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Bibliometric analysis of digitalized veterinary surveillance frameworks for zoonotic disease mitigation in resource-limited countries

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Abstract

Digital veterinary surveillance constitutes a critical component of infrastructure for mitigating zoonotic disease transmission within the One Health framework adopted by developing economies. This bibliometric analysis examines global scholarly output on technology-enhanced livestock monitoring approaches targeting zoonotic threats in resource-limited settings. The study aimed to quantify publication impact and to identify evolutionary patterns and thematic structures within this research domain. Bibliographic records were retrieved from Scopus and analyzed using Biblioshiny (Bibliometrix v4.1.4) and VOSviewer (v1.6.18), incorporating metadata on authorship, institutional affiliations, keywords, and citation performance. The dataset comprised 473 publications spanning 1986–2024, predominantly research articles (66.6%) and reviews (24.3%), published primarily in English (96.8%). Contributions from 103 countries involved 2,156 authors, yielding a collaboration index of 4.56. The United States accounted for the largest share of publications (42.9%), followed by the United Kingdom (33.2%), Nigeria (18.2%), India (17.8%), and Kenya (17.1%). The corpus accumulated 15,418 citations (mean of 32.6 per document), corresponding to an overall h-index of 58 and a compound annual growth rate of 2.78%. Keyword co-occurrence analysis identified 44 consolidated descriptors forming seven thematic clusters. “Zoonosis” emerged as the most frequent term (73 occurrences), followed by “one health” (64), “surveillance” (52), and “epidemiology” (48). This study provides the first comprehensive bibliometric mapping of digital veterinary surveillance research focused on zoonotic disease prevention in developing contexts. Targeted investment in surveillance capacity within endemic regions may further strengthen global preparedness against zoonotic threats.

Introduction

Pathogenic agents capable of crossing species barriers from fauna to humans constitute a paramount challenge for worldwide population wellbeing (1). Scientific consensus indicates that roughly six out of ten novel human pathogens demonstrate zoological ancestry, predominantly stemming from undomesticated animal reservoirs (2). Economically disadvantaged nations experience heightened vulnerability to these cross-species infections owing to intimate livestock-human cohabitation patterns, constrained medical

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service availability, and suboptimal epidemiological monitoring capabilities (3, 4). The intersection between animal husbandry practices and public health outcomes has garnered increasing attention from international health organizations, particularly following recent pandemic events that underscored the critical importance of early detection systems at the human-animal interface.

Technology-enhanced veterinary intelligence networks represent the convergence of computational innovations with animal healthcare delivery for outbreak detection, preemptive alert generation, and cross-species disease interdiction (5-7). Such platforms constitute foundational elements within the integrative health paradigm, acknowledging the symbiotic relationship linking human vitality, livestock welfare, and ecological integrity (8). This holistic framework advocates multisectoral cooperation spanning scientific disciplines to optimize wellness outcomes while forestalling pathogen spillover incidents (9, 10). The implementation of digital surveillance systems has demonstrated considerable promise in facilitating rapid response mechanisms, enabling real-time data sharing across institutional boundaries, and supporting evidence-based policy formulation in resource-constrained environments.

The conceptualization of One Health as an integrated approach recognizes that human health, animal health, and environmental health are inextricably linked (11). This paradigm has gained substantial traction among international health agencies, veterinary organizations, and environmental protection bodies as the preferred framework for addressing complex health challenges that transcend traditional disciplinary boundaries. Within developing nations, where approximately 75% of emerging infectious diseases originate, the implementation of coordinated surveillance systems assumes particular urgency given limited healthcare infrastructure and competing development priorities.

Scientometric investigation constitutes a numerical approach for appraising scholarly productivity and knowledge advancement trajectories. Contemporary academic interest has intensified regarding such analytical frameworks given escalating requirements for evaluating research outcomes across individual, organizational, and territorial dimensions (12, 13). Practitioners employ these methodologies for diverse applications encompassing trend identification in scholarly communication, periodical influence metrics, cooperative network characterization, and constituent element examination (14, 15). Bibliometric analysis provides objective quantification of research landscapes, enabling identification of knowledge gaps, emerging research frontiers, and influential contributors within specified domains.

The application of bibliometric methodologies to veterinary and public health literature has expanded considerably in recent years, facilitating systematic assessment of research progress across various disease categories and geographical regions (16, 17). Such analyses prove particularly valuable for informing research priority setting, resource allocation decisions, and capacity building initiatives within developing country contexts where empirical evidence regarding research ecosystem characteristics remains limited.

Despite proliferating scientometric examinations within veterinary scholarship recently, analogous investigations targeting computerized livestock health intelligence systems for zoonotic containment within developing territories remain notably sparse (18, 19). Furthermore, no comparable examination addressing technology-enabled animal health monitoring systems for zoonotic prevention within resource-constrained territories was identified within accessible literature. This knowledge gap impedes comprehensive understanding of research evolution patterns, collaboration networks, and thematic priorities that could inform strategic investment in surveillance infrastructure development.

The current undertaking applies bibliometric methodologies to contemporary literature

addressing technology-enabled animal wellness monitoring frameworks designed for cross-species disease prevention in resource-constrained settings. Our fundamental purpose entailed assessing scholarly impact within this domain while simultaneously uncovering developmental trajectories and conceptual aggregations. This investigation aims to provide actionable intelligence for researchers, policymakers, and funding agencies seeking to optimize investments in digital veterinary surveillance capacity within developing regions.

Materials and Methods

Study Design and Data Source

This scientometric examination followed established bibliometric analysis guidelines (12,14). Elsevier's Scopus repository (Amsterdam, Netherlands) was selected for data acquisition based on its comprehensive indexing scope and superior suitability for citation-based analyses compared to alternative databases (20). Scopus provides extensive coverage of peer-reviewed literature across scientific, technical, medical, and social science domains, indexing approximately 84 million records from over 27,000 active titles. The platform's standardized metadata structure and robust analytical capabilities render it particularly appropriate for large-scale bibliometric investigations spanning multiple disciplinary areas.

Search Strategy

The search was executed in Scopus on December 2024 using the following query string: TITLE-ABS-KEY ("animal health" OR "veterinary" OR "livestock") AND ("information system" OR "digital" OR "surveillance") AND ("developing country*" OR "low-income" OR "middle-income" OR "zoonosis" OR "zoonotic")). No additional filters were applied for document type, publication year, or language at the database level. The query retrieved 473 documents. The search strategy was intentionally designed to maximize retrieval sensitivity, consistent with established bibliometric methodology guidelines (12). Disease-type descriptors ("zoonosis", "zoonotic") were included to capture the full scope of zoonotic surveillance literature, while geographic or economic relevance was not enforced at the database query stage. We acknowledge that the Boolean structure does not operate as a formal geographic filter. Accordingly, relevance to developing or resource-limited country contexts was determined through a structured post-retrieval screening process rather than inferred from the search string itself. This approach was adopted because zoonotic surveillance studies relevant to low- and middle-income settings may omit explicit geographic or economic descriptors in titles, abstracts, or keywords, particularly in studies led by researchers based in high-income institutions addressing diseases endemic to developing regions.

Data Extraction and Processing

Extracted metadata encompassing titles, typological classifications, chronological markers, contributor names, organizational affiliations, descriptor terminology, synopsis content, Hirsch indices, and citation tallies were archived in BibTeX structure. Data harvesting occurred during December 2024. Document selection encompassed all scholarly categories including original investigations, systematic reviews, edited volume contributions, and conference proceedings. Temporal boundaries spanned publications appearing between 1986 and 2024. Duplicate records were identified and removed through automated screening supplemented by manual verification.

Eligibility Screening

To ensure alignment with the stated review scope, all 473 retrieved records underwent systematic screening. Records were retained if they met at least one of the following inclusion criteria: (a) explicit identification of study location within countries classified as low- or middle-income (LMICs) according to World Bank classification at the time of publication; (b) explicit contextual framing of the surveillance system or application as intended for, or applicable to, resource-limited settings; or (c) focus on zoonotic diseases widely recognized as

predominantly affecting developing regions (e.g., rabies, brucellosis, Rift Valley fever, bovine tuberculosis), accompanied by discussion of implementation challenges or surveillance constraints characteristic of such contexts. Records were excluded if they: (a) were conducted exclusively in high-income country settings without stated relevance or applicability to LMIC contexts; (b) addressed non-zoonotic animal diseases without surveillance system components; or (c) comprised editorials, letters, or commentaries without original research content. Two reviewers independently screened all titles and abstracts against the eligibility criteria. Full-text review was conducted for records where eligibility could not be determined from title and abstract alone. Disagreements were resolved through consensus discussion. Relevance to developing country contexts was determined based on explicit textual content in titles, abstracts, or keywords—not inferred from author affiliations alone. All 473 retrieved records met at least one predefined inclusion criterion and were therefore retained for bibliometric analysis, reflecting the intentionally inclusive search strategy combined with context-based eligibility assessment.

Analytical Platforms and Procedures

Dual complementary computational platforms facilitated exhaustive scientometric examination. Initially, R statistical environment (release 4.3.2) equipped with the Bibliometrix toolkit (release 4.1.4) operated via the Biblioshiny web interface (14). Bibliometrix analysis parameters were configured as follows: annual publication trends with compound annual growth rate (CAGR) calculation; author productivity metrics using fractional counting method; country scientific production based on corresponding author affiliation; source impact analysis using Bradford's Law with three-zone distribution; keyword analysis using author keywords (DE field) with minimum frequency threshold of 5 occurrences; citation analysis employing local citation counting to identify most influential documents within the dataset; and Hirsch index (h-index) calculated at corpus level to assess overall research impact.

Additionally, VOSviewer visualization software (release 1.6.18) for Windows operating systems generated knowledge mapping and network representations (21). For keyword co-occurrence analysis, the following parameters were applied: type of analysis = co-occurrence; unit of analysis = author keywords; counting method = full counting; minimum number of occurrences = 5; of the 1,847 total author keywords, 89 met the threshold. Of these 89 author keywords meeting the minimum occurrence threshold, 44 unique descriptors were retained for network visualization after consolidation of synonyms and closely related terms, following standard VOSviewer preprocessing procedures. For bibliographic coupling analysis of countries: unit of analysis = countries; counting method = full counting; minimum number of documents per country = 5; of 103 countries, 38 met the threshold. Network visualization employed the LinLog/modularity normalization method with attraction parameter = 2 and repulsion parameter = 1. Clustering utilized the association strength method with resolution = 1.0 and minimum cluster size = 5. Layout parameters included random seed = 1 to ensure reproducibility of network configurations.

Bibliometric Indicators

Key performance indicators examined included publication volume trajectories, citation accumulation patterns, h-index calculations, international collaboration indices, and keyword frequency distributions. Bradford's law was applied to identify core journals within the field, while Lotka's law informed author productivity assessments. Geographic distribution analysis incorporated both absolute publication counts and population-normalized productivity metrics to account for differential research capacity across territories.

Results

Publication Output and Temporal Trends

Query execution retrieved 473 indexed documents addressing this thematic domain within Scopus spanning 1986 through 2024. Typological breakdown revealed 315 primary research articles (66.6%), 115 review syntheses (24.3%), 23 monograph chapters (4.9%), and 20 conference contributions (4.2%). English constituted the dominant communication medium (96.8%), with French (1.5%), Spanish (1.1%), and other languages (0.6%) representing secondary linguistic preferences. The preponderance of English-language publications reflects established patterns in international scientific communication, though may also indicate potential underrepresentation of research published in other languages.

Temporal analysis revealed sustained growth in publication activity throughout the study period. Initial output during the 1986-2005 interval remained modest, averaging fewer than five documents annually. Post-2006 annual output consistently exceeded five documents, signalling transition toward established research domain status. Peak productivity materialized during 2021 and 2022 with 46 publications annually, followed by 2023 yielding 41 outputs. Compound annual growth registered 2.78%, indicating robust expansion trajectory for this research field (Figure 1).

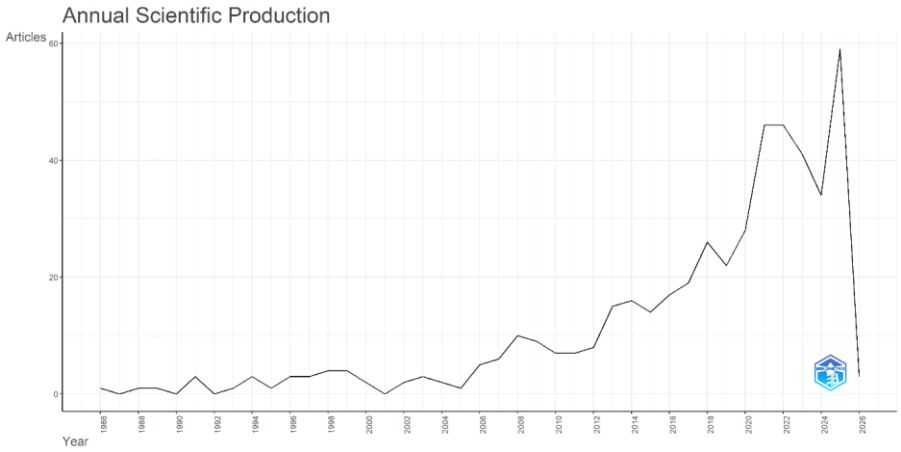

Fig. 1. Chronological distribution of scholarly output addressing computerized veterinary intelligence frameworks for zoonotic mitigation in developing territories (1986-2024). The graph demonstrates accelerating publication trends with marked expansion following 2010. Generated via Biblioshiny (Bibliometrix R toolkit, v4.1.4).

Geographic Distribution and Institutional Analysis

Scholarly contributions originated from 103 distinct territories worldwide, demonstrating substantial international engagement with this research domain. American institutions dominated productivity rankings with 203 total outputs (42.9% of corpus). British affiliations contributed 157 documents (33.2%), followed by Nigerian (86, 18.2%), Indian (84, 17.8%), and Kenyan (81, 17.1%) outputs constituting the five most productive territories (Table 1). The prominence of developing country contributors, particularly from Africa and South Asia, reflects direct engagement with surveillance challenges within endemic regions.

Institutional analysis revealed British, American, and Kenyan organizations as leading contributors. Glasgow University registered maximum institutional output (28 documents, 5.9% of total), reflecting that institution's established expertise in veterinary public health and tropical disease research. Other prominent institutions included the United States Centers for Disease Control and Prevention (CDC, 22 documents), the International Livestock Research Institute (ILRI, Kenya, 18 documents), and multiple academic veterinary

faculties across participating countries. Predominant disciplinary domains encompassed Veterinary Sciences, Public Health Medicine, and Agricultural-Biological Sciences.

Citation Analysis and Impact Metrics

Cumulative citation tally reached 15,418 (averaging 32.6 per document) with aggregate Hirsch index of 58, indicating substantial scholarly impact for this research domain. Citation accumulation demonstrated consistent temporal growth with marked acceleration following 2010. Publications from 2010-2014 achieved maximum mean citations per document (64.34), reflecting citation accumulation advantages for older publications while simultaneously indicating high-impact contributions during this period.

The 2020-2024 interval produced highest document volume (254 outputs, 53.7% of corpus), demonstrating intensifying research interest aligned with global health security priorities and pandemic preparedness initiatives. Citation metrics and publication quantities exhibited sustained expansion following 2010, suggesting maturation toward established research field status with growing recognition within broader scientific discourse.

Table 1. Leading contributor territories, institutions, and citation metrics for digital veterinary surveillance research.

Territory	Docs	Citations	Top Institution	Docs	% Total
United States	203	2,196	CDC	22	4.7
United Kingdom	157	2,599	Glasgow University	28	5.9
Nigeria	86	171	U. Ibadan	12	2.5
India	84	574	IVRI	9	1.9
Kenya	81	438	ILRI	18	3.8

Abbreviations: CDC, Centers for Disease Control and Prevention; IVRI, Indian Veterinary Research Institute; ILRI, International Livestock Research Institute. % Total indicates institutional contribution as percentage of entire corpus (n=473).

Collaboration Networks and Keyword Analysis

The collaborative authorship network illustrates partnership configurations among territories, revealing robust linkages between American, British, and African scholarly communities. International collaboration indices indicated that 47.3% of publications involved multi-country author teams, substantially exceeding global averages for biomedical research. North-South collaboration patterns predominated, with particular intensity between United Kingdom institutions and African partner organizations.

Keyword co-occurrence analysis identified 89 author keywords meeting the minimum threshold (≥5 occurrences), of which 44 consolidated descriptors were mapped into seven thematic clusters encompassing 248 linkages and cumulative connection strength of 390 (Figure 2). "Zoonosis" emerged as predominant terminology (73 instances), succeeded by "one health" (64 instances), "zoonoses" (59 instances), and "surveillance" (52 instances). Additional high-frequency descriptors included "epidemiology" (48 instances), "antimicrobial resistance" (31 instances), "infectious disease" (28 instances), and "developing country" (26 instances), reflecting the strong epidemiological orientation of digital veterinary surveillance research.

Discussion

Scientometric investigations illuminate disciplinary advancement trajectories while revealing influential contributions, organizational leaders, territorial distributions, and prominent scholars (22). The present analysis provides inaugural comprehensive mapping of research addressing digital veterinary

surveillance systems for zoonotic disease mitigation in developing country contexts. Our findings reveal a dynamic research landscape characterized by accelerating publication output, substantial international collaboration, and thematic emphasis on integrated health approaches.

Despite proliferating citation-based examinations within veterinary scholarship recently, analogous investigations targeting computerized livestock wellness intelligence frameworks for cross-species disease containment remain comparatively sparse (18, 19). Furthermore, no comparable examination addressing technology-enabled animal health monitoring systems for zoonotic prevention within resource-constrained territories was identified within accessible literature. This investigation addresses this knowledge gap through systematic quantification of research landscape characteristics.

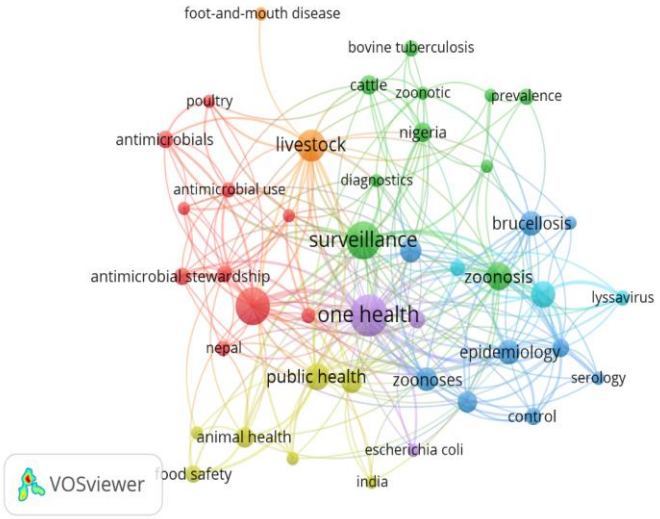

Fig. 2. Descriptor co-occurrence network depicting thematic clustering within digitalized veterinary surveillance scholarship. Seven clusters identified: Antimicrobial Stewardship (Red), Livestock Health Systems (Orange), Surveillance Infrastructure (Green), Integrated Health Framework (Purple), Zoonotic Epidemiology (Cyan), Emerging Pathogens (Blue), Food Safety (Yellow). Node size reflects keyword frequency; line thickness indicates co-occurrence strength. Generated via VOSviewer (v1.6.18).

Within scientometric research, Elsevier's Scopus platform enjoys widespread utilization alongside Clarivate's Web of Science repository (12, 18, 20). This investigation employed Scopus for data extraction, revealing multinational contributions spanning American, European, Asian, and African territories, with American and British institutions demonstrating maximum productivity. Such dominance reflects robust research infrastructure and funding accessibility supporting integrated health scholarship within these nations (8, 23). However, the substantial contributions from developing country researchers, particularly from Nigeria, India, and Kenya, indicate growing indigenous research capacity within endemic regions.

The predominance of "zoonosis" as leading descriptor (73 instances) followed by "one health" (64 instances) underscores the centrality of integrative approaches within computerized veterinary systems targeting cross-species disease mitigation. This finding aligns with contemporary policy frameworks emphasizing coordinated human-animal-environment health surveillance as optimal strategy for emerging disease detection and response (24, 25). Prominence of surveillance,

antimicrobial resistance, and zoonoses terminology indicates primary contemporary research emphases reflecting global health priority areas.

Robust collaboration between industrialized and developing territories, particularly African nations, reflects worldwide acknowledgment that cross-species pathogen threats necessitate transnational cooperation for effective prevention and management (26, 27). The intensity of North-South research partnerships observed in this analysis suggests effective knowledge transfer mechanisms operating within this field, though sustainability of such arrangements warrants ongoing attention.

The temporal publication pattern observed, with marked acceleration following 2010 and peak output during 2021-2022, likely reflects multiple converging factors including expanded funding availability for One Health research, growing policy attention to zoonotic disease preparedness, and technological advances enabling more sophisticated surveillance system development. The COVID-19 pandemic may have contributed to heightened interest during the 2020-2022 period, though this requires further investigation.

Scientometric methodology constitutes an efficient approach for quantifying overarching research activity trajectories while elucidating interconnections among relevant scholarly organizations, territories, and contributors. Such analyses additionally enable assessment of scholarly output quantities and evolutionary patterns across nations and temporal periods, proving particularly valuable for emerging disciplines whose broader veterinary and public health implications remain incompletely characterized (14, 21, 28).

Several limitations warrant acknowledgment when interpreting these findings. First, restriction to Scopus-indexed publications may exclude relevant literature appearing in regional journals or grey literature sources not captured by this database. Second, English language predominance within indexed literature may underrepresent research published in other languages, particularly from non-Anglophone developing regions. Third, citation-based metrics inherently favor older publications with greater citation accumulation opportunity, potentially understating impact of recent contributions. Fourth, keyword co-occurrence analysis depends upon author-assigned descriptors that may vary in specificity and consistency across publications. Future investigations might beneficially incorporate multiple databases and expand temporal coverage to address these constraints.

Conclusion

To characterize thematic progression and intellectual landscape trajectories within this domain, we constructed comprehensive knowledge maps spanning territories, organizations, contributors, cited sources, and trending descriptors utilizing R-based Biblioshiny and VOSviewer platforms. American and British scholarship exerts substantial influence within this field, though developing country contributions demonstrate meaningful and growing research engagement. "Zoonosis" constituted the most prevalent descriptor (73 instances), followed by "one health" (64 instances), emphasizing integrative approach significance for cross-species disease prevention. Publications from 2010-2014 achieved maximum mean citation impact, while post-2015 output demonstrated sustained growth trajectories. The seven thematic clusters identified encompass surveillance infrastructure, antimicrobial stewardship, livestock health systems, integrated health frameworks, zoonotic epidemiology, emerging pathogens, and food safety domains. Enhanced research funding allocation toward endemic disease territories may catalyze expanded future scholarly productivity from these critical regions. Strategic investment in digital surveillance infrastructure within developing nations, coupled with sustained international collaboration mechanisms, holds

potential to strengthen global health security through improved early warning capabilities for zoonotic disease emergence.

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Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this manuscript.

Ethical approval

Not applicable. This study involved bibliometric analysis of publicly available bibliographic data from the Scopus database and did not involve human subjects, animal experimentation, or collection of primary data requiring ethical review.

Artificial Intelligence Statement

No artificial intelligence tools were used in the data collection, analysis, or interpretation of results in this study. AI-assisted tools were used only for language editing and grammar checking purposes during manuscript preparation.

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