces in emerging infectious diseases.* Washington, DC, USA: ASM Press; **2014**. p. 33-52.

[27]Dreyer S, Dreier M, Dietze K. Demystifying a buzzword: Use of the term "human-animal-interface" in One Health oriented research based on a literature review and expert interviews. *One Health* 2023; **16**:100560.

[28]Alexander KA, McNutt JW. Human behavior influences infectious disease emergence at the human–animal interface. *Front Ecol Environ* 2010; **8**(10): 522-526.

[29]Hassell JM, Begon M, Ward MJ, Fèvre EM. Urbanization and disease emergence: Dynamics at the wildlife–livestock–human interface. *Trends Ecol Evol* 2017; **32**(1): 55-67.

[30]Magouras I, Brookes VJ, Jori F, Martin A, Pfeiffer DU, Dürr S. Emerging zoonotic diseases: Should we rethink the animal–human interface? *Front Vet Sci* 2020; **7**: 582743.

[31]Sabin NS, Calliope AS, Simpson SV, Arima H, Ito H, Nishimura T, et al. Implications of human activities for (re)emerging infectious diseases, including COVID-19. *J Physiol Anthropol* 2020; **39**(1): 29.

[32]Moher D. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. *Ann Intern Med* 2009; **151**(4): 264.

[33]Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 2016; **5**(1): 210.

[34]Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, et al. *Systematic reviews of etiology and risk.* In: JBI Manual for Evidence Synthesis. Adelaide (AU): JBI; **2020**.

[35]Galadima AN, Zulkefli NAM, Said SM, Ahmad N. Factors influencing childhood immunisation uptake in Africa: A systematic review. *BMC Public Health* 2021; **21**(1): 1475.

[36]Szmyd-Potapczuk AV. Molecular Epidemiology of Human Rabies Diagnosed in South Africa Between 1983 and 2007 [dissertation (MSc)]. University of Pretoria (South Africa); **2009**.

[37]Weyer J, Le Roux CA, Kajese C, Fernandes L. A dog bite study in a dog rabies-affected area in South Africa. *S Afr J Infect Dis* 2020; **35**(1): 1-7.

[38]Kubheka V, Govender P, Margot B, Kuonza LR. Dog bites and human rabies in the Uthungulu District of KwaZulu-Natal Province, 2008-2010: A review of surveillance data. *S Afr J Epidemiol Infect* 2013; **28**(1): 33-40.

[39]Mollentze N, Weyer J, Markotter W, Le Roux K, Nel LH. Dog rabies in southern Africa: Regional surveillance and phylogeographical analyses are an important component of control and elimination strategies. *Virus Genes* 2013; **47**(3): 569-573.

[40]Pfukenyi DM, Pawandiwa D, Makaya PV, Ushewokunze-Obatolu U. A retrospective study of rabies in humans in Zimbabwe, between 1992 and 2003. *Acta Trop* 2007; **102**(3): 190-196.

[41]Chikanya E, Macherera M, Maviza A. An assessment of risk factors for contracting rabies among dog bite cases recorded in Ward 30, Murewa District, Zimbabwe. *PLoS Negl Trop Dis* 2021; **15**(3): e0009305.

[42]Salomão C, Nacima A, Cuamba L, Gujral L, Amiel O, Baltazar C, et al. Epidemiology, clinical features and risk factors for human rabies and animal bites during an outbreak of rabies in Maputo and Matola cities, Mozambique, 2014: Implications for public health interventions for rabies control. *PLoS Negl Trop Di*s 2017; **11**(7): e0005787.

[43]Hikufe EH, Freuling CM, Athingo R, Shilongo A, Ndevaetela EE, Helao M, et al. Ecology and epidemiology of rabies in humans, domestic animals and wildlife in Namibia, 2011-2017. *PLoS Negl Trop Dis* 2019; **13**(4): e0007355.

[44]Archer BN, Thomas J, Weyer J, Cengimbo A, Landoh DE, Jacobs C, et al. Epidemiologic investigations into outbreaks of Rift Valley fever in humans, South Africa, 2008-2011. *Emerg Infect Dis* 2013; **19**(12): 1918-1925.

[45]Gummow B. A survey of zoonotic diseases contracted by South African veterinarians. *J S Afr Vet Assoc* 2003; **74**(3): 72-76.

[46]Msimang V, Thompson PN, van Vuren PJ, Tempia S, Cordel C, Kgaladi J, et al. Rift valley fever virus exposure amongst farmers, farm workers, and veterinary professionals in central South Africa. *Viruses* 2019;**11**(2): 140.

[47]Van Vuren PJ, Kgaladi J, Patharoo V, Ohaebosim P, Msimang V, Nyokong B, et al. Human cases of Rift Valley fever in South Africa, 2018. *Vector–Borne Zoonotic Diss* 2018; **18**(12): 713-715.

[48]Vawda S, Goedhals D, Bester PA, Burt F. Seroepidemiologic survey of crimean-congo hemorrhagic fever virus in selected risk groups, South Africa. *Emerg Infect Dis* 2018; **24**(7): 1360-1363.

[49]Msimang V, Weyer J, le Roux C, Kemp A, Burt FJ, Tempia S, et al. Risk factors associated with exposure to Crimean-Congo haemorrhagic fever virus in animal workers and cattle, and molecular detection in ticks, South Africa. *PLoS Negl Trop Dis* 2021; **15**(5): e0009384.

[50]Oludele J, Alho P, Chongo I, Maholela P, Magaia V, Muianga A, et al. Emerging Zoonotic diseases among pastoral communities of Caia and Búzi districts, Sofala, Mozambique: Evidence of antibodies against brucella, leptospira, rickettsia, and Crimean-Congo hemorrhagic fever virus. *Viruses* 2023; **15**(12): 2379.

[51]El Zowalaty ME, Abdelgadir A, Borkenhagen LK, Ducatez MF, Bailey ES, Gray GC. Influenza A viruses are likely highly prevalent in South African swine farms. *Transbound Emerg Dis* 2022; **69**(4): 2373-2383.

[52]Venter M, Treurnicht FK, Buys A, Tempia S, Samudzi R, McAnerney J, et al. Risk of human infections with Highly Pathogenic H5N2 and Low Pathogenic H7N1 Avian Influenza strains during outbreaks in ostriches in South Africa. *J Infect Dis* 2017; **216**(suppl_4): S512-S519.

[53]Venter M, Steyl J, Human S, Weyer J, Zaayman D, Blumberg L, Leman PA, Paweska J, Swanepoel R. Transmission of West Nile virus during horse autopsy. *Emerg Infect Dis* 2010; **16**(3): 573-575.

[54]Van Eeden C, Venter M. *Investigation of viral causes of undiagnosed neurological disease in animals and their zoonotic risk to humans in South Africa.* PhD dissertation. Pretoria (South Africa): University of Pretoria; **2014**.

[55]Simpson GJG, Quan V, Frean J, Knobel DL, Rossouw J, Weyer J, et al.

Prevalence of selected zoonotic diseases and risk factors at a human-wildlife-livestock interface in Mpumalanga Province, South Africa. *Vector Borne Zoonotic Dis* 2018; **18**(6): 303-310.

[56]van der Westhuizen CG, Burt FJ, van Heerden N, van Zyl W, Anthonissen T, Musoke J. Prevalence and occupational exposure to zoonotic diseases in high-risk populations in the Free State Province, South Africa. *Front Microbiol* 2023; **14**: 1196044.

[57]Weyer J, Thomas J, Leman PA, Grobbelaar AA, Kemp A, Paweska JT. Human cases of Wesselsbron disease, South Africa 2010-2011. *Vector Borne Zoonotic Dis* 2013; **13**(5): 330-336.

[58]Dwyer JP, Douglas TS, van As AB. Dog bite injuries in children: A review of data from a South African paediatric trauma unit. *S Afr Med J* 2007; **97**(8): 597-600.

[59]Duncan-Sutherland N, Lissaman AC, Shepherd M, Kool B. Systematic review of dog bite prevention strategies. *Injury Prev* 2022; **28**(3): 288-297.

[60]Dlamini BN, Mdluli S, Mudyanavana C, Chikuni NE, Masarirambi MT. Rabies in Eswatini: What are the issues and challenges? *J Adv Microbiol* 2020; **20**(7): 21-28.

[61]Cleaveland S, Kaare M, Tiringa P, Mlengeya T, Barrat J. A dog rabies vaccination campaign in rural Africa: Impact on the incidence of dog rabies and human dog-bite injuries. *Vaccine* 2003; **21**(17-18): 1965-1973.

[62]Sánchez-Soriano C, Gibson AD, Gamble L, Burdon Bailey JL, Mayer D, Lohr F, et al. Implementation of a mass canine rabies vaccination campaign in both rural and urban regions in Southern Malawi. *PLoS Negl Trop Dis* 2020; **14**(1): 1-19.

[63]Hampson K, Cleaveland S, Briggs D. Evaluation of cost-effective strategies for rabies post-exposure vaccination in low-income countries. *PLoS Negl Trop Dis* 2011; **5**(3): e982.

[64]Nicholas DE, Jacobsen KH, Waters NM. Risk factors associated with human Rift Valley fever infection: Systematic review and meta-analysis. *Tropic Med Int Health* 2014; **19**(12): 1420-1429.

[65]Gudo ES, Lesko B, Vene S, Lagerqvist N, Candido SI, Razão de Deus N, et al. Seroepidemiologic screening for zoonotic viral infections, Maputo, Mozambique. *Emerg Infect Dis* 2016; **22**(5): 915-917.

[66]Vonesch N, Binazzi A, Bonafede M, Melis P, Ruggieri A, Iavicoli S, et al. Emerging zoonotic viral infections of occupational health importance. *Pathog Dis* 2019; **77**(2): ftz018.

[67]Riccò M, Peruzzi S, Ranzieri S, Magnavita N. Occupational hantavirus infections in agricultural and forestry workers: A systematic review and metanalysis. *Viruses* 2021; **13**(11): 2150.

[68]Riccò M, Baldassarre A, Corrado S, Bottazzoli M, Marchesi F. Seroprevalence of Crimean-Congo hemorrhagic fever virus in occupational settings: Systematic review and meta-analysis. *Trop Med Infect Dis* 2023; **8**(9): 452.

[69]Kainga H, Mponela J, Basikolo L, Phonera MC, Mpundu P, Munyeme M, et al. Assessment of knowledge, attitudes, and practices towards Rift Valley fever among livestock farmers in selected districts of Malawi. *Trop Med Infect Dis* 2022; **7**(8): 158.

[70]Hines JZ, Fwoloshi S, Kampamba D, Barradas DT, Banda D, Zulu JE, et al. SARS-CoV-2 Prevalence among outpatients during community transmission, Zambia, July 2020. *Emerg Infect Dis* 2021; **27**(8): 2166-2168.

[71]Tambo E, Ugwu EC, Ngogang JY. Need of surveillance response systems to combat Ebola outbreaks and other emerging infectious diseases in African countries. *Infect Dis Poverty* 2014; **3**: 1-8.

[72]Zinsstag J, Utzinger J, Probst-Hensch N, Shan L, Zhou XN. Towards integrated surveillance-response systems for the prevention of future pandemics. *Infect Dis Poverty* 2020; **9**(1): 140.

[73]Pawęska JT, Jansen van Vuren P, Kemp A, Storm N, Grobbelaar AA, Wiley MR, et al. Marburg virus infection in Egyptian Rousette bats, South Africa, 2013-2014. *Emerg Infect Dis* 2018; **24**(6): 1134-1137.

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