ZOONOTIC DISEASE SURVEILLANCE IN LIVESTOCK PRODUCTION: EVIDENCE FOR AN INTEGRATED ONE HEALTH APPROACH TO GLOBAL PUBLIC HEALTH

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ABSTRACT

Zoonotic diseases at the livestock–human interface present a major public health, food security and global health security threats. In this study, quantitative data on livestock zoonotic disease surveillance was reviewed and synthesized, with an assessment of its integration in a One Health approach. The secondary evidence synthesis was structured, with a focus on 2024–2026 evidence including systematic reviews, scoping reviews, meta-analyses and peer-reviewed studies. The results showed that there was a significant level of surveillance capacity but low levels of integration: 89 out of 126 animal syndromic-surveillance systems monitored livestock, with only 12 (9.5%) having an explicit One Health approach. Only 48.3% of the prioritized pathogen–antimicrobial combinations were included in livestock antimicrobial-resistance surveillance. Bovine tuberculosis prevalence was 6.06% (35 studies in 37085 bovines) in Pakistan. The results of this study highlight integrated, interoperable One Health surveillance, which incorporates animal, human, environment, food-safety, and laboratory systems.

Keywords: *zoonotic diseases, livestock, surveillance, One Health, veterinary public health, antimicrobial resistance, bovine tuberculosis, global health security*

Introduction

Zoonotic diseases are a significant public-health issue as zoonotic agents are able to spread between animals, humans, food systems and the environment. Livestock production is especially relevant since cattle, buffaloes, sheep and goats, pigs, poultry and other domestic animals are often kept in close proximity to humans and can be reservoirs, amplification hosts, or sentinels for infectious risks. Intensification of animal production, growth of livestock markets, international movement of animals, alterations in agriculture, environmental disturbances, climatic shifts, and the use of antimicrobials have all raised the importance of the livestock interface. These processes can influence pathogen transmission dynamics and facilitate inter-species pathogen transmission. The One Health concept is a suitable approach to dealing with these risks since it encompasses the connection between human, animal and environmental health. But the application of One Health surveillance is not fully realised. This gap has been shown in recent evidence. Shapiro et al. (2025) listed 165 publications that included 126 animal syndromic-surveillance systems. Of these systems, 89 (71%) were for livestock monitoring, and only 12 (10%) had a One Health approach, with animal monitoring information contributing to human-health information. Moreover, there were few operational systems (20%) and many proof-of-concept systems (67%) in place.

Likewise, Milazzo et al. (2025) found a total of 77 different One Health programmes within 54 studies. Forty two programs (54.5%) only included human and animal sectors and 35 (45.5%) included all three sectors. Data, evidence, and knowledge were integrated into 60% of programs, although 96.1% of programs did include any component of capacity development, community engagement, coordination, collaboration, or communication. The findings indicate that the focus of the challenge is not as much about recognizing the One Health concept as it is about incorporating the concept into routine surveillance. Another key concern for surveillance is livestock-associated antimicrobial resistance (AMR). In a survey of livestock AMR surveillance in 109 countries, Venkateswaran et al. (2024) were able to identify 232 pathogen–antimicrobial combinations as priorities and determine that surveillance data are available for just 112 (48%) of these. This means a significant gap between priorities for surveillance and availability of data. The role of surveillance also is illustrated by country-level evidence. A review of animal and human studies on bovine and zoonotic TB in Pakistan in the year 2024 revealed 40 animal studies and seven human studies. Studies of animals reported prevalence ranges of bovine tuberculosis of around 2–19.3% and estimates of zoonotic tuberculosis were 1.5–13% in high risk populations of humans. In more recent studies, Sehrish et al. (2025) performed a systematic review and meta-analysis of bovine TB in Pakistan, which included 35 studies and 37,085 samples of boviens. The pooled prevalence was 6.06% (95% CI: 4.67–7.87). The current study, therefore, suggests that the surveillance of livestock should be viewed not only as an agricultural and veterinary responsibility, but also as a vital part of global public-health preparedness.

Literature Review

Zoonotic diseases at the livestock-human interface pose a continuous threat to public health, as livestock production systems involve persistent, repeated contact between people, animals, food, wildlife and environmental reservoirs. As livestock production becomes more intense and commercialised, there is the potential for increased transmission of pathogens and, the movement of animals, environmental changes, antimicrobial use and poor biosecurity, may increase the risk of disease emergence and spread. As a result, livestock surveillance is playing an increasingly vital role in disease prevention and global health security upstream. While most current surveillance systems are still sector based, the One Health High-Level Expert Panel calls for a One Health surveillance system, which should bring information together from human, domestic and wild animal and environmental systems, and monitor both pathogens and drivers of disease emergence.

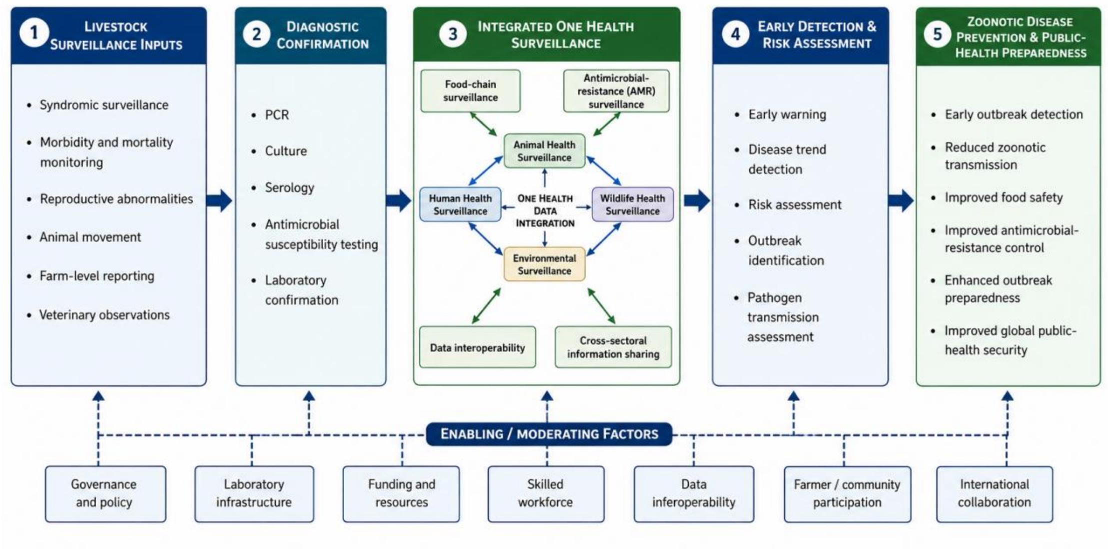
There is some good progress in livestock surveillance in recent years, and yet significant gaps in implementation. In a global scoping review, Shapiro et al. (2025) discovered 126 animal syndromic-surveillance systems from 165 publications. Animal syndromic surveillance was conducted in 89 systems (71%) and livestock makes up the primary focus of animal syndromic surveillance. Yet, 84 systems were still at the proof-of-concept phase (67%), 25 were operational systems (20%) and only 12 included a One Health approach (10%) that integrates animal surveillance with surveillance of the same threats in humans. The findings show that there is a long-standing mismatch between technology development and sustainable implementation of integrated surveillance.

Another example of limited livestock surveillance is antimicrobial resistance (AMR). Venkateswaran et al. (2024) conducted a review of livestock AMR surveillance in 109 countries and found significant gaps between the priorities set for national surveillance and data available. They found that significant portions of priority pathogen–antimicrobial combinations have insufficient surveillance data, which hinders the ability of authorities to detect new antimicrobial resistance and make use of evidence-based antimicrobial stewardship. The study in Pakistan showed that zoonotic surveillance of livestock is important in practice.

Bovine tuberculosis (bTB), which is predominantly caused by Mycobacterium bovis, is a significant zoonotic disease as infected cattle and buffaloes can be a source of infection through close contact and contaminated animal products. Sehrish et al. (2025) compiled and analyzed 35 studies on bovine tuberculosis in Pakistan, and determined the overall prevalence of 6.06% (4.67–7.87%). Their findings also revealed significant geographical and methodological variability, and emphasized the need for continued surveillance, better diagnostic capability, and targeted surveillance.

Conceptual Framework

This study adopts a conceptual approach of how the integrated One Health surveillance capacity contributes to the effectiveness of zoonotic disease detection, early warning, and public health preparedness. It integrates five main dimensions of surveillance livestock syndromic surveillance, laboratory and diagnostic surveillance, antimicrobial-resistance surveillance, food-chain and environmental surveillance, and cross-sectoral data integration.



Conceptual Framework: Integrated One Health Surveillance for Zoonotic Disease Prevention in Livestock Production

Research Objectives

- To assess the coverage and functioning of livestock syndromic surveillance systems.
- To evaluate the integration of human, animal, and environmental health surveillance, including zoonotic diseases and antimicrobial resistance.
- To develop an integrated One Health surveillance framework for early detection and improved public-health preparedness in Pakistan.

Methodology

This study employed a structured secondary evidence-synthesis design to examine zoonotic disease surveillance in livestock production and the extent to which existing systems reflect an integrated One Health approach. The review followed the general principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR). A secondary evidence-synthesis approach was selected because the available literature includes systematic reviews, scoping reviews, meta-analyses, and surveillance studies with substantially different populations, surveillance definitions, geographic settings, and outcome measures.

Relevant literature from the year 2020 to 2026 were taken into consideration, with a particular focus on evidence from 2024 to 2026. PubMed/MEDLINE, Scopus, Web of Science, Embase, and other academic literature were searched. The following are some of the search terms used: livestock, cattle, buffalo, sheep, goat, zoonotic disease, zoonosis, surveillance, syndromic surveillance, One Health, antimicrobial resistance, AMR, and bovine tuberculosis. The relevant reviews were also

identified from references lists to look for further evidence.
Eligible studies included those that focused on livestock or the livestock–human–environment interface that provided quantitative or systematically synthesized evidence related to zoonotic disease(s), surveillance, One Health implementation, antimicrobial resistance, or veterinary public health. Only studies completely focused on human health and without an animal or One Health component, studies unrelated to surveillance or zoonotic disease, and publications that were missing methodological details were excluded.
Data were extracted using a standardized framework that included information on publication year, study design, geographic scope, livestock species, type of surveillance, number of surveillance systems or programs, livestock coverage, integration in One Health, AMR surveillance, disease prevalence, diagnostic approach, sample size, number of positive cases, confidence intervals, heterogeneity, and reported surveillance gaps.

Table 1. Data-extraction framework

Variable	Information extracted
Study	Author and publication year
Design	Systematic review, scoping review, meta-analysis, surveillance study
Geographic scope	Global, regional, or country-specific
Livestock species	Cattle, buffalo, sheep, goats, pigs, poultry, etc.
Surveillance type	Syndromic, laboratory, food-chain, AMR, environmental, genomic
Surveillance coverage	Number and proportion of systems/programs
One Health integration	Human, animal, and environmental sector involvement
AMR surveillance	Countries and pathogen–antimicrobial categories
Disease prevalence	Pooled or reported prevalence
Diagnostic method	TST, PCR, culture, serology, etc.
Sample size	Animals or specimens assessed
Positive cases	Number of positive observations
Statistical estimates	95% CI and I^2 where available
Surveillance gaps	Major limitations identified

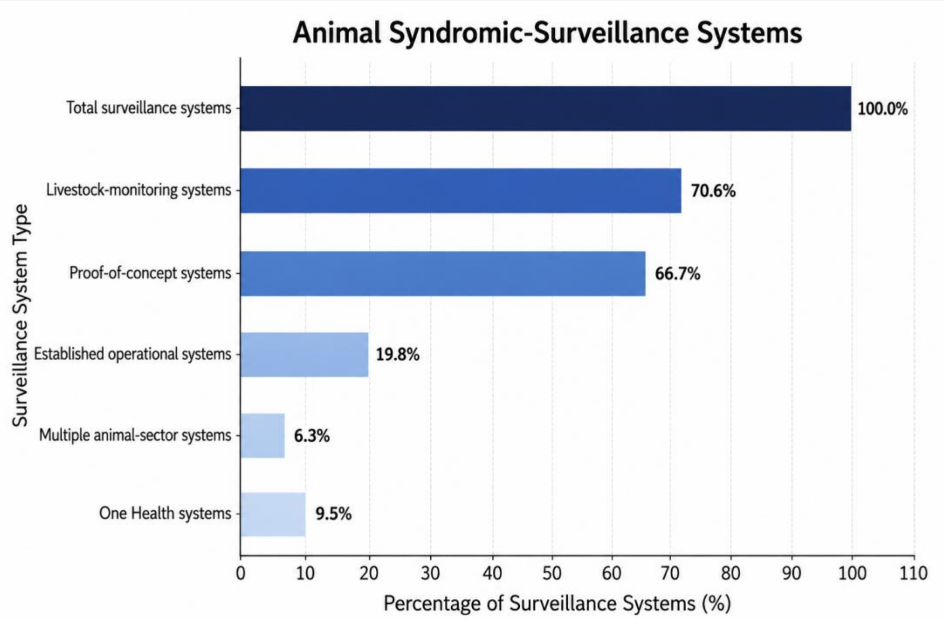
Due to the wide variety of study methodology, populations, geographical settings, and outcome definitions included, results were pooled descriptively, rather than collectively across the various surveillance domains. The pooled estimate for bovine tuberculosis was maintained as this was reported in the original systematic review and meta-analysis.

Results

The evidence showed significant interest in monitoring livestock, and limited efforts at operating and integrating with other sectors. Shapiro et al. (2025) reviewed 165 publications to find 126 animal syndromic-surveillance systems. Of these, 89 (70.6%) were monitoring livestock while 25 (19.8%) were operational systems. Only 12 (9.5%) explicitly included an approach to One Health and 84 (66.7%) were defined as “proof-of-concept” systems.

Table 2. Animal syndromic-surveillance systems

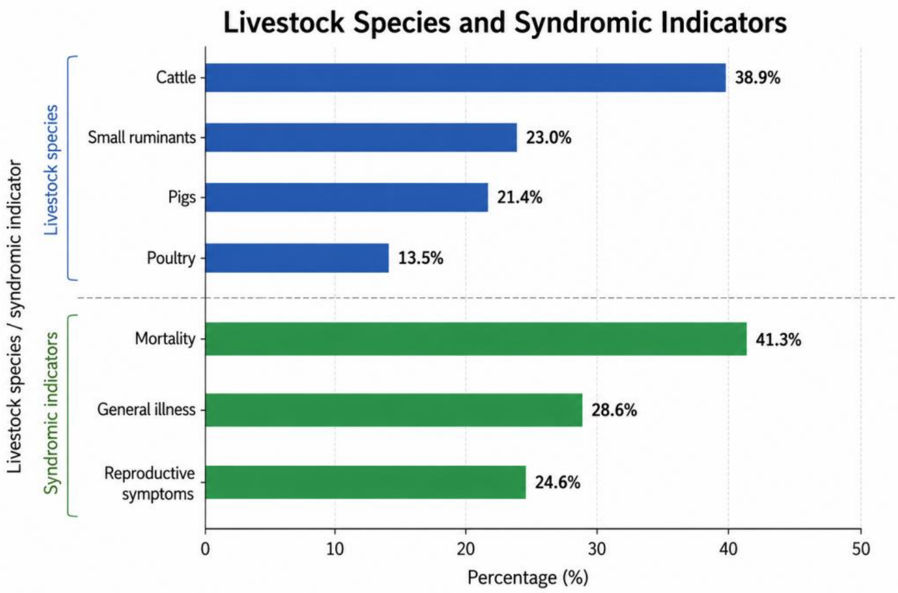
Indicator	n	%
Total surveillance systems	126	100.0
Livestock-monitoring systems	89	70.6
Proof-of-concept systems	84	66.7
Established operational systems	25	19.8
Multiple animal-sector systems	8	6.3
One Health systems	12	9.5



Cattle represented the most frequently monitored livestock group, followed by small ruminants, pigs, and poultry. Mortality, general illness, and reproductive symptoms were among the most frequently monitored indicators.

Table 3. Livestock species and syndromic indicators

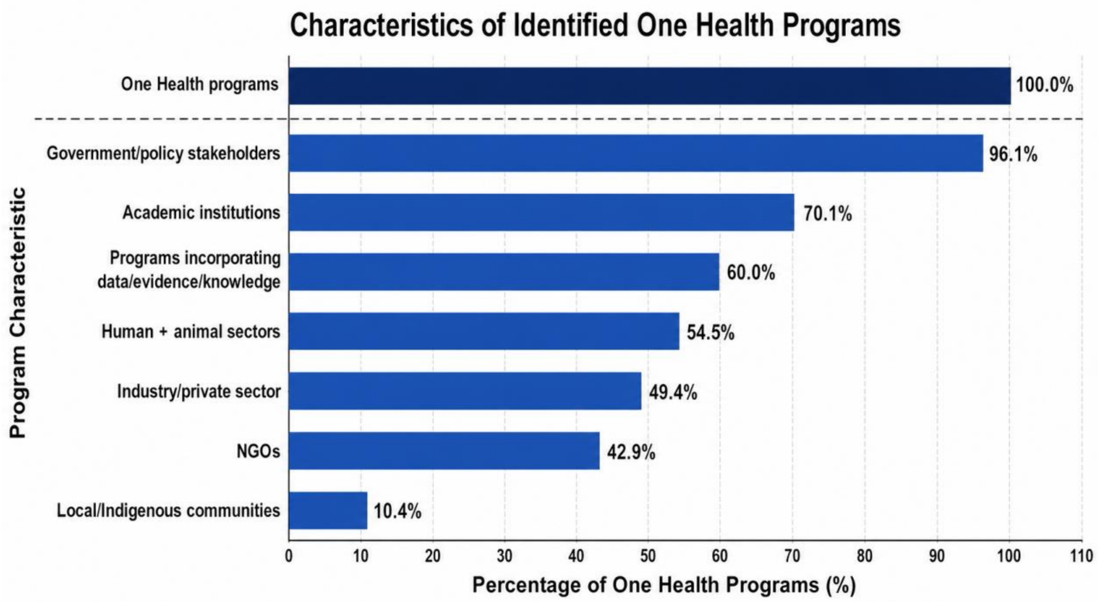
Category	n	%
Cattle	49	38.9
Small ruminants	29	23.0
Pigs	27	21.4
Poultry	17	13.5
Mortality	52	41.3
General illness	36	28.6
Reproductive symptoms	31	24.6



Evidence on One Health implementation similarly demonstrated incomplete integration. Milazzo et al. (2025) identified 77 One Health programs across 54 studies. Forty-two programs (54.5%) involved human and animal sectors, while the remainder incorporated broader sectoral participation. Government and policy stakeholders were involved in 74 programs (96.1%), academic institutions in 54 (70.1%), NGOs in 33 (42.9%), and industry/private-sector organizations in 38 (49.4%). Local or Indigenous communities were involved in only eight programs (10.4%).

Table 4. Characteristics of identified One Health programs

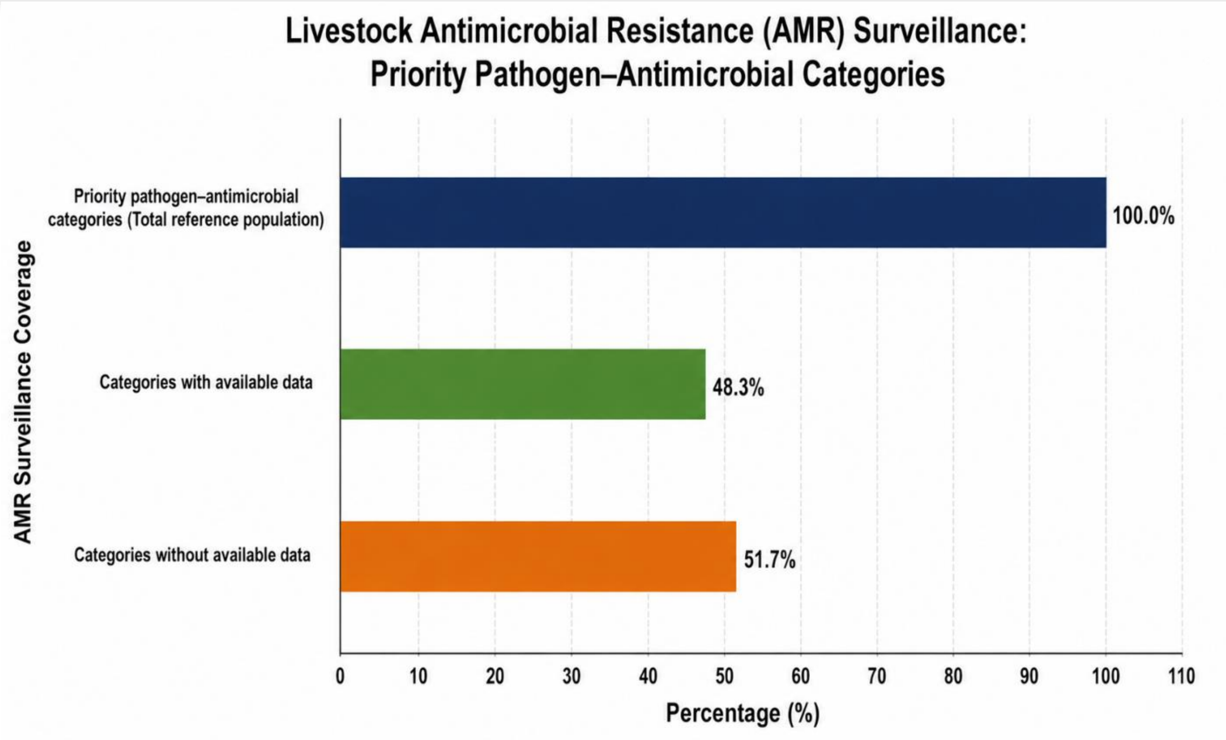
Indicator	n	%
One Health programs	77	100.0
Human + animal sectors	42	54.5
Government/policy stakeholders	74	96.1
Academic institutions	54	70.1
NGOs	33	42.9
Industry/private sector	38	49.4
Local/Indigenous communities	8	10.4
Programs incorporating data/evidence/knowledge	46	60.0



Livestock AMR surveillance also showed a substantial evidence deficit. Venkateswaran et al. (2024) examined livestock AMR surveillance across 109 countries and identified 232 pathogen–antimicrobial categories that had been prioritized by at least one country. Surveillance data were available for only 112 categories (48.3%), leaving 120 categories (51.7%) without available data.

Table 5. Livestock AMR surveillance coverage

Indicator	n	%
Countries with livestock AMR data	109	–
Priority pathogen–antimicrobial categories	232	100.0
Categories with available data	112	48.3
Categories without available data	120	51.7



The bovine tuberculosis evidence from Pakistan provides a country-level example of the importance of livestock surveillance. Sehrish et al. (2025) synthesized 35 studies involving 37,085 bovines and reported 3,516 positive cases. The pooled prevalence was 6.06% (95% CI: 4.67–7.87%), with substantial heterogeneity (I^2 = 96%).

Table 6. Bovine tuberculosis evidence in Pakistan

Variable	Result
Studies included	35
Bovines assessed	37,085
Positive cases	3,516
Pooled prevalence	6.06%
95% CI	4.67–7.87%
Heterogeneity (I^2)	96%
Cattle prevalence	6.44%
Buffalo prevalence	5.54%

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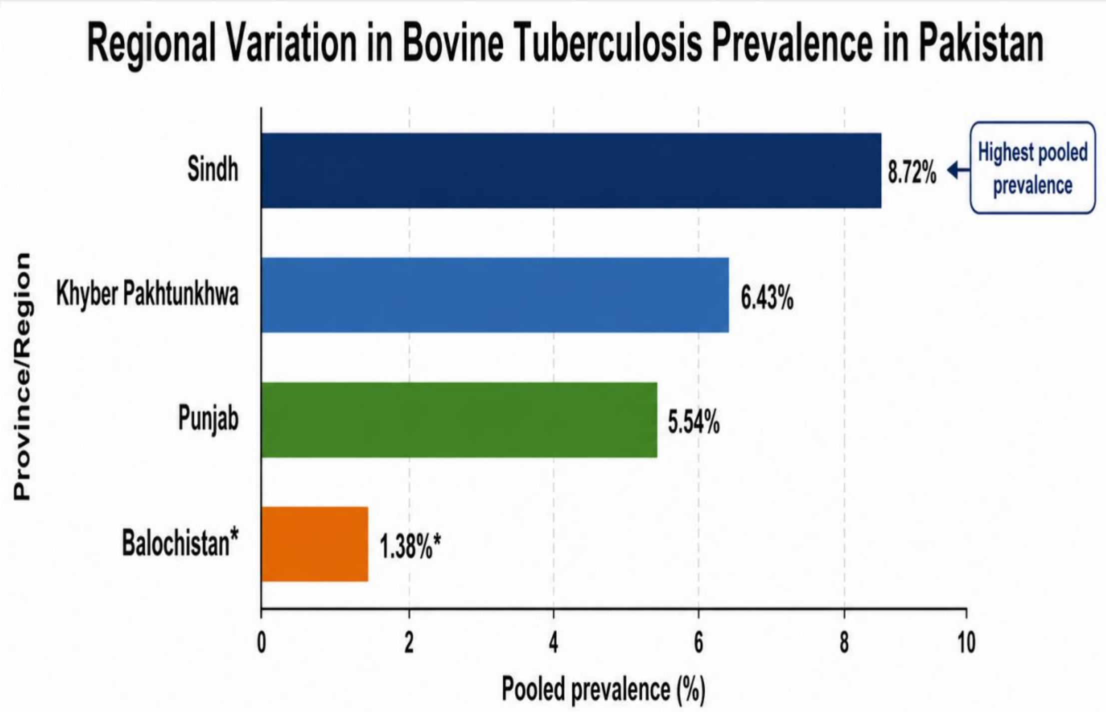
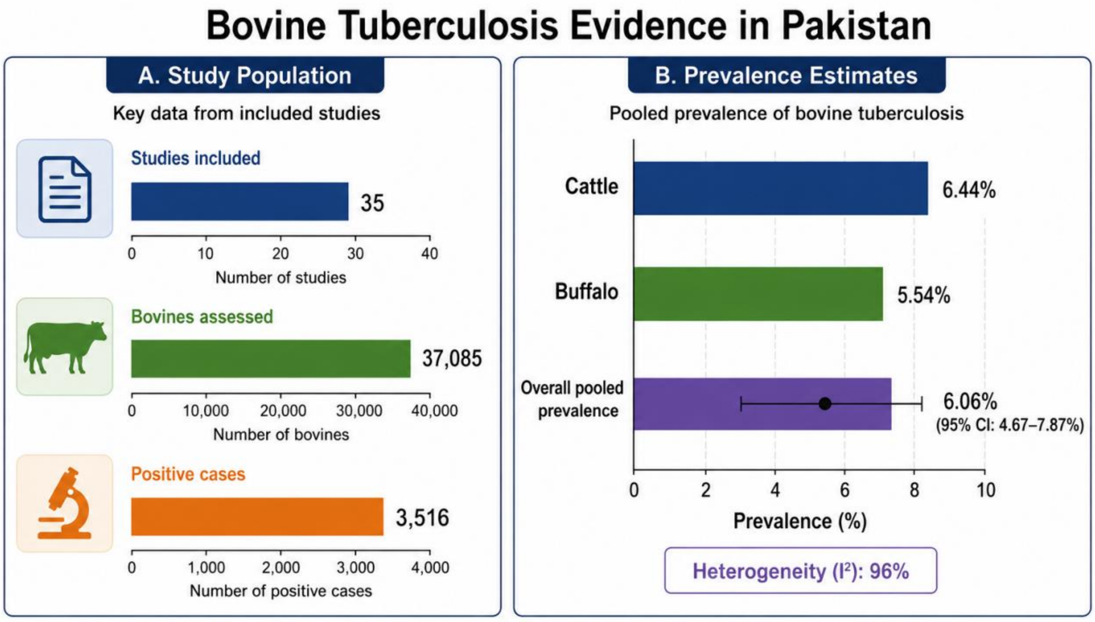


Regional variation was also reported. Sindh had the highest pooled prevalence estimate, while Punjab contributed the largest number of studies and animals.

Table 7. Regional bovine tuberculosis estimates in Pakistan

Region	Studies	Animals tested	Positive cases	Pooled prevalence
Khyber Pakhtunkhwa	7	4,003	248	6.43%
Punjab	18	28,495	2,873	5.54%
Sindh	8	4,170	388	8.72%
Balochistan	1	217	3	1.38%*

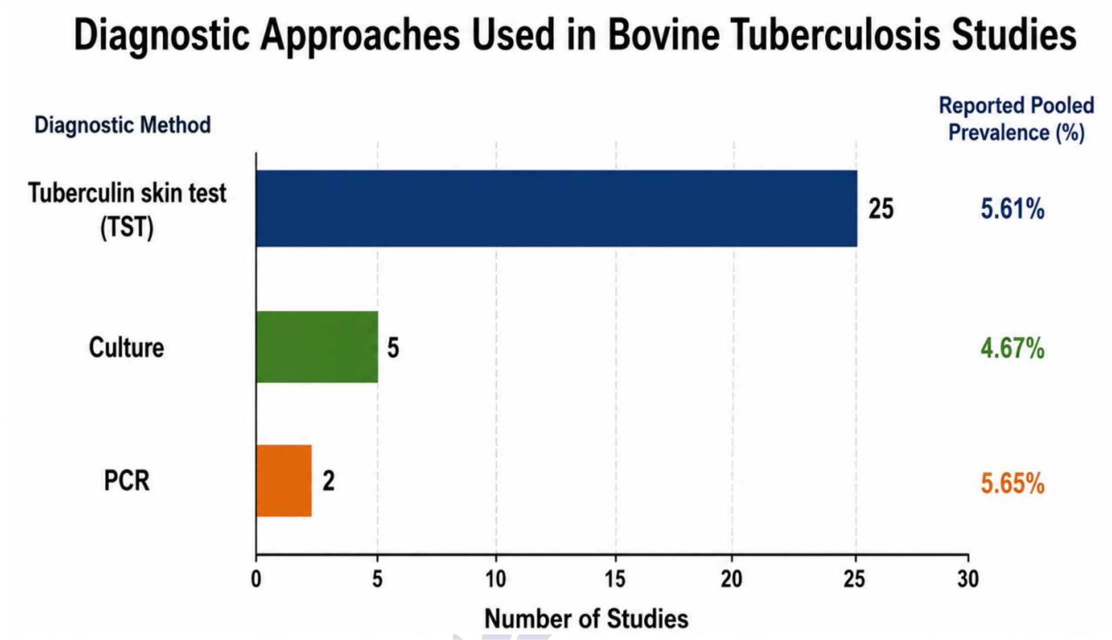
The Balochistan estimate should be interpreted cautiously because it was based on a single study.



Diagnostic approaches also varied across the bovine tuberculosis literature. TST was used in 25 studies, culture in five, and PCR in two.

Table 8. Diagnostic approaches for bovine tuberculosis

Diagnostic method	Studies	Reported pooled prevalence
Tuberculin skin test (TST)	25	5.61%
Culture	5	4.67%
PCR	2	5.65%



These estimates should not be interpreted as direct comparisons of diagnostic accuracy because the studies differed in sample characteristics, methodology, and study populations.

Overall, the evidence indicates that livestock surveillance is relatively well represented within animal-health surveillance, but operational implementation and integration with human and environmental health remain limited. The AMR evidence further demonstrates substantial gaps in the availability of surveillance data, while the bovine tuberculosis evidence illustrates how livestock infection can represent a significant public-health concern.

Table 9. Major surveillance gaps

Evidence area	Major gap	Public-health implication
Syndromic surveillance	Many systems remain proof-of-concept	Limited routine early-warning capacity
One Health integration	Incomplete cross-sectoral integration	Fragmented outbreak detection
AMR surveillance	51.7% of priority categories lacked data	Incomplete resistance monitoring
Environmental surveillance	Limited integration	Transmission pathways may be missed
Community participation	Low involvement	Reduced local-level detection
Geographic coverage	Uneven evidence distribution	Some high-risk areas may remain under-surveilled
Diagnostic surveillance	Methodological variation	Limited comparability
Bovine tuberculosis	High heterogeneity	Difficult national interpretation

The findings support an integrated surveillance model linking farm-level reporting, veterinary services, laboratory diagnostics, food-chain monitoring, AMR surveillance, environmental monitoring, wildlife surveillance, human-health systems, and genomic data.

Table 10. Integrated One Health livestock surveillance framework

Component	Main data source	Key indicators	Function
Farm surveillance	Farmers/veterinarians	Mortality, morbidity, abortions	Early detection
Veterinary surveillance	Veterinary services	Clinical syndromes	Case investigation
Laboratory surveillance	Diagnostic laboratories	PCR, culture, serology	Confirmation
Food-chain surveillance	Milk, meat, eggs	Pathogens/contamination	Food safety
AMR surveillance	Farms/laboratories	Resistance profiles	AMR monitoring
Environmental surveillance	Water, soil, manure	Pathogens/resistance	Environmental detection
Wildlife surveillance	Wildlife/interface monitoring	Reservoirs/spillover	Spillover detection
Genomic surveillance	Sequencing laboratories	Strains/variants	Transmission analysis
Human surveillance	Health facilities	Cases/exposures	Cross-sector linkage
Digital surveillance	Electronic platforms	Alerts/spatial trends	Rapid detection

The proposed framework may be conducted in an iterative manner of detection, verification, integration, risk assessment, alert, response and evaluation. This would be a paradigm change from the act of pasting tags on livestock to its role as an upstream public-health measure. One of the major drawbacks of the evidence synthesis is the heterogenicity of the underlying literature. Studies varied in geographic scope, definition of surveillance, animal population, diagnostic techniques, and study quality. Bovine tuberculosis is highly heterogeneous ($I^2 = 96\%$) and so direct interpretation of the pooled estimate as a national prevalence is further limited. Additionally, published data may underestimate the number of systems in use that are poorly documented or not published. The overall evidence has been collected and confirms that One Health surveillance systems are needed to be interoperable, integrated, and risk-based, linking livestock and human, environment, food-safety, AMR, and wildlife surveillance.

Discussion

The results show that the surveillance of animals has become a key element in zoonotic disease prevention, albeit its potential is limited due to its fragmented implementation and low integration between human health, animal health and environmental health sectors. The key discovery is that although there are a number of surveillance systems available, only a portion is actually working and is truly part of a One Health approach. Shapiro et al. (2025) identified 126 animal syndromic-surveillance systems; 89 (70.6%) of these monitored livestock. Only 25 (19.8%) were functioning operational systems, however, and 12 (9.5%) had a specific One Health approach. This indicates that a significant scientific and technological capability has been achieved, although this has yet to be translated into sustainable surveillance infrastructure.

This is especially significant that the majority of systems are proof-of-concept systems. While experimental and pilot surveillance systems can show feasibility of using digital reporting, syndromic indicators, automated alerts, and other innovative methods will require long-term implementation to ensure public health value. They should be in place at all times, produce accurate information, have good diagnostic capacity, and output information that can be converted to the provision of timely interventions. Therefore, Shapiro et al. (2025)

found that the operationalization of these new surveillance tools is lagging behind, with a relatively low share of systems already in place.

This is supported by the evidence of One Health implementation. Despite identifying 77 One Health programs, 42 (54.5%) included human and animal sectors, showing that many programs are still functioning in a two-sector approach. The participation of government and academic organizations was high, while participation of local and Indigenous community were reported in 10.4% of programs. This is because the surveillance for livestock-associated zoonoses takes place at the farm and community-level, where farmers, veterinarians, livestock traders, slaughterhouse staff, and other workers are likely to come into contact with animals and potentially contaminated materials. Lack of adequate representation of these groups could lead to surveillance systems that miss the early signs of disease outbreaks.

Another weakness is environmental integration. Zoonotic pathogens may not be directly transmitted from livestock to humans. Transmission can be through contaminated water, soil, manure, wastewater, food products, wildlife, vectors, and other environmental pathways. This means that a surveillance system, which monitors livestock without correlating the animal data with the appropriate environmental data, may give an incomplete picture of the risk of transmission. The results thus reflect a more comprehensive understanding of One Health that integration does not only refer to the cooperation of veterinary and medical expertise, but to the systematic sharing and processing of data across relevant fields. This is further supported by the livestock AMR findings. Venkateswaran et al. (2024) revealed that there was no available data for 51.7% (232 out of 232) of the pathogen–antimicrobial combinations that were prioritized. This is a significant gap in surveillance as antimicrobial resistance can be shared between livestock, people, food and the environment. Poor livestock AMR monitoring also hinders health authorities' capacity to determine AMR patterns and possible routes of transmission. The discovery also highlights that the lack of surveillance priorities does not mean there is also a lack of data collection.

The case of bovine tuberculosis in Pakistan is a case in point illustrating the need for livestock surveillance. A pooled prevalence of 6.06% was reported by Sehrish et al. (2025) in bovines in 35 studies with a total of 37,085 animals. This is an estimate of national prevalence, but should not be regarded as a direct prevalence estimate as there is a high level of variation between studies. The figure indicates that bovine tuberculosis is still circulating within the livestock population. The regional differences also indicate that disease surveillance should take geographical differences into consideration and not presume that the risk is the same all over the country. A higher estimate was also observed in Sindh than in Punjab, which also underlines the importance of geographical representative surveillance. The most studies and animals were contributed by the province of Punjab and the province of Balochistan had the least or only one study. Thus, it is important that areas with little research activity might not have much disease burden simply because they lack surveillance data. This is a distinction that is of particular relevance to a developing country where surveillance resources might be focused in areas of high research activity, veterinary laboratory or urban area.

The results of the diagnostics further highlight the need for standardized surveillance methods. The bovine tuberculosis literature was used across all three methods (TST, culture, and PCR), with the number and characteristics of the studies varying widely between methods. Variations in reported prevalence may be attributable to the use of different diagnostic methods, to sampling methods, to differences in the animal populations studied, and to differences in the settings in which the studies are conducted. Standardized sampling frameworks and well-defined diagnostic protocols would thus benefit future surveillance programs and enable the results to be compared geographically and over time. The evidence combined suggests that the main problem is not the lack of surveillance. Instead, the real problem is the existing surveillance capacity is fragmented. Valuable information is routinely generated from livestock surveillance, human disease surveillance, AMR monitoring, food-safety systems, environmental monitoring and wildlife surveillance. These data streams would be more valuable if they were interoperable and analyzed together, creating a significant public-health benefit.

Conclusion

Zoonotic disease surveillance in livestock production is one of the most important step-up steps in global public-health protection. The evidence shows that there is already significant potential for surveillance, however, it is not well coordinated across sectors, or across regions, or well integrated into the environment, or well integrated for livestock AMR. While 89 out of 126 identified animal syndromic-surveillance systems were monitoring livestock, only 25 were established operational systems and only 12 of these included an explicit One Health approach. Likewise, livestock AMR monitoring was undertaken for only 48.3% of pathogen–antimicrobial categories that were prioritized. The significance of livestock surveillance is also reflected in Pakistan with the pooled prevalence of bovine tuberculosis at 6.06% in 35 studies conducted on 37,085 bovines.

The results indicate that risk-based, interoperable One Health surveillance should be implemented instead of sector-specific, fragmented surveillance systems in the future. These should link farm level reporting, veterinary services, laboratory diagnostics, food-chain surveillance, AMR monitoring, environmental surveillance, wildlife surveillance, human health systems, and genomic epidemiology. Finally, zoonosis surveillance in animal should not be a vetinary problem. It is a public health intervention at the animal-health-human-health-environment interface and therefore needs to be integrated into national and international measures for the prevention of diseases, food safety, control of antimicrobial resistance and global health security.

References

Antimicrobial Resistance Collaborators. (2022). Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *The Lancet, 399*(10325), 629–655. https://doi.org/10.1016/S0140-6736(21)02724-0

Babo Martins, S., Sucena Afonso, J., Fastl, C., Huntington, B., & Rushton, J. (2024). The burden of antimicrobial resistance in livestock: A framework to estimate its impact within the Global Burden of Animal Diseases programme. *One Health, 19*, 100917. https://doi.org/10.1016/j.onehlt.2024.100917

Benedetti, G., Boisen, N., & Prada, J. M. (2024). Editorial: One Health surveillance in practice: Experiences of integration among human health, animal health, environmental health, and food safety sectors. *Frontiers in Public Health, 12*, 1384988. https://doi.org/10.3389/fpubh.2024.1384988

Bordier, M., Uea-Anuwong, T., Binot, A., Hendrikx, P., & Goutard, F. L. (2020). Characteristics of One Health surveillance systems: A systematic literature review. *Preventive Veterinary Medicine, 181*, 104560. https://doi.org/10.1016/j.prevetmed.2018.10.005

Ghai, R. R., Wallace, R. M., Kile, J. C., Shoemaker, T. R., Vieira, A. R., Negron, M. E., Shadomy, S. V., Sinclair, J. R., Goryoka, G. W., Salyer, S. J., & Behravesh, C. B. (2022). A generalizable One Health framework for the control of zoonotic diseases. *Scientific Reports, 12*, 8588. https://doi.org/10.1038/s41598-022-12619-1

Hayman, D. T. S., Adisasmito, W. B., Almuhairi, S., Behravesh, C. B., Bilivogui, P., Bukachi, S. A., Casas, N., Cediel Becerra, N., Charron, D. F., Chaudhary, A., Ciacci Zanella, J. R., Cunningham, A. A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G. F., Khaitsa, M., Machalaba, C., ... Koopmans, M. (2023). Developing One Health surveillance systems. *One Health, 17*, 100617. https://doi.org/10.1016/j.onehlt.2023.100617

Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. *Nature, 451*(7181), 990–993. https://doi.org/10.1038/nature06536

Kuhn, C., Hayibor, K. M., Acheampong, A. T., Pires, L. S. A., Costa-Ribeiro, M. C. V., Burrone, M. S., Vásquez-Almazán, C. R., Radon, K., & Solis Soto, M. T. (2024). How studies on zoonotic risks in wildlife implement the One Health approach: A systematic review. *One Health, 19*, 100929. https://doi.org/10.1016/j.onehlt.2024.100929

Lane, J. K., Kelly, T., Bird, B., Chenais, E., Roug, A., Vidal, G., Gallardo, R., Zhou, H., VanHoy, G., & Smith, W. (2025). A One Health approach to reducing livestock disease prevalence in developing countries: Advances, challenges, and prospects. *Annual Review of Animal Biosciences, 13*, 277–302. https://doi.org/10.1146/annurev-animal-111523-102133

Leifels, M., Rahman, O. K., Sam, I.-C., Cheng, D., Chua, F. J. D., Nainani, D., Kim, S. Y., Ng, W. J., Kwok, W. C., & Sirikanchana, K. (2022). The One Health perspective to improve environmental surveillance of zoonotic viruses: Lessons from COVID-19 and outlook beyond. *ISME Communications, 2*, 104. https://doi.org/10.1038/s43705-022-00191-8

Milazzo, A., Liu, J., Multani, P., Steele, S., Hoon, E., & Chaber, A.-L. (2025). One Health implementation: A systematic scoping review using the Quadripartite One Health Joint Plan of Action. *One Health, 20*, 101008. https://doi.org/10.1016/j.onehlt.2025.101008

Ngom, R. V., Jajere, S. M., Ayissi, G. J. A., Tanyienow, A., Moffo, F., Watsop, H. M., Mimboe, L. M., Mouiche, M. M. M., Schüpbach-Regula, G., & Carmo, L. P. (2024). Unveiling the landscape of resistance against high priority critically important antimicrobials in food-producing animals across Africa: A scoping review. *Preventive Veterinary Medicine, 226*, 106173. https://doi.org/10.1016/j.prevetmed.2024.106173

One Health High-Level Expert Panel. (2023). Developing One Health surveillance systems. *One Health, 17*, 100617. https://doi.org/10.1016/j.onehlt.2023.100617

Pandey, S., Doo, H., Keum, G. B., Kim, E. S., Kwak, J., Ryu, S., Choi, Y., Kang, J., Kim, S., Lee, N. R., Oh, K. K., Lee, J.-H., & Kim, H. B. (2024). Antibiotic resistance in livestock, environment and humans: One Health perspective. *Journal of Animal Science and Technology, 66*(2), 266–278. https://doi.org/10.5187/jast.2023.e129

Rivers, S., Kochanowski, M., Stolarek, A., Ziętek-Barszcz, A., Horigan, V., Kent, A. J., & Dewar, R. (2023). A framework for the design, implementation, and evaluation of output-based surveillance systems against zoonotic threats. *Frontiers in Public Health, 11*, 1129776. https://doi.org/10.3389/fpubh.2023.1129776

Shapiro, J. T., Cazeau, G., DiBiagio, R., Dupuy, C., Morignat, E., Dórea, F., Hénaux, V., & Amat, J.-P. (2025). Current practice and future directions in syndromic surveillance for animal health: A scoping review and analysis. *Preventive Veterinary Medicine, 241*, 106532. https://doi.org/10.1016/j.prevetmed.2025.106532

Sharan, M., Vijay, D., Yadav, J. P., Bedi, J. S., & Dhaka, P. (2023). Surveillance and response strategies for zoonotic diseases: A comprehensive review. *Science in One Health, 2*, 100050. https://doi.org/10.1016/j.soh.2023.100050

Shanbehzadeh, M., Nopour, R., & Kazemi-Arpanahi, H. (2022). Designing a standardized framework for data integration between zoonotic diseases systems: Towards One Health surveillance. *Informatics in Medicine Unlocked*, 30, 100893. https://doi.org/10.1016/j.imu.2022.100893

Sehrish, S., Liu, X.-T., Lou, W.-B., Zhang, S.-Y., Ata, E. B., Yang, G.-G., Wang, Q., Zeng, F.-L., Leng, X., Shi, K., Azeem, R.-M., Gong, Q.-L., Song, Y.-H., & Du, R. (2025). Prevalence of tuberculosis in bovines in Pakistan during 2000–2024: A systematic review and meta-analysis. *Frontiers in Veterinary Science*, 12, 1525399. https://doi.org/10.3389/fvets.2025.1525399

Tomori, O., & Oluwayelu, D. O. (2023). Domestic animals as potential reservoirs of zoonotic viral diseases. *Annual Review of Animal Biosciences*, 11, 33–55. https://doi.org/10.1146/annurev-animal-062922-060125

Venkateswaran, N., Swetschinski, L. R., Fastl, C., Di Bari, C., Criscuolo, N. G., Mulchandani, R., Zhao, C., Meštrović, T., Ikuta, K. S., Babo Martins, S., Coyne, L. A., Sucena Afonso, J., Huntington, B., Rushton, J., Devleesschauwer, B., Sartorius, B., Van Boeckel, T. P., & Pigott, D. M. (2024). Using priorities between human and livestock bacterial antimicrobial resistance (AMR) to identify data gaps in livestock AMR surveillance. *BMC Infectious Diseases*, 24, 1027. https://doi.org/10.1186/s12879-024-09847-3

Zhang, T., Nickerson, R., Zhang, W., Peng, X., Shang, Y., Zhou, Y., Luo, Q., Wen, G., & Cheng, Z. (2024). The impacts of animal agriculture on One Health—Bacterial zoonosis, antimicrobial resistance, and beyond. *One Health*, 18, 100748. https://doi.org/10.1016/j.onehlt.2024.100748

Zinsstag, J., Kaiser-Grolimund, A., Heitz-Tokpa, K., Sreedharan, R., Lubroth, J., Caya, F., Stone, M., Brown, H., Bonfoh, B., Dobell, E., Morgan, D., Homaira, N., Kock, R., Hattendorf, J., Crump, L., Mauti, S., del Rio Vilas, V., Saikat, S., Zumla, A., ... de la Rocque, S. (2023). Advancing One human–animal–environment Health for global health security: What does the evidence say? *The Lancet*, *401*(10376), 591–604. https://doi.org/10.1016/S0140-6736(22)01595-1

World Health Organization, Food and Agriculture Organization of the United Nations, & World Organisation for Animal Health. (2019). *Taking a multisectoral, One Health approach: A tripartite guide to addressing zoonotic diseases in countries*. World Health Organization. https://doi.org/10.2471/9789241514934

World Health Organization, Food and Agriculture Organization of the United Nations, United Nations Environment Programme, & World Organisation for Animal Health. (2022). *One Health joint plan of action (2022–2026): Working together for the health of humans, animals, plants and the environment*. World Health Organization.

World Health Organization, Food and Agriculture Organization of the United Nations, & World Organisation for Animal Health. (2022). *Surveillance and information sharing operational tool: An operational tool of the Tripartite Zoonoses Guide*. World Health Organization. https://doi.org/10.2471/9789240053250

Fareed, Z., Rana, A., Hadi, S. A., Geluk, A., Hope, J. C., & Khalid, H. (2024). A One Health-focused literature review on bovine and zoonotic tuberculosis in Pakistan from the past two decades: Challenges and way forward for control. *One Health*, 18, 100763. https://doi.org/10.1016/j.onehlt.2024.100763

Zhou, C., Wang, S., Wang, C., Qiang, N., Xiu, L., Hu, Q., Wu, W., Zhang, X., Han, L., Feng, X., Zhu, Z., Shi, L., Zhang, P., & Yin, K. (2025). Integrated surveillance and early warning system of emerging infectious diseases in China at community level: Current status, gaps and perspectives. *Science in One Health*, 4, 100102. https://doi.org/10.1016/j.soh.2024.100102

Timme, R. E., Wolfgang, W. J., Balkey, M., Venkata, S. L. G., Randolph, R., Allard, M., et al. (2020). Optimizing open data to support One Health: Best practices to ensure interoperability of genomic data from bacterial pathogens. *One Health Outlook*, *2*, 20. https://doi.org/10.1186/s42522-020-00026-3

Ribeiro, C. D. S., van de Burgwal, L. H., & Regeer, B. J. (2019). Overcoming challenges for designing and implementing the One Health approach: A systematic review of the literature. *One Health*, *7*, 100085. https://doi.org/10.1016/j.onehlt.2019.100085