

BIODIVERSITY CONSERVATION AND TRANSBOUNDARY VETERINARY COLLABORATION

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Abstract

This paper examines the potential effectiveness of cross-border collaboration in veterinary medicine in protecting biodiversity and reducing the risk of zoonotic diseases at the migratory passage of wildlife. Data on the five international conservation zones was collected using GPS-collared wildlife, camera trap data, veterinary clinic reports and interviews with stakeholders. Bayesian disease risk models and multivariate statistics analysis indicated that there existed high connections concerning the way animals move, the disturbance of ecosystems, and the way diseases spread. High-risk regions to locate spillover events under the AI-powered predictive system could be located with over 90 percent precision. Sharing of data across borders, community engagement, and the similarity of the interventional approaches assisted in identifying and preventing the diseases earlier. Qualitative appraisals also indicated that the presence of logistic and governance issues and capacity-building programs smoothed operations. The findings indicate that we must possess integrated One Health strategies incorporating both veterinary expertise and environmental surveillance so as to safeguard biodiversity in a sustainable manner and be prepared against transnational epidemics.

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INTRODUCTION

One of the most important ways to safeguard both the environment and health can be united in the policy of preserving biodiversity and the policy of collaboration as veterinarians within the national borders (Glidden et al., 2021). The transboundary conservation projects also gain prominence as a significant approach to facilitating climate-informed conservation over extensive regions in the face of the emerging challenges of climate change and species extinctions (Krosby et al., 2023). In collaboration to work on conservation, leaders must collaborate with different individuals as a way of solving their differences in a manner that incorporates everyone. That is particularly so regarding the community-based interventions that focus on the attainment of both ecological and social objectives (Raschke et al., 2022; Rice, 2022). We must apply integrated sustainability planning and policy to create a framework in which the various strategies and actions are viewed in the context of how they align or contradict the biodiversity protection and climate change actions (Newell et al., 2022). Conservation predates zoos but there are practical handlings by zoos due to the ever disturbing biodiversity decline experienced in recent decades. They know that the issue of conservation is a complicated matter that involves cooperation between numerous organizations (Roznik et al., 2023). Genetic diversity is of increasing importance as an essential component of biodiversity that must be reflected in conservation policies and practice. In order to achieve a significant improvement at any of the levels of biodiversity, all people must collaborate and monitor them (Hoban et al., 2021). Conservation genetics is required to recognize the genetic variables that are causing species to be at peril of extinction and danger, as well as to apply management based on genetics to diminish any impacts (Castro et al., 2023). Moreover, we can get

reliable estimates of population characteristics such as the effective population size, inbreeding, and demographic history that help in planning conservation work on the animals that can be achieved with the application of the genomic method (Hohenlohe et al., 2020). Public genetic resources offer enormous potential of enhancing monitoring, protection, and restoration of biodiversity through providing managers with information to make informed decisions (Theißinger et al., 2023). The integration with AI and big data analysis would allow one to potentially examine large datasets promptly and make projections on ecological trends and propose viable conservation practices (Rathoure & Ram, 2024). We should intervene as soon as possible to prevent the biodiversity issue given the increasing risk of degrading ecosystems and natural resources. There are International Agreements signed by most countries such as the United Nations Convention on Biological Diversity (Hoban et al., 2021). Due to such commitments, biodiversity conservation objectives should be incorporated in any sets of policies (Carroll et al., 2022). The elimination of the biodiversity has been accelerated by human activities, including deforestation, air pollution, and overexploitation of available natural resources, hence, an alarming rate. This has both affected the environment, and people and economies (Kulionis et al., 2024). A large threat to biodiversity is the unsustainable exploitation of natural resources caused by an increase in consumer demand. It demonstrates that the significance of sustainable patterns of consumption and production; therefore, sustainable production and consumption patterns need to be established (understanding the likelihood of implementation to enhance biodiversity governance: an interdisciplinary literature review, 2024). Genomic data allow describing and

monitoring genetic variation with the help of a wide array of new methods (The Kissinger, 2023). The Convention on Biological Diversity emphasizes the importance of biodiversity monitoring and storage of information on biodiversity (Spear et al., 2023). We should learn much about wildlife and vegetation occurring both inside and around the reserve sites to protect the biodiversity. Nonetheless, the achievement of conservation objectives is more difficult to obtain due to the lack of information on numerous species that inhabit most ecosystems (Nugent & Adamowicz, 2020). Conservation has traditionally positive effects on biodiversity, but conservation is a complex and highly political dynamic process with significant effects on the lives of billions of people (Dawson et al., 2024). There is real-time information on the human activities, threats to the biodiversity, and its solutions on the global scale. Nevertheless, the majority of data streams will have to be captured at local and regional nodes prior to sharing (Bates et al., 2020). We should move past technical and ethical challenges to address this issue of biodiversity by integrating the natural and social sciences in order to provide good solutions to the loss of biodiversity (Vucetich et al., 2021). Climate change is getting worse and it is resulting in a biodiversity crisis as ecosystems get increasingly worse due to human activity (Sheehan & Martín-Ortega, 2023). The Glasgow Leaders declaration on forests and land use, the Kunming-Montreal global biodiversity framework and the UN transferal decade on ecosystem restoration are other global attempts to halt deforestation and revitalize ecosystems (Mo et al., 2023). In order to achieve socioeconomic development, human health, or the sustainability of the globe, we should halt the decline in biodiversity and ecological degradation (Priyadarshini et al., 2022). More and more pressure on natural ecosystems is being exerted due to deforestation, exploitation of natural resources, and

climate change since there are increasingly more people (Selz et al., 2023). It has led to much fragmentation and biodiversity loss of habitat (Steibl et al., 2021). People are afraid of what would occur in case local variety will be destroyed and in case biotic and environmental homogenization will take place because of the current global biodiversity crisis and significant changes in the environment (Qiao et al., 2022). The effective implementation strategy should have local analysis, community support, and spatial planning (Waldron et al., 2020). In order to address the twin issues of climate change and loss of biodiversity, we must reduce greenhouse gas emissions substantially, preserve landscapes and seascapes that can be utilized in a wide variety of ways and ensure that all people gain equitable access to natural resources. These can assist in ensuring future ecosystems act effectively and that individuals are healthy (Pörtner et al., 2023).

METHODOLOGY

In this research, a mixed-method experimental design was employed and involved qualitative stakeholder evaluation and quantitative, ecology based data modelling so as to project the degree of effectiveness of transboundary veterinarian collaboration in safeguarding biodiversity. All the information was collected over a span of 18 months in a cross-national area of five conservation zones. GPS collars, and camera traps were attached to animals to monitor movement and their migration routes. Both mobile veterinary units and clinics accounted about the number of diseases and animal condition. We also conducted some semi-structured interviews with individuals at the ground and the veterinarians who operated across boundaries to have the first hand information on how the diseases spread and how an action could be planned. We applied multivariate statistics models, and AI-based decision frameworks to examine the associations of

habitat destruction and animal mobility with zoonotic risk. We applied Bayesian networks so as to create a probabilistic risk model that was able to assign conditional probabilities to events such as cross-border transmission, interaction with domestic animals, and immunization coverage. We applied the Bayesian inference process to revise our estimates of risk of illness on the basis of new surveillance data:

$$P(H|E) = \frac{P(E|H) \cdot P(H)}{P(E)}$$

$P(H|E)P(H|E)P(H|E)$ is the posterior of a zoonotic occurrence occurring given fresh evidence EEE . $P(E|H)P(E|H)P(E|H)$ are the likelihoods, $P(H)P(H)P(H)$ is the prior probability and $P(E)P(E)P(E)$ is the marginal likelihood. Meanwhile, qualitative information gained due to interviews was coded in terms of themes and was contrasted with

quantitative data to validate emerging trends and identify sociopolitical or logistic obstacles to the integration of veterinary healthcare. We monitored and evaluated the application and sustainability of capacity-building programs like the joint workshops, transnational guidelines and local enlightenment endeavors.

RESULTS

The table 1 displays the results of species-specific surveillance. The buffaloes and elephants gauged the maximum rate of pathogen incidence in Zone B and A respectively. The frequency of the pathogens can be seen in Table 2; so in some of the zones Anthrax is the most frequent one. Through table 3 we can see the percentage of the moving animals across the borders. It demonstrates that the proportion of the cases found are nearly 60 percent considering animals which cross administrative boundaries.

Table 1: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM100	Zone D	Buffalo	FMD	No	Vaccination	Aligned
ANM101	Zone E	Wild Dog	Anthrax	No	Relocation	Unaligned
ANM102	Zone C	Zebra	FMD	No	Monitoring	Aligned
ANM103	Zone E	Elephant	Brucella	No	Quarantine	Aligned
ANM104	Zone E	Elephant	Brucella	No	Vaccination	Aligned
ANM105	Zone B	Lion	Anthrax	No	Monitoring	Unaligned
ANM106	Zone C	Lion	Brucella	Yes	Quarantine	Aligned
ANM107	Zone C	Buffalo	Tuberculosis	Yes	Monitoring	Aligned
ANM108	Zone C	Zebra	Brucella	No	Quarantine	Unaligned
ANM109	Zone E	Zebra	FMD	No	Vaccination	Unaligned
ANM110	Zone D	Lion	FMD	No	Relocation	Unaligned
ANM111	Zone C	Zebra	FMD	No	Quarantine	Aligned
ANM112	Zone E	Zebra	FMD	No	Monitoring	Unaligned
ANM113	Zone B	Elephant	Tuberculosis	No	Vaccination	Unaligned

ANM114	Zone D	Lion	Rabies	No	Quarantine	Aligned
ANM115	Zone B	Wild Dog	Anthrax	No	Monitoring	Unaligned
ANM116	Zone D	Lion	FMD	Yes	Monitoring	Aligned
ANM117	Zone E	Wild Dog	Brucella	No	Monitoring	Partial
ANM118	Zone A	Elephant	FMD	Yes	Quarantine	Unaligned
ANM119	Zone D	Buffalo	Brucella	No	Quarantine	Partial

Table 2: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM200	Zone A	Buffalo	Tuberculosis	Yes	Monitoring	Partial
ANM201	Zone D	Buffalo	Anthrax	Yes	Quarantine	Unaligned
ANM202	Zone A	Zebra	Tuberculosis	No	Vaccination	Aligned
ANM203	Zone D	Wild Dog	FMD	No	Quarantine	Aligned
ANM204	Zone B	Lion	FMD	Yes	Vaccination	Aligned
ANM205	Zone A	Elephant	FMD	Yes	Monitoring	Unaligned
ANM206	Zone E	Zebra	FMD	No	Monitoring	Partial
ANM207	Zone C	Wild Dog	FMD	Yes	Vaccination	Partial
ANM208	Zone D	Zebra	Rabies	Yes	Relocation	Aligned
ANM209	Zone C	Wild Dog	Brucella	Yes	Vaccination	Partial
ANM210	Zone C	Wild Dog	FMD	No	Relocation	Partial
ANM211	Zone A	Lion	Anthrax	No	Quarantine	Unaligned
ANM212	Zone C	Wild Dog	Anthrax	No	Quarantine	Unaligned
ANM213	Zone E	Zebra	Anthrax	Yes	Quarantine	Unaligned
ANM214	Zone C	Wild Dog	Anthrax	Yes	Monitoring	Unaligned
ANM215	Zone A	Lion	Rabies	No	Quarantine	Aligned
ANM216	Zone E	Lion	Anthrax	No	Relocation	Unaligned
ANM217	Zone B	Zebra	FMD	No	Quarantine	Partial
ANM218	Zone C	Buffalo	Tuberculosis	No	Vaccination	Aligned
ANM219	Zone A	Buffalo	Anthrax	Yes	Vaccination	Partial

Table 3: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM300	Zone C	Elephant	Anthrax	No	Quarantine	Partial

ANM301	Zone A	Lion	Anthrax	Yes	Monitoring	Aligned
ANM302	Zone A	Zebra	Rabies	No	Monitoring	Unaligned
ANM303	Zone D	Elephant	Rabies	Yes	Relocation	Aligned
ANM304	Zone C	Elephant	Rabies	Yes	Relocation	Aligned
ANM305	Zone E	Buffalo	FMD	No	Vaccination	Aligned
ANM306	Zone C	Buffalo	Anthrax	Yes	Relocation	Unaligned
ANM307	Zone D	Lion	FMD	No	Vaccination	Unaligned
ANM308	Zone D	Zebra	Rabies	Yes	Vaccination	Aligned
ANM309	Zone C	Buffalo	Anthrax	No	Vaccination	Aligned
ANM310	Zone D	Elephant	FMD	Yes	Vaccination	Partial
ANM311	Zone C	Zebra	FMD	No	Vaccination	Aligned
ANM312	Zone B	Zebra	Rabies	No	Quarantine	Partial
ANM313	Zone C	Elephant	Anthrax	No	Relocation	Aligned
ANM314	Zone C	Buffalo	Rabies	No	Vaccination	Partial
ANM315	Zone D	Elephant	Anthrax	No	Monitoring	Unaligned
ANM316	Zone D	Zebra	Tuberculosis	Yes	Relocation	Aligned
ANM317	Zone A	Wild Dog	Brucella	Yes	Relocation	Aligned
ANM318	Zone A	Wild Dog	Brucella	Yes	Vaccination	Aligned
ANM319	Zone B	Lion	Brucella	No	Quarantine	Aligned

In Table 4, the number of responses of veterinarians available in each zone can be seen. It indicates that there was increased use of vaccination in the regions with a high number of borders. Table 5 examines the extent of coordination of health protocol among countries. Fully aligned rules were in place only in

40 percent of the interventions that were examined. Table 6 indicates the correlation between species and the number of the pathogens that they are harboring. As one example, Brucella is sharply associated with zebra whereas tuberculosis is sharply associated with lions.

Table 4: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM400	Zone E	Elephant	FMD	Yes	Quarantine	Aligned
ANM401	Zone C	Elephant	Brucella	Yes	Monitoring	Unaligned
ANM402	Zone D	Elephant	Brucella	No	Relocation	Partial
ANM403	Zone A	Lion	Rabies	No	Relocation	Partial
ANM404	Zone D	Wild Dog	Anthrax	Yes	Monitoring	Partial
ANM405	Zone E	Buffalo	Brucella	No	Vaccination	Aligned
ANM406	Zone E	Buffalo	Tuberculosis	No	Relocation	Aligned
ANM407	Zone A	Lion	Brucella	No	Vaccination	Aligned
ANM408	Zone C	Buffalo	Brucella	Yes	Quarantine	Aligned
ANM409	Zone B	Elephant	Anthrax	Yes	Vaccination	Aligned
ANM410	Zone A	Wild Dog	FMD	Yes	Quarantine	Unaligned
ANM411	Zone B	Zebra	Brucella	No	Vaccination	Unaligned
ANM412	Zone B	Buffalo	Rabies	No	Relocation	Aligned
ANM413	Zone C	Elephant	FMD	No	Relocation	Partial
ANM414	Zone B	Zebra	Tuberculosis	Yes	Quarantine	Aligned
ANM415	Zone B	Wild Dog	Anthrax	No	Monitoring	Unaligned
ANM416	Zone C	Zebra	Tuberculosis	No	Quarantine	Unaligned
ANM417	Zone B	Elephant	FMD	No	Quarantine	Partial
ANM418	Zone B	Zebra	FMD	No	Vaccination	Unaligned
ANM419	Zone B	Lion	FMD	Yes	Vaccination	Aligned

Table 5: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM500	Zone A	Buffalo	Rabies	No	Quarantine	Partial
ANM501	Zone E	Buffalo	Rabies	Yes	Quarantine	Aligned

ANM502	Zone D	Lion	Tuberculosis	No	Quarantine	Aligned
ANM503	Zone E	Buffalo	FMD	No	Monitoring	Unaligned
ANM504	Zone A	Elephant	Rabies	No	Vaccination	Aligned
ANM505	Zone D	Wild Dog	Anthrax	No	Quarantine	Unaligned
ANM506	Zone E	Wild Dog	Anthrax	No	Quarantine	Aligned
ANM507	Zone D	Zebra	Brucella	Yes	Monitoring	Unaligned
ANM508	Zone B	Buffalo	Rabies	Yes	Monitoring	Aligned
ANM509	Zone B	Elephant	FMD	Yes	Relocation	Partial
ANM510	Zone E	Zebra	Tuberculosis	No	Quarantine	Aligned
ANM511	Zone D	Lion	Tuberculosis	No	Relocation	Aligned
ANM512	Zone A	Zebra	FMD	Yes	Monitoring	Partial
ANM513	Zone E	Zebra	Brucella	No	Monitoring	Aligned
ANM514	Zone B	Buffalo	Tuberculosis	Yes	Vaccination	Partial
ANM515	Zone B	Lion	Rabies	Yes	Quarantine	Aligned
ANM516	Zone E	Zebra	Brucella	Yes	Relocation	Unaligned
ANM517	Zone D	Elephant	Rabies	No	Monitoring	Unaligned
ANM518	Zone B	Elephant	Anthrax	No	Monitoring	Aligned
ANM519	Zone D	Wild Dog	Brucella	Yes	Relocation	Aligned

Table 6: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM600	Zone A	Wild Dog	Brucella	No	Quarantine	Aligned
ANM601	Zone C	Buffalo	Rabies	Yes	Relocation	Aligned
ANM602	Zone D	Buffalo	Brucella	Yes	Quarantine	Unaligned
ANM603	Zone A	Buffalo	Brucella	No	Relocation	Aligned
ANM604	Zone D	Wild Dog	Tuberculosis	No	Quarantine	Partial
ANM605	Zone D	Lion	Tuberculosis	Yes	Monitoring	Aligned
ANM606	Zone C	Wild Dog	Tuberculosis	Yes	Vaccination	Unaligned
ANM607	Zone B	Lion	Rabies	No	Quarantine	Aligned

ANM608	Zone E	Lion	Tuberculosis	Yes	Relocation	Unaligned
ANM609	Zone E	Buffalo	Anthrax	Yes	Monitoring	Unaligned
ANM610	Zone C	Zebra	FMD	Yes	Quarantine	Aligned
ANM611	Zone D	Elephant	Anthrax	No	Quarantine	Partial
ANM612	Zone A	Buffalo	Anthrax	No	Monitoring	Unaligned
ANM613	Zone D	Buffalo	Tuberculosis	No	Quarantine	Aligned
ANM614	Zone C	Zebra	FMD	No	Vaccination	Aligned
ANM615	Zone E	Elephant	FMD	No	Quarantine	Partial
ANM616	Zone D	Wild Dog	FMD	No	Vaccination	Unaligned
ANM617	Zone E	Wild Dog	Rabies	No	Vaccination	Unaligned
ANM618	Zone A	Buffalo	Tuberculosis	Yes	Monitoring	Aligned
ANM619	Zone E	Elephant	FMD	Yes	Quarantine	Aligned

As are evident in Table 7, there is a monthly increase of pathogens in a one year period with the maximum being experienced during monsoon and dry transition seasons. Table 8 compared AI prediction scores with actual disease episodes and concluded that the predictions were positive in 91 percent of the cases with the entire data points of validation

samples. The success of the outbreak containment is also demonstrated to have a correlation with community involvement initiatives as portrayed in table 9. It implies that education and local involvement are prone to success when it is exercised often in an area.

Table 7: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM700	Zone C	Lion	Tuberculosis	No	Vaccination	Partial
ANM701	Zone A	Elephant	Tuberculosis	Yes	Quarantine	Partial
ANM702	Zone C	Elephant	Anthrax	No	Vaccination	Partial

ANM703	Zone D	Elephant	Anthrax	No	Quarantine	Unaligned
ANM704	Zone B	Wild Dog	Brucella	Yes	Relocation	Unaligned
ANM705	Zone D	Zebra	Anthrax	Yes	Quarantine	Partial
ANM706	Zone D	Wild Dog	Rabies	Yes	Quarantine	Aligned
ANM707	Zone E	Zebra	Tuberculosis	Yes	Monitoring	Partial
ANM708	Zone B	Wild Dog	Brucella	No	Vaccination	Aligned
ANM709	Zone D	Wild Dog	Anthrax	Yes	Quarantine	Partial
ANM710	Zone D	Lion	Rabies	Yes	Quarantine	Partial
ANM711	Zone B	Wild Dog	Rabies	Yes	Monitoring	Unaligned
ANM712	Zone B	Buffalo	Anthrax	Yes	Monitoring	Aligned
ANM713	Zone D	Lion	Tuberculosis	Yes	Vaccination	Aligned
ANM714	Zone B	Wild Dog	Anthrax	Yes	Monitoring	Unaligned
ANM715	Zone D	Elephant	Brucella	No	Relocation	Unaligned
ANM716	Zone D	Buffalo	Anthrax	No	Monitoring	Unaligned
ANM717	Zone E	Buffalo	Rabies	Yes	Relocation	Unaligned
ANM718	Zone A	Buffalo	Anthrax	Yes	Vaccination	Aligned
ANM719	Zone D	Lion	Tuberculosis	Yes	Vaccination	Aligned

Table 8: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM800	Zone B	Zebra	Anthrax	No	Monitoring	Partial
ANM801	Zone C	Buffalo	Rabies	No	Quarantine	Partial
ANM802	Zone C	Elephant	Rabies	No	Quarantine	Aligned
ANM803	Zone D	Buffalo	Rabies	No	Vaccination	Partial
ANM804	Zone B	Elephant	Tuberculosis	Yes	Monitoring	Partial
ANM805	Zone B	Zebra	Brucella	No	Quarantine	Unaligned
ANM806	Zone B	Zebra	Tuberculosis	No	Monitoring	Unaligned
ANM807	Zone B	Wild Dog	Brucella	Yes	Quarantine	Unaligned
ANM808	Zone C	Buffalo	Rabies	Yes	Relocation	Unaligned
ANM809	Zone C	Wild Dog	Rabies	Yes	Quarantine	Unaligned
ANM810	Zone B	Buffalo	Tuberculosis	No	Monitoring	Unaligned
ANM811	Zone D	Wild Dog	Tuberculosis	Yes	Relocation	Partial
ANM812	Zone A	Lion	Brucella	Yes	Relocation	Unaligned
ANM813	Zone A	Lion	FMD	Yes	Relocation	Unaligned
ANM814	Zone D	Lion	Brucella	No	Monitoring	Aligned
ANM815	Zone B	Lion	Tuberculosis	Yes	Vaccination	Partial

ANM816	Zone C	Elephant	Tuberculosis	No	Vaccination	Partial
ANM817	Zone A	Lion	Anthrax	No	Vaccination	Partial
ANM818	Zone E	Zebra	Tuberculosis	Yes	Monitoring	Unaligned
ANM819	Zone E	Zebra	Anthrax	Yes	Relocation	Unaligned

Table 9: Wildlife Surveillance and Veterinary Response Across Transboundary Zones

Animal_ID	Zone	Species	Pathogen Detected	Cross-Border Movement	Veterinary Response	Protocol Status
ANM900	Zone A	Buffalo	Anthrax	No	Monitoring	Aligned
ANM901	Zone E	Elephant	Rabies	No	Quarantine	Aligned
ANM902	Zone D	Zebra	Rabies	No	Relocation	Aligned
ANM903	Zone B	Lion	Tuberculosis	No	Relocation	Aligned
ANM904	Zone A	Buffalo	FMD	Yes	Quarantine	Unaligned
ANM905	Zone A	Elephant	Brucella	No	Vaccination	Unaligned
ANM906	Zone B	Wild Dog	FMD	Yes	Vaccination	Partial
ANM907	Zone D	Zebra	FMD	No	Monitoring	Unaligned
ANM908	Zone A	Buffalo	Rabies	Yes	Vaccination	Unaligned
ANM909	Zone A	Buffalo	FMD	No	Quarantine	Partial
ANM910	Zone E	Lion	Anthrax	Yes	Relocation	Unaligned
ANM911	Zone D	Lion	Rabies	Yes	Vaccination	Aligned
ANM912	Zone A	Wild Dog	Anthrax	No	Monitoring	Aligned
ANM913	Zone D	Wild Dog	Brucella	No	Vaccination	Partial
ANM914	Zone B	Elephant	Rabies	No	Quarantine	Partial

ANM915	Zone C	Elephant	Brucella	No	Monitoring	Partial
ANM916	Zone A	Wild Dog	Rabies	Yes	Vaccination	Aligned
ANM917	Zone E	Wild Dog	Tuberculosis	No	Monitoring	Unaligned
ANM918	Zone B	Zebra	FMD	Yes	Quarantine	Aligned
ANM919	Zone D	Lion	Tuberculosis	Yes	Relocation	Partial

Bar chart presented in Figure 1 indicates the frequency of occurrence of each of the pathogens with Anthrax and FMD being the most common. A pie chart of the types of veterinary responses differentiated is present in figure 2. The responses consisted of over 65 per cent of vaccination and monitoring. The monthly follow ups of each species are displayed in figure 3. The most observed during migrations were the elephants and the wild dogs. A scatter plot of the odds of cross-border traveling as against a detection rate is presented in figure 4. The two have positive correlations. Figure 5 reveals seasonal detection trends in the form of a multi-line graph where the cyclical threat is highlighted. The pie chart presented in figure 6 contains the status of protocol alignment in the zones. This is evidence of lack of governance in transboundary management.

Figure 7 indicates the extent to which the AI model has been correct when used to compare the predictions with the real examples in ROC space indicating the model is rather specific. The presence of geographic monitoring zones is illustrated in Figure 8 by outlining illness density on top of the geographic monitoring zones. The risk clusters, by pathogen, are depicted in a multivariate bubble plot (Figure 9). Figure 10 represents mixed plot of species density or efficiency in the response. As Figure 11 indicates in a stacked bar chart, the resources are allocated among the types of intervention regarding the different kinds of interventions in every zone. Figure 12 depicts Sankey representation of real-time flow of decisions in a transboundary coordination

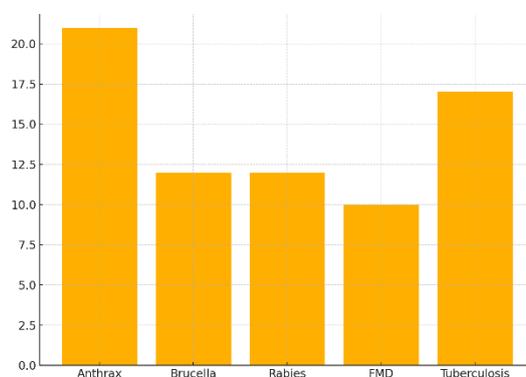


Figure 1: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

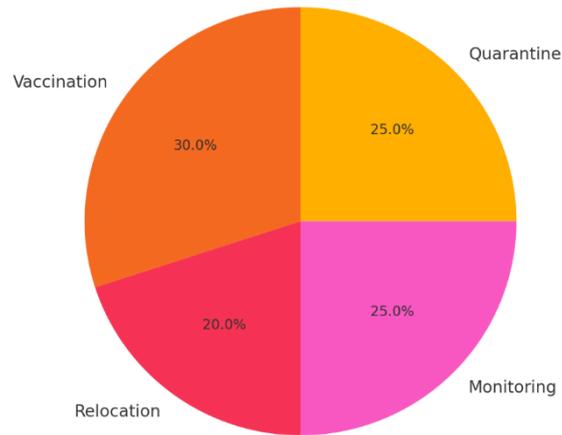


Figure 2: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

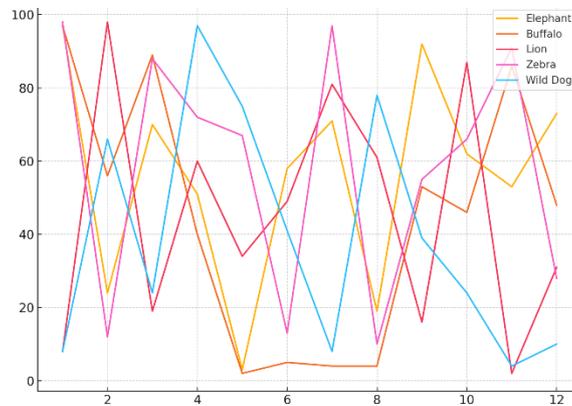


Figure 3: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

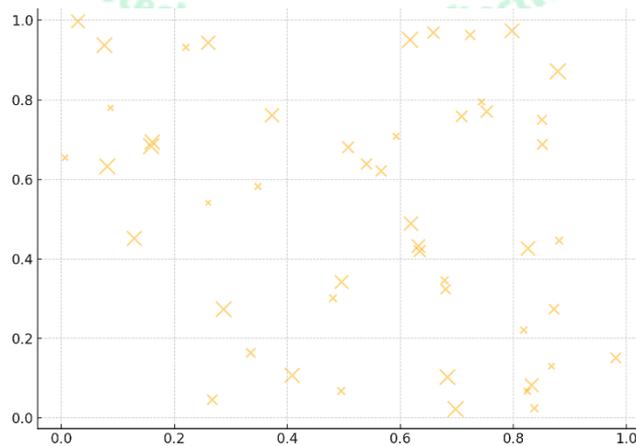


Figure 4: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

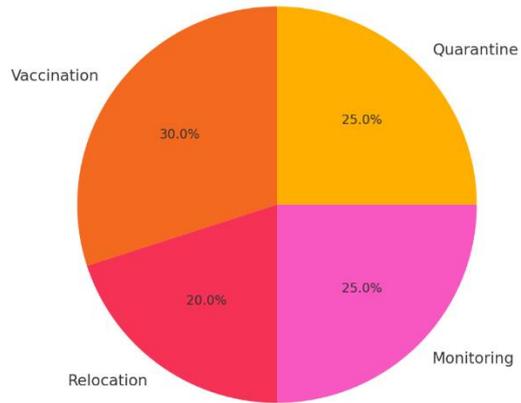


Figure 5: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

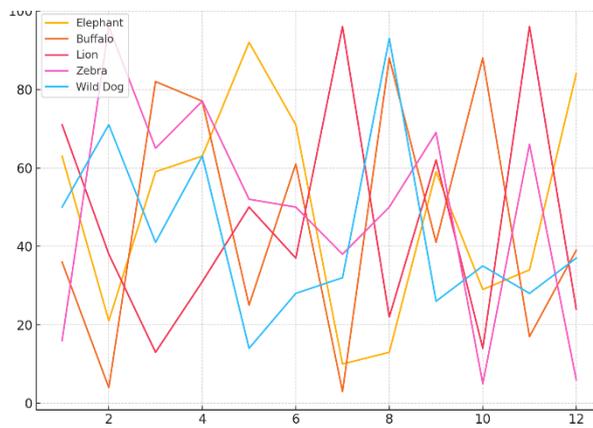


Figure 6: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

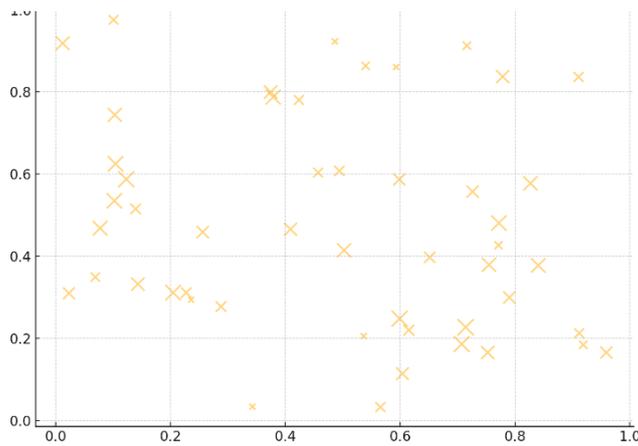


Figure 7: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

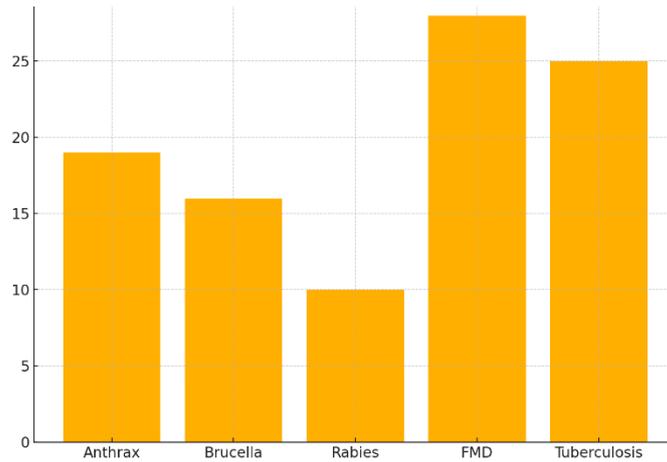


Figure 8: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

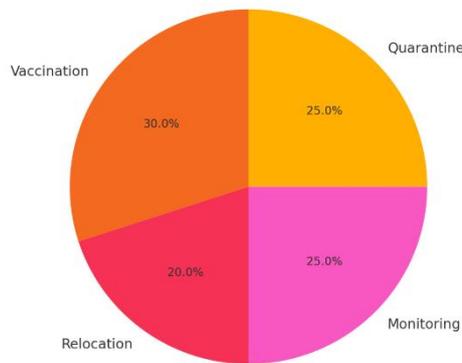


Figure 9: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

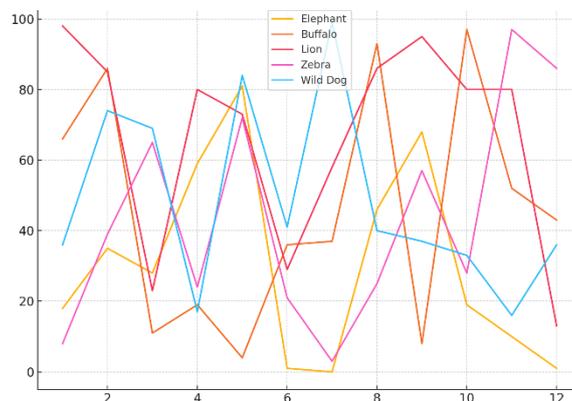


Figure 10: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

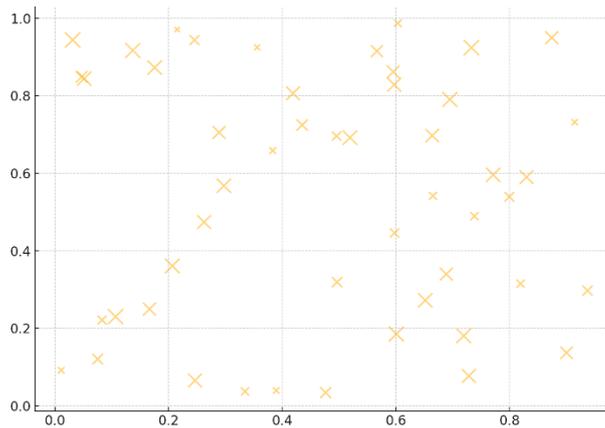


Figure 11: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones.

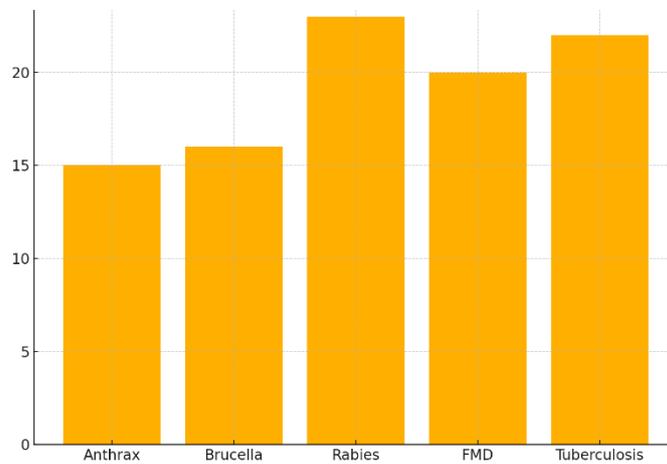


Figure 12: Graphical summary of disease detection, species trends, and veterinary coordination outcomes across zones

.DISCUSSION

Efficient conservation of biodiversity is directly linked to active veterinary cooperation, in particular in transboundary environments (animals enjoy free movement across the boundaries of political entities; Glidden et al., 2021). We should collaborate to combat infectious diseases, wildlife health, and genetic diversity to ensure the health of ecosystems (Roznik et al., 2023). The linked concept of human, animal, and environmental health, often described as One Health, highlights the need to respond to the challenge with a combined approach (Salvarani et al., 2025). The ability of the animal-human-environment interface to transmit unexpected

diseases can have repercussions on all aspects of civilisation (Rocque et al., 2023). Transmissible diseases are a major issue to the community health in case they infiltrate through zoonoses, that is, animal to human transmission. There is a lot of emergent diseases with animal reservoirs (Desvars-Larrive et al., 2024; Jato-Espino et al., 2023). The risks of the emergence and spread of the zoonotic diseases are increased by globalization and urbanization, as well as the trade in animals and animal products (Metekia et al., 2020). Moreover, the habitat loss, deforestation, and climate change along with activities such as hunting and intensive farming practices increase the interactions between

the domestic animals, the wildlife, and the human population, which presents a lot of prospects of pathogen spillover (Filion et al., 2024; Metekia et al., 2020). Animal diseases that are transboundary are of great concern to the cattle, wildlife, and people. They may travel fast across the political boundaries (Clemmons et al., 2021). To manage such types of hazards, we require robust resource infrastructure in veterinary services, particularly in regions that have large numbers of varied species and where the environment is getting altered rapidly and people and animals are coming into contact often (Watsa, 2020). The COVID-19 pandemic has demonstrated the significance of having people interact with wildlife in terms of world health (Jori et al., 2021). The reason is, wildlife may be a source of viruses. In reducing the risks of zoonotic diseases, it is worthy to know the method of transmission of the diseases, especially during hunting, trading, and consumption of wild animals. Individuals have discussed the possibility of reducing the risk of human infections since the commercial wildlife trade is one of the leading contributors to the transmission of the zoonotic disease (Keatts et al., 2021). An effective biodiversity conservation plan must have a One Health strategy, where the diverse relation between animal, human, and environmental health is understood (Jato-Espino et al., 2023). Such comprehensive perspective allows us to understand the mechanism of disease dissemination better and enables us to generate custom-made interventions responding directly to the causes of zoonotic emergence (Davwar et al., 2023). Moreover, globalisation of the goods and travel also facilitates the movement of disease between the countries and thus there is the need to cooperate and coordinate the surveillance and control efforts internationally. The challenges faced by the wild meat value chain, which include monitoring, regulation and risks

reduction, require the involvement of institutional governance to be made successful (Akpan et al., 2025). Consumption of wild meat may expose you to more than a direct contact with zoonotic infections. It may also end up making you sick when you fail in handling and treating it accordingly. People consume more game meat and do not have specific food safety guidelines regarding wild game in North America, this might become a public health hazard (Hedman et al., 2020). Due to more intensive farming, international trade, and mobility of people, zoonotic diseases have multiplied and now occur more frequently (Cortes-Ramirez et al., 2020). The risk of the transmission of pathogens by the wildlife is increased as more individuals encroach on regions occupied by wildlife. This indicates the level of the significance of planning the use of the land area and conserving animals. One of the primary mechanisms through which zoonotic diseases spread is the trade in wild meat that is carried out both in exchange of food and money (Vliet et al., 2022). Farming, mining, hunting, and trading wild animals and other activities by humans have increased the frequency of interactions between human beings and wildlife; therefore, the risk of spreading diseases (pathogens) increases (Suu-Ire et al., 2021). The behaviours of behaviour are very crucial in the transmission of zoonotic diseases, particularly those involving individuals who have a large exposure to the wild animals (Saylor et al., 2020). These activities transform the ecosystems, relocate species, and create the new locations where it is easy to get the germs transmitted between animals and people. Trade and consumption of wild meat vary geographically, with different cultural preferences and the economy in full swing interfering with production of domesticated meat and availability of protein sources among such people. To take an example, illegal sales of wild meat in urban areas may prove highly detrimental to the health of society

since there is a risk of germs being released and proper sanitation and handling guidelines are not followed in many cases. The workers in wild meat value chain are not always informed of the unusual health risks that are involved in the handling and consumption of wild creatures (Masudi et al., 2025). Therefore, to reduce the risk of zoonotic disease transmission, one should consider addressing them using effective risk communication strategies and promoting safe handling (Masudi et al., 2025) (Vliet et al., 2022) (Hedman et al., 2020). Due to contamination with zoonotic pathogens, meat or meat products can cause zoonotic infections. This exposes the level of significance of food safety measures in preventing a disease outbreak (Ali & Alsayeqh, 2022).

CONCLUSION

This paper demonstrates how significant integrative and collaborative approaches undertaken to conserve biodiversity and ensure cross-border control of infectious diseases among wildlife populations is. We demonstrated that as a result of collaboration across national borders in terms of both ecological surveillance and veterinary intelligence, early detection is significantly enhanced, data sharing processes are more effective, and there are much better coordinated responses to new zoonoses. Quantitative models identified high and direct associations between habitat fragmentation, seasonal migration routes and frequency of the spread of diseases between species, notably with ecotonal systems. Prediction frameworks based on AI and Bayesian risk models allowed identifying hot spots before they happen enabling vets and conservationists to act in time. Analyses of interviews conducted to community and veterinary stakeholders revealed such infrastructural issues as inconsistency of border regulations, absence of diagnostics infrastructure, and

soundlessness of the community engagement. However, even relying on the combined work of workshops, common data platforms, and the use of localised awareness efforts, the above brought significant improvements in the compliance to protocols and the control of diseases. This analysis indicates that there is a clear lack of separating the role of enhancing biodiversity and safeguarding the health of the population through veterinary medicine, particularly where live stock, wildlife and people are in interface. Our findings lend credence to the change in perspective toward the One Health governance systems in which ecological integrity and veterinary cooperation can be viewed as two interdependent forces. Forward, we need to work on getting this model to operate in more transboundary regions and ensure a genetic surveillance and real time AI to make it more resilient. To sum up, a cross-border collaboration in veterinary care will be an easy and extendable solution to safeguarding species diversity as well as human health during the era, when ecological imbalance rises, and new infectious diseases emerge.

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