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BIBLIOMETRIC REVIEW ARTICLE

A comprehensive bibliometric review of One Health research in Saudi Arabia

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ABSTRACT

Background and Aim: One Health (OH) is an interdisciplinary framework integrating human, animal, and environmental health to address complex health challenges such as zoonotic diseases and antimicrobial resistance. Despite global adoption, the OH approach in Saudi Arabia lacks comprehensive bibliometric evaluation to reveal trends, collaborations, and research domains. This study aims to provide a bibliometric review of OH research in Saudi Arabia to identify gaps and propose improvements.

Materials and Methods: A systematic bibliometric analysis was conducted on OH-related publications from 2011 to 2024. Data were sourced from seven international databases, including Scopus and PubMed. Studies were filtered using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to include those focusing on OH perspectives within Saudi Arabia. Bibliometric tools like VOSviewer and Biblioshiny were employed to analyze publication trends, citation patterns, and thematic areas.

Results: A total of 178 publications were analyzed. The Ministry of Health, King Saud University, and King Abdulaziz University emerged as leading contributors. Key themes identified included zoonotic diseases, environmental health, and antimicrobial resistance. The Saudi Medical Journal and the Saudi Journal of Biological Sciences were primary publication platforms. Citations peaked in 2012, largely due to seminal work on Middle East respiratory syndrome coronavirus. Collaboration patterns showed that domestic partnerships outperformed regional and international collaborations in terms of output, though the latter had higher citation averages. Riyadh was identified as the most productive region.

Conclusion: The analysis highlights Saudi Arabia's growing contributions to OH research, emphasizing the importance of inter-sectoral collaboration. However, challenges remain in aligning research outputs with practical applications, particularly in disease surveillance and public awareness. Strengthening partnerships, enhancing resource allocation, and addressing underrepresented regions are critical for advancing OH implementation.

Keywords: antimicrobial resistance, bibliometric analysis, One Health, Saudi Arabia, zoonotic diseases.

INTRODUCTION

One Health (OH) concept emphasizes the collaboration of humans, animals, and the environmental sectors [1]. This perspective is critical for addressing complex health issues such as zoonotic diseases, antibiotic resistance (antimicrobial resistance [AMR]), and food and environmental issues [2]. After its formulation in the early 2000s, the OH framework gained global traction to address interconnected health issues [1–3]. In Europe, OH research has involved consortia focusing on AMR, whereas America has incorporated multisectoral collaboration for better zoonotic control [2, 3].

The OH strategy is effectively reflected in Saudi Arabia, especially in response to health emergencies such as Middle East respiratory syndrome (MERS), avian influenza, and Rift Valley disease [4]. The OH approach has been instrumental in enhancing the control of complex health issues by integrating the veterinary and public health sectors [5]. There are still gaps for improvement due to constraints on the scope of activities and sharing of information across systems

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in the health-care industry [6, 7]. Saudi Arabia has also invested in health and biomedical research to make the kingdom a leading scientific institution [8, 9]. These include the construction of highly sophisticated research infrastructure and health-care enhancements under the National Transformation Program 2020 Vision 2030, which aligned the international trends of investments in OH-related issues [10]. Nevertheless, OH institutions need further enhancement of governance and resource exchange in the preparedness stage [7].

This study establishes a benchmark for these efforts and provides the necessary information for researchers and policymakers. Consequently, applying bibliometric analysis in this study will systematically reveal research trends, challenges, and successful interdisciplinary milestones in OH research in Saudi Arabia. As bibliometric evaluations provide necessary instruments for assessing the current state of research, they reveal both advancements and deficits [11]. The results of this investigation will also help the global community expand OH knowledge and practice to create more coherent strategies for health management.

MATERIALS AND METHODS

Ethical approval

This study did not require ethical approval. This systematic review was conducted based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The bibliometric method was applied to analyze research and publication patterns on OH perceptions in Saudi Arabia in scholarly publications such as research articles, conference papers, and books. The model presents the scientific landscape of authors, countries, organizations, and collaborations contributing to the worldwide scientific literature [12].

Study period and location

The bibliometric review began in March 2024 to analyze articles published from 2011 through 2024 which discussed One Health research in Saudi Arabia. The review focuses on studies carried out throughout Saudi Arabia, with a special focus on the Saudi cities involving data from multiple regions.

Search strategy

PubMed, Scopus, Web of Science, Dimensions, Semantic Scholars, OpenAlex, and ProQuest were chosen to obtain bibliographic data that reflect a wide range of databases and topics in health science. The broad search query was framed to retrieve the most relevant data on OH perceptions in Saudi Arabia. The search covered the period from 2011 to 2024 to reflect the OH framework's introduction in the early 2000s and the subsequent growth in OH-related research globally and in Saudi Arabia. The following search query was run in English and involved scanning the title, abstract, and keywords from multiple databases covering the index of OH-relevant studies, especially those concerning zoonoses, AMR, and ecosystem health (human* AND (animal* OR wildlife) AND (environment* OR plant* OR eco*) AND (zoon* OR "antimicrobial resistance" OR "antibiotic resistance" OR "anti-bacterial resistance" OR "food safety" OR "food security" OR "vector-borne" OR "One Health" OR "One Medicine" OR "human animal interface" OR "human-animal interface" OR "human-livestock interface" OR "human-wildlife interface" OR "ecosystem health*" OR "ecosystem approach*")) AND ("Saudi Arabia"). This search string was developed and refined by the research directorate of library affairs and approved by a university professor specializing in systematic review methodology from Imam Abdulrahman Bin Faisal University.

Inclusion and exclusion criteria

The inclusion criteria only cover studies in Saudi Arabia regarding the perception, experience, or implementation of various OH aspects. In this regard, research on OH approach collaboration and preventive measures adopted in different contexts that focus on humans, animals, and the environment. In contrast, research conducted outside Saudi Arabia and studies that do not directly focus on OH perception, experience, or implementation are excluded. Any research based on disease/health hazards that does not focus on the OH approach and have insufficient data was also excluded from the analysis.

Study selection

Figure 1 presents the multiple stages of the overall search and filtration process. The data filtration for the bibliometrics paper followed a systematic approach based on the PRISMA guidelines [13]. Articles were screened by title and abstract through Zotero (https://www.zotero.org) and Rayyan (https://www.rayyan.ai) [14]. Initially, 4,455 studies were identified through a database search of OH in Saudi Arabia. After removing 450 duplicate records and 10 retracted articles, 3995 abstracts were assessed for eligibility. From these, 3,311 studies were excluded because they were from an irrelevant geographic region, and 635 studies were discarded because they did not focus on OH. In addition, three studies were excluded because they were insufficiently relevant to the research objectives. Snowball citations were used to retrieve 46 selected reports, initially yielding 1,510 records, of which two pre-published articles, 25 duplicate records, and 80 studies that did not focus on OH were removed. A further 1271 records were excluded because they were irrelevant to the research objectives. Finally, after rigorous evaluation, 178 publications were selected for inclusion in the bibliometric analysis.

Statistical analysis

The records were exported from Zotero and Rayyan into Microsoft Excel 365 Version 2301 (Microsoft Office, Washington, USA). The data accuracy was verified by two independent team members of the research group to ensure consistency. Descriptive statistical analysis including frequencies, percentages, mean citations

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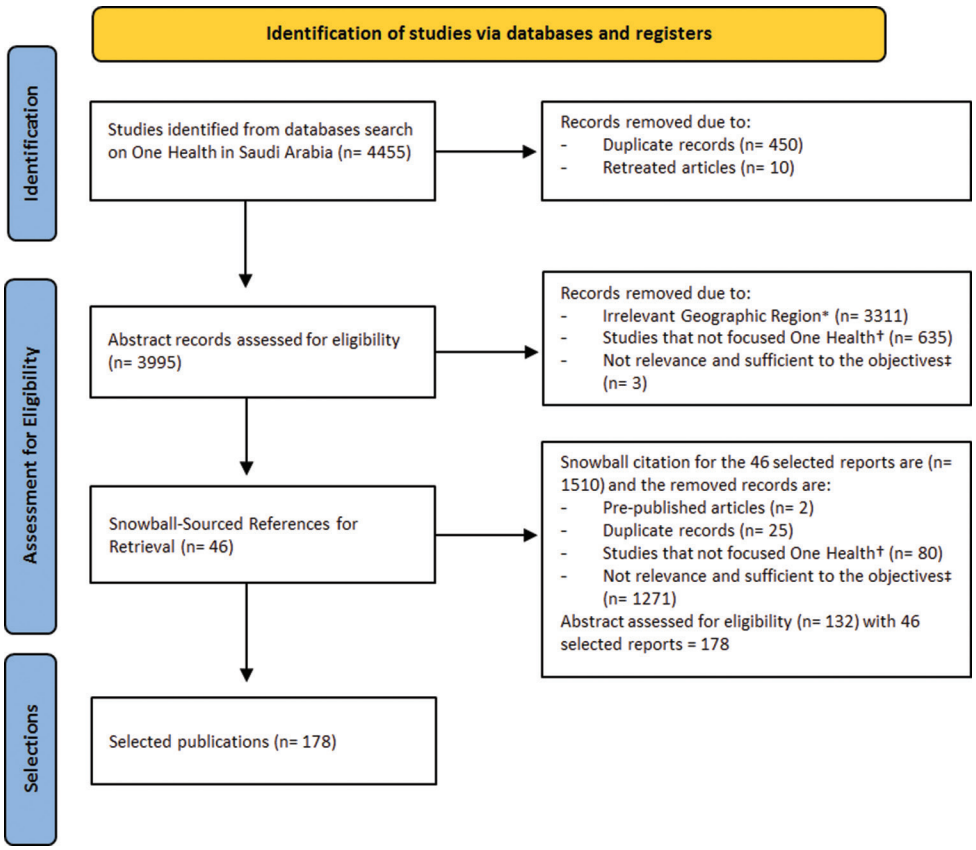

Figure 1: Preferred reporting items for systematic reviews and meta-analyses flow diagram of One Health in Saudi Arabia. *Studies conducted outside Saudi Arabia or not specifically addressing One Health perception, experiences, and implementation in the country.
†Studies that solely focused on individual diseases or health issues without considering the broader One Health perspective. Studies that primarily involve stakeholders from sectors not directly related to human, animal, or environmental health.
‡Studies with insufficient data or lack of relevance to the study's research objectives.

per publication (ACPP) and average citations per year (ACPY) to measure both publication output and citation influence. The dataset was analyzed using VOSviewer by Centre for Science and Technology Studies at Leiden University, Netherlands (https://www.vosviewer.com/) and Biblioshiny as part of the Bibliometrix package by Massimo Aria and Vincenzo Cuccurullo (https://www.bibliometrix.org/home/), and MS Excel, which offered precise outcomes to examine co-authorship, co-citation, and keyword co-occurrence networks, providing insights into collaboration patterns and thematic clusters [15, 16]. The h-index applied to measures publication productivity and citation rate in Saudi Arabia's OH research landscape. Institutional and geographical factors were classified by publications comparison according to organization and Saudi province. The study analyzed time-related trends of OH research publications and citations to determine peak periods and influential works in OH research. Studies focused on One Health concepts in Saudi Arabia, which were incorporated through systematic filtering and followed the PRISMA guidelines. The study used graphical displays, including trend plots, thematic evolution maps, and cluster networks to illustrate the findings. These statistical and bibliometric methods provided gaps, strengths, and opportunities to capture inter-sectoral collaborations for addressing essential health issues in Saudi Arabia.

RESULTS

Table 1 presents the categorized distribution of the journals, publishers, and countries that participated in studies of OH perception in Saudi Arabia based on their publication and journal metrics. The "Transactions of the Royal Society of Tropical Medicine and Hygiene," published by Oxford University Press in the United Kingdom, has six publications with 410 citations and an ACPP of 68.33 and quartile rank Q 1. The "Saudi Journal of Biological Sciences," an Elsevier publication from Saudi Arabia, has five publications with 694 citations, resulting in an impressive ACPP of 138.80 and ranking in Q1. The "Journal of Infection and Public Health," another Elsevier publication from Saudi Arabia, has five publications with 190 citations (ACPP 38.00) and a Q1 ranking. The "Saudi Medical Journal" published by the Saudi Arabian Armed Forces Hospital has four publications that have been cited 231 times, with an ACPP of 57.75 and a Q2 Quartile ranking. One journal titled "PLoS Neglected Tropical Diseases" from the United States has four publications with 355 citations (ACPP 88.75), which shows the good impact and belongs to the Q1 index.

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Table 1: Influential journals of One Health perception on Saudi Arabia publications.

Journal	Publisher	Country	NP	NC	ACPP	CS-2023	Q (CS)
Transactions of the Royal Society of Tropical Medicine and Hygiene	Oxford University Press	United Kingdom	6	410	68.33	4	1
Saudi Journal of Biological Sciences	Elsevier	Saudi Arabia	5	694	138.80	9.3	1
Journal of Infection and Public Health	Elsevier	Saudi Arabia	5	190	38.00	13.1	1
Saudi Medical Journal	Saudi Arabian Armed Forces Hospital	Saudi Arabia	4	231	57.75	2.3	2
PLoS Neglected Tropical Diseases	Public Library of Science (PLoS)	United States	4	355	88.75	7.4	1
Parasites and Vectors	Springer Nature	United Kingdom	4	139	34.75	6.3	1
International Journal of Environmental Research and Public Health	MDPI	Switzerland	4	137	34.25	7.3	1
Annals of Saudi Medicine	King Faisal Specialist Hospital and Research Centre	Saudi Arabia	4	143	35.75	2.8	2
Tropical Animal Health and Production	Springer Nature	Netherlands	4	153	38.25	3.4	2
Emerging Infectious Diseases	Centers for Disease Control and Prevention (CDC)	United States	4	324	81.00	17.3	1
Water	MDPI	Switzerland	4	93	23.25	5.8	1

*NP: Total number of publications from the source/journal.

†NC: Number of citations received by all publications from the source/journal.

‡ACPP: Average number of citations received per publication from the source/journal.

§CS-2023: A metric indicating the journal's current impact score or ranking for 2023. This can be based on various citation metrics or impact factor calculations.

|Q (CS): This represents the quartile ranking of the journal based on its current score. Quartiles divide journals into four rank groups: Q1 (top 25%), Q2 (between top 25% and 50%), Q3 (between top 50% and 75%), and Q4 (bottom 25%)

Table 2: Influential affiliation of One Health perception on Saudi Arabia publications.

Rank	Organization	Region	YoE	Age	Publications	Citations	ACPP	ACPY
1	King Saud University	Riyadh	1957	67	61	1768	28.98	26.39
2	Ministry of Health	Riyadh	1950	74	45	8732	194.04	118.00
3	King Abdul aziz University	Jeddah	1967	57	25	2214	88.56	38.84
4	King Khalid University	Abha	1998	26	13	454	34.92	17.46
5	King Faisal University	Hofuf	1975	49	11	240	21.82	4.90
6	Jazan University	Jubail	2006	18	5	115	23.00	6.39
6	Taibah University	Medina	2003	21	5	132	26.40	6.29
6	King Abdullah University of Science and Technology	Thuwal	2009	15	5	124	24.80	8.27
9	Taif University	Taif	2003	21	4	26	6.50	1.24
9	Qassim University	Al-Qassim Province	2004	20	4	127	31.75	6.35
9	Najran University	Najran	2006	18	4	173	43.25	9.61

*YoE: Year of establishment. Indicates the year the organization was established.

†Age: The number of years the organization has existed up to the year 2024.

‡ACPP: Average number of citations received per publication by the organization.

‡ACPY: Average number of citations received per year by publications from the organization

Table 2 summarizes the number of publications, citation counts, ACPP, and ACPY with institutions related to OH research in Saudi Arabia. King Saud University in Riyadh contributed 61 articles and 1768 citations, with an ACPP of 28.98 and an ACPY of 26.39. The Ministry of Health in Riyadh has the highest citation count (8732), with fewer article publications of 45, an exceptional ACPP of 194.04, and an ACPY of 118.00, suggesting significant participation in health research. King Abdulaziz University in Jeddah came in the third place with 25 publications and 2214 citations, which gives an ACPP of 88.56 and an ACPY of 38.84, implying the University's effort. Likewise, King Khalid University in Abha reported 13 publications with 454 citations and an ACPP of 34.92 with an ACPY of 17.46, reflecting its active participation in research. Another conclusion marked by a steady output with an ACPP of 69.25 and a feeble ACPY of 2.64 is King Faisal University in Hofuf, which has 11 publications and 240 cites.

Table 3 presents notable research works on OH in Saudi Arabia published in reputed journals. First, Zaki Ali Moh's research on the isolation of a novel coronavirus (CoVs) from a man with pneumonia in Riyadh has been cited 6879 times and has an ACPY of 573.25. This paper raises the bar for the interconnections between human

Table 3: Most influential articles on health perception in Saudi Arabia.

Citations	Title	Journal	Saudi regions	Year	Lead Authors	ACPY*
6879	Isolation of a novel coronavirus from a patient with pneumonia in Saudi Arabia	New England Journal of Medicine	Riyadh	2012	Zaki and Ali Moh	573.25
584	Field accumulation risks of heavy metals in soil and vegetable crops irrigated with sewage water in the western region of Saudi Arabia	Saudi Journal of Biological Sciences	Multiple Saudi Provinces (Western Region)	2015	Balkhair, Khaled S.	64.89
454	Cocirculation of three camel coronavirus species and recombination of MERS and CoVs in Saudi Arabia	Science (New York, N.Y.)	Saudi Arabia	2015	Sabir, Jamal S. M.	50.44
338	Climate change and water scarcity: The case of Saudi Arabia	Annals of Global Health	Saudi Arabia	2015	DeNicola, Erica	37.56
288	The spread, circulation, and evolution of the MERS-CoV	mBio	Multiple Saudi Provinces (Al Hasa, Asir, Bisha, Hafr-Al-Batin, Madinah, Riyadh, Taif, Wadi-Ad-Dawasir)	2014	Cotten, Matthew	28.80
224	Leishmaniasis in the Middle East: Incidence and epidemiology	PLoS neglected tropical diseases	International (Middle East including Saudi Arabia)	2014	Salam, Nasir	22.40
189	Brucellosis in children: Clinical observations of 115 cases	International Journal of Infectious Diseases: official publication of the International Society for Infectious Diseases	Riyadh	2002	Al Shaalan, Mohammed	8.59
163	Isolation of a flavivirus related to the tick-borne encephalitis complex from human cases in Saudi Arabia	The Royal Society of Tropical Medicine and Hygiene	Makkah	1997	Zaki, and Mohamed	6.04
130	Trends of climate change in Saudi Arabia: Implications for water resources	Climate	Multiple Saudi Provinces (Riyadh, Unaizah; Hail, Al-Jouf, Tabouk; Abha, Al-Baha, Jazan;: Dammam, Al-Hofuf; Jeddah, Taif, Makkah, Al-Madinah)	2018	Tarawneh, Qassem Y.	21.67
122	Tropism and replication of MERS-CoV in dromedary camels in the human respiratory tract: An *in vitro* and *ex vivo* study	The Lancet. Respiratory medicine	International (Saudi Arabia and Egypt)	2014	Chan, Renee W. Y.	12.20
120	Alkhurma hemorrhagic fever in *Ornithodoros savignyi* ticks	Emerging infectious diseases	Multiple Saudi Provinces (Jeddah and Taif)	2007	Charrel, RÃ©mi N.	7.06
120	Unraveling the drivers of MERS-CoV transmission	The Proceedings of the National Academy of Sciences of the United States of America	Saudi Arabia	2016	Cauchemez, Simon	15.00
118	*Phlebotomus sergenti*, a vector of *Leishmania tropica*, in Saudi Arabia	The Royal Society of Tropical Medicine and Hygiene	Saudi Arabia	1988	Al Zahrani, M.A.	3.28
112	Analysis of 506 consecutive positive serologic tests for brucellosis in Saudi Arabia	Clinical Microbiology	Riyadh	1987	Kiel, F. W.	3.03
110	Antimicrobial resistance in Saudi Arabia. Urgent call for immediate action	Saudi medical journal	Saudi Arabia	2016	Zowawi, Hosam M.	13.75
99	Seroepidemiological survey of brucellosis antibodies in Saudi Arabia	The Annals of Saudi Medicine	Saudi Arabia	1999	Al, Sekait, Mohammed A.	3.96

(*Contd*...)

Table 3: (*Continued*).

Citations	Title	Journal	Saudi regions	Year	Lead Authors	ACPY*
98	Childhood brucellosis in Saudi Arabia: a 5-year experience	Journal of Tropical Pediatrics	Asir	1992	Benjamin, B.	3.06
85	Ancient ancestry of KFDV and AHFV revealed by complete genome analyses of viruses isolated from tick and mammalian hosts.	PLoS neglected tropical diseases	Saudi Arabia	2011	Dodd, Kimberly A.	6.54
82	Molecular detection of the novel Anaplasmataceae closely related to *Anaplasma platys* and *Ehrlichia canis* in the dromedary camel (*Camelus dromedarius*)	Veterinary Microbiology	Qassim	2015	Bastos, Armanda D. S.	9.11
81	Serological and molecular diagnosis of human brucellosis in Najran, Saudi Arabia	Journal of infection and public health	Najran	2012	Asaad, and Ahmed Morad	6.75

*ACPY: Average citations per year, calculated by dividing the total number of citations by the number of years since publication.
MERS-CoV=Middle East respiratory syndrome coronavirus, KFDV=Kyasanur Forest disease virus, AHFV=Alkhurma hemorrhagic fever virus

health and emerging infectious diseases. Research on heavy metal accumulation in crops in the western region is related to studies on environmental health. This work contains 584 citations and ACPY 64.89, which was conducted by Khaled S. Balkhair. Research work by Jamal S. M. Sabir on the co-circulation of three camel CoVs species and the recombination of MERS-CoVs in Saudi Arabia received 454 citations and an ACPY of 50.44. Climate change and water scarcity in Saudi Arabia, as reported by Erica DeNicola, received 338 citations, and its ACPY was 37.56.

Table 4 details prominent researchers contributing to OH in Saudi Arabia. One of the most productive and influential authors reflected in the data is Ziad A. Memish, Senior Infectious Disease Consultant, Director of the Research and Innovation Center at King Saud Medical City, and a professor at Alfaisal University. He has 13 published papers, with 482 citations, and an h-index of 8, proving his impact on the topic. Among the contributors, Assistant Professor in the Department of Surgery, University of Florida, USA, Abdullah D. Alanazi is prominent and has contributed with 7 publications,131 citations, and 6 h-index. Jaffar A. Al-Tawfiq is affiliated with Johns Hopkins Aramco Healthcare and has seven publications and 188 citations, indicating high citation relevance and a score of 4. Another key figure in research production from the MoH is Abdullah M. Assiri, who has six articles, 175 citations, and an h-index of 5. Esam I. Azhar, a Professor of Medical Virology working at King Abdulaziz University, demonstrated research productivity as evidenced by six articles, 59 total citations, and an h-index score of 5. The public health directorate at the Ministry of Health, Rafat F. Alhakeem has published six papers, which have been cited 197 times overall and have an h-index of 4, demonstrating his commitment to public health science. The international representation included scholars with Alimuddin Zumla from University College London, who contributed to the research with six articles and 96 total citations with an h-index of 4. Further, there are additional contributors to Ali Albarrak's publications from the Mathematical Modeling of Infectious Diseases Unit at the Ministry of Health, with five papers, 171 citations, and an h-index = 4. Similarly, Mohamed S. Alyousif and Osama B. Mohammed from the Department of Zoology of the Kingdom Saud University also contributed with h-index = 4 and 5 papers, respectively, and 171 citations.

The evaluation of publications and citations in Table 5 identifies changes in the scientific productivity volume per province in Saudi Arabia. The entire research dataset comprises articles from various regions across the country. There are 71 research articles, which have accumulated 3,935 citations, securing an ACPP of 55.42 for the "Multiple Saudi Provinces" category. Regarding this, Riyadh can be established as the most productive area, with 35 publications and a total citation of 7,843, which developed the ACPP of 224.09, testifying to the scholars' interest in these materials.

Other provinces include the Eastern Provinces, Asir, Makkah, Najran, and Madinah; these provinces also differ in their research frequency and citation indexes. The Eastern Province has 16 articles with 236 citations, the ACPP of which is 14.75; for Asir, 13 articles, of which 270 were cited, the ACPP is 20.77. With 12 publications, Makkah obtained 368 citations (C.R. of 30.67). Among the Provinces, Najran and Madinah have the highest number of publications, with five citation counts of 215 and 213, respectively, resulting in an ACPP of 43.00 and 42.60. The outcome of this study also indicates that the overall research productivity in the form of published articles is comparatively less in the regions of Qassim (ACPP of 18.00), Hail (ACPP of 22.00), and Jazan (ACPP of 0.67), where the published articles count is 4, 3, and 3, respectively. Al-Baha, Al-Jouf, and the Northern Borders regions published two papers; however, the cited

Table 4: Most influential authors on "One Health perception" in Saudi Arabia.

Author	Affiliation	Country	NP*	TC†	ACPP‡	h-index§
Mimish Ziad A.	Senior ID consultant and Director of the Research and Innovation Center at King Saud Medical City, Professor at the College of Medicine at Alfaisal University.	Saudi Arabia	13	482	37.08	8
Alanazi Abdullah D.	Assistant Professor, Department of Surgery, College of Medicine, University of Florida.	Saudi Arabia	7	131	18.71	6
Al-Tawfiq Jaffar, A.	Director of Accreditation and Infection Control, Internal Medicine and Infectious Diseases, Johns Hopkins Aramco Healthcare.	Saudi Arabia	7	188	26.86	4
Assiri Abdullah M.	Assistant Deputy Minister for Preventive Health, Ministry of Health.	Saudi Arabia	6	175	29.17	5
Azhar Esam I.	Professor, King Abdulaziz University.	Saudi Arabia	6	59	9.83	5
Alhakeem Rafat F.	Public Health Directorate, Ministry of Health.	Saudi Arabia	6	197	32.83	4
Zumla Alimuddin	Professor of Infectious Diseases and International Health, University College London.	United Kingdom	6	96	16.00	4
Albarrak Ali	Mathematical Modeling of Infectious Diseases Unit, Ministry of Health.	Saudi Arabia	5	171	34.20	4
Alyousif Mohamed S.	Department of Zoology, College of Science, King Saud University.	Saudi Arabia	5	76	15.20	4
Mohammed Osama B.	Professor in Molecular Parasitology and Faculty Member, Department of Zoology, College of Science, King Saud University.	Saudi Arabia	4	609	152.25	4

*NP: Number of publications authored by the author.
†TC: Total citations received by all authors.
‡ACPP: Average number of citations per publication received per publication.
§h_index: A metric that measures both the productivity and citation impact of the publications by the author

Table 5: The most influential Saudi regions on One Health perception in Saudi Arabia publications.

Rank	Provinces	Publications	Citations	ACPP*
1	Multiple Saudi provinces†	71	3935	55.42
2	Riyadh	35	7843	224.09
3	Eastern province	16	236	14.75
4	Asir	13	270	20.77
5	Makkah	12	368	30.67
6	Najran	5	215	43.00
6	International and Saudi Regions‡	5	423	84.60
6	Madinah	5	213	42.60
9	Qassim	4	72	18.00
10	Hail	3	66	22.00
10	Jazan	3	2	0.67
12	Al-Baha	2	54	27.00
12	Al-Jouf	2	2	1.00
12	Northern Borders	2	31	15.50

*ACPP: Average citations per publication calculated by dividing the total number of citations by the total number of publications from that region.
†Multiple Saudi Provinces: This study either covered Saudi Arabia as a whole or captured multiple cities within the country.
‡International and Saudi Regions: local Saudi region initiatives with international efforts to address One Health challenges

frequency differs, resulting in ACPPs of 27.00, 1.00, and 15.50, respectively. ACPP has shown that even when the research output of a province is small, compared to the number of publications, the influence of research work emanating from Al-Baha province could be substantial.

Figure 2 presents the trend of publication and citation from 1983 to 2024 regarding the OH approach in Saudi Arabia. Overall, the figure reveals a relatively steady increase in the number of publications over the years, contributing to overall growth within this research field. Thus, a noticeable peak in citations was observed in 2012, mainly due to the publication of a highly cited paper on the isolation of the novel MERS-CoV. These multiples present variations over time in the publication and citation rates, which could be due to the accessibility of the new policies, variations in the research grants, and even changes in the paradigms in academia. The evident trend indicates the increase in the number of publications in recent years, particularly in 2021 and 2022, which is likely explained by the increased interest in zoonotic diseases and public health caused by the COVID-19 outbreak.

Figure 3 presents an analysis of the frequency of authorship collaboration in OH publications in the Saudi Arabian context. The data analysis shows that the majority of publications are authored with the help of several researchers, reflecting the research field's cooperative nature. The findings reveal that publications with five authors are characterized by the highest maximum number of publications (25) and citations, implying the great prominence of these papers. The same is true for papers with authors in the amounts of three, four, and six, as these works receive higher citation rates than monographs. This analysis focuses on co-authored papers that acquire a subsequent citation count rather than single-authored ones for novices, reflecting the increase in collaborative research. Regarding the pattern observed in the current investigation, it is important to suggest that

international and interdisciplinary collaborations yield a higher positive impact because of the heterogeneity of the teams and a broader targeting of audiences. According to the figure, with 130 publications and 11,869 citations, domestic collaborations are the most prolific and impactful pattern. Although international collaborations produce fewer publications (30) than domestic ones, they still attract a high number of citations (1317), indicating their significant relevance to the research community. Despite the 18 publications and 544 citations, regional collaborations contributed modestly to the overall research output.

Figure 4 illustrates the topics applied to OH research in Saudi Arabia over the years. The groups reflect the subfields within the general research domain related to the keywords "public health," "prevalence," and "epidemiology," which are related to the detection and occurrence of diseases. Another cluster of keywords mentioned "animals," "brucellosis," "infections," and "and sheep," which indicates the zoonotic diseases and the perspectives of veterinarians. The words "drug resistance," "antibacterial agents," and "bacteria" were classified with a view to showing resistance to antimicrobial agents. Color coding can easily assist in tracking the time of the studies, such as when older studies are shaded purple and the most recent ones are shaded yellow. For instance, the Body of Knowledge categorized articles from 2012 to 2014 that were closely associated with keywords such as "public health," "infections," "humans," and "brucellosis." Articles identified in the period 2015–2018 show focus on certain diseases and diagnostic methods; keywords are "MERS-CoV," "leishmaniasis," "prevalence," and "polymerase chain reaction." Research between 2019 and 2022 highlights a growing interest in environmental health and AMR based on keywords including "drug resistance," "health risks," "heavy metals," and "*Escherichia coli*."

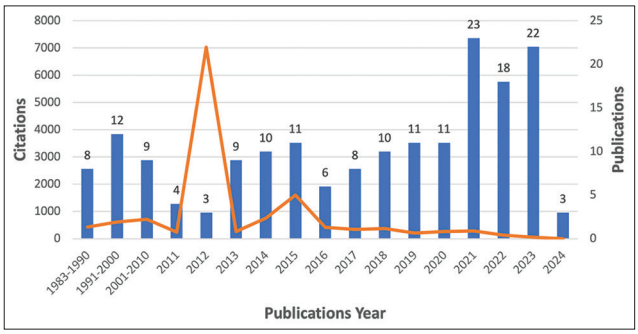

Figure 2: Publication and citation trends of One Health in Saudi Arabia.

Figure 5 presents a three-field plot that visually represents the evolution of research themes and keyword co-occurrences in OH perception in Saudi Arabia over three distinct periods. During the first period from 1983 to 2010, published articles focused mainly on the transmission of diseases, epidemiology, Humanism, and brucellosis. The foundation for studying infectious diseases was characterized by comparative brucellosis and the behaviors of the Papio hamadryas. The focus in the expertise domain between 2011 and 2017 was on more varied themes, ranging from antibacterial agents to the effects of meat on human diets and schistosomiasis. The mid-term also witnessed a growing interest in genomic science and its implications for public health. Hence, research adopts a more diversified approach by collaborating in multidisciplinary research fields. The last 7 years, from 2018 to 2024, show efforts toward drug resistance and improving public health. More specific topics, including disease outbreaks, cutaneous diseases, anaplasma, and MERS-CoV, have become topical, demonstrating that they address new threats. The period marked the development of large extended cooperation networks and more interdisciplinary projects.

Figure 6 depicts the OH articles focusing on Saudi Arabia. The clustering pattern map shows the complex

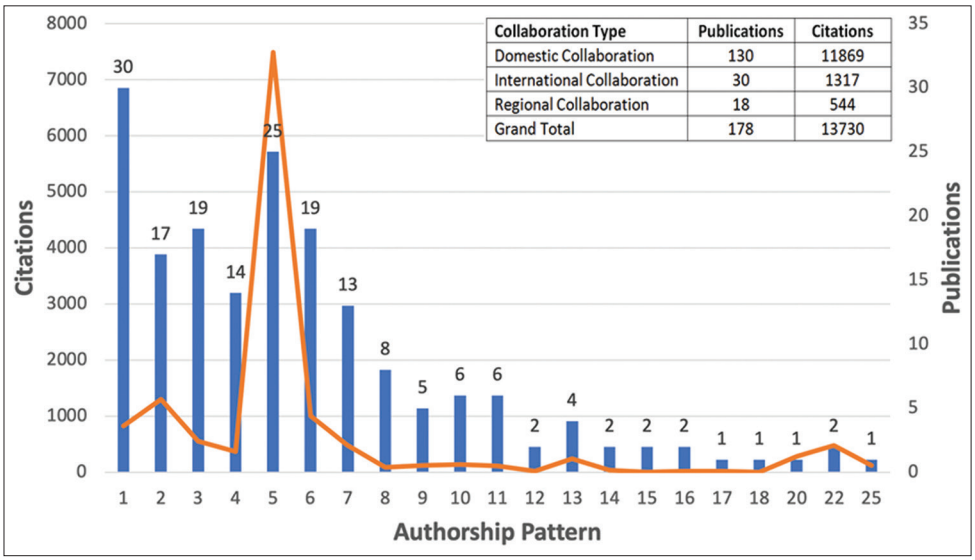

Figure 3: Publications and citations by authorship pattern for One Health in Saudi Arabia.

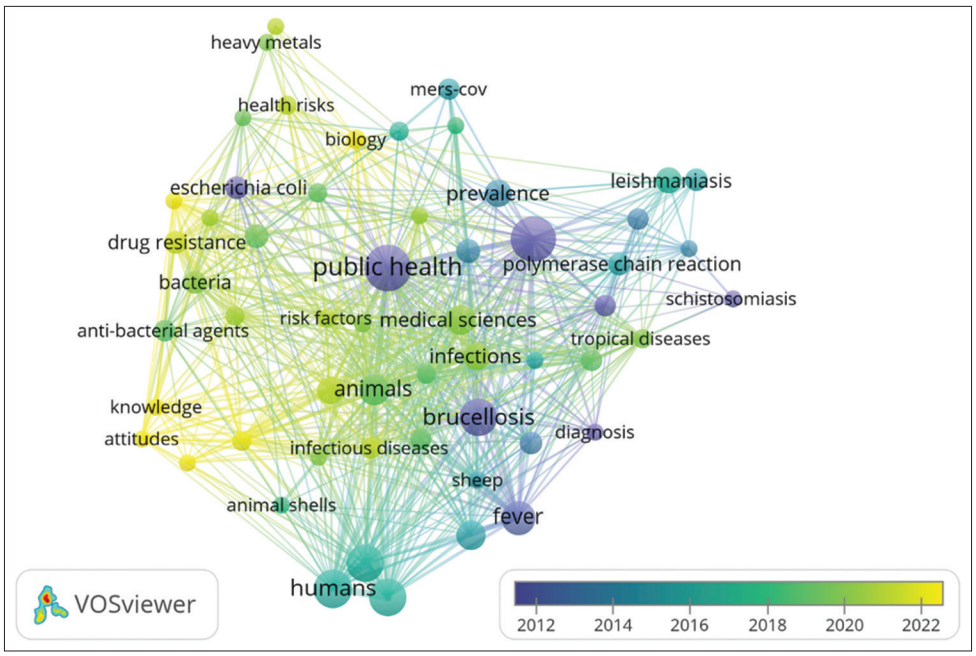

Figure 4: Keyword co-occurrence over time in One Health research study in Saudi Arabia.

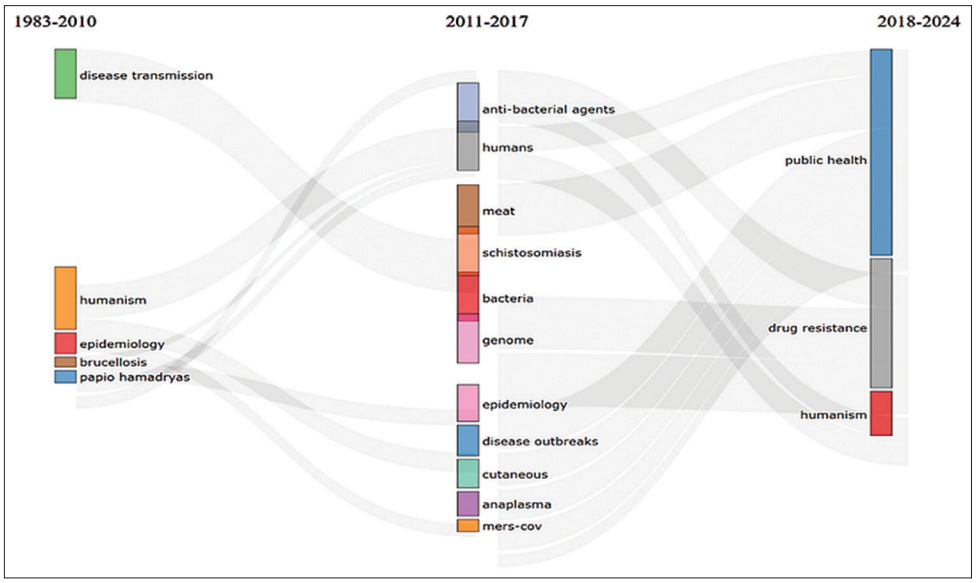

Figure 5: Keyword co-occurrences by thematic evolution of One Health in Saudi Arabia.

interconnection of the research themes, which are highlighted in different colors. The centralized purple cluster includes keywords such as "Public Health," "Infections," and "MERS-CoV," reflecting the OH core agenda of assessing and managing infectious diseases that affect the population in Saudi Arabia. The subjects were asked to describe the presence and understanding of viral pathogens such as "MERS-CoV" and their impact on the health-care system. In terms of the Red Cluster, a range of significant keywords was identified for OH research: "Microbiology," "Genomes," "Biology," "Antimicrobial Agents," "Drug Resistance," "Bacteria," "Antibiotics," "Health Risks," and "Heavy Metals." The terms indicate that AMR has a significant share of problems affecting human and veterinary medicine. "Heavy Metals" and "Health Risks" also amplify the OH, environment, which underscores the effect of pollutants on health. The keywords used in the Green Cluster include "Medical Sciences," "Leishmaniasis," "Cutaneous Leishmaniasis," "Schistosomiasis," "Tropical Diseases," "Polymerase Chain Reaction," "Diagnose," and "Brucellosis" which can be stated as diverse focuses on various kinds of diagnostics, including parasitic and tropical diseases prevalent in addition to "Polymerase Chain Reaction" underlines the applicability of molecular biology methods in the diagnosis and investigation of these ailments. The Turquoise Cluster theme is related to veterinary and zoological approaches and zoonotic diseases related to livestock health, such as "Animals," "Animal Shells," "Sheep," and "Fever." The Yellow Cluster consists of the boomerang of humanities and social sciences into OH in "Knowledge," "Questionnaires," "Humanism," and "Humanities." The point investigations

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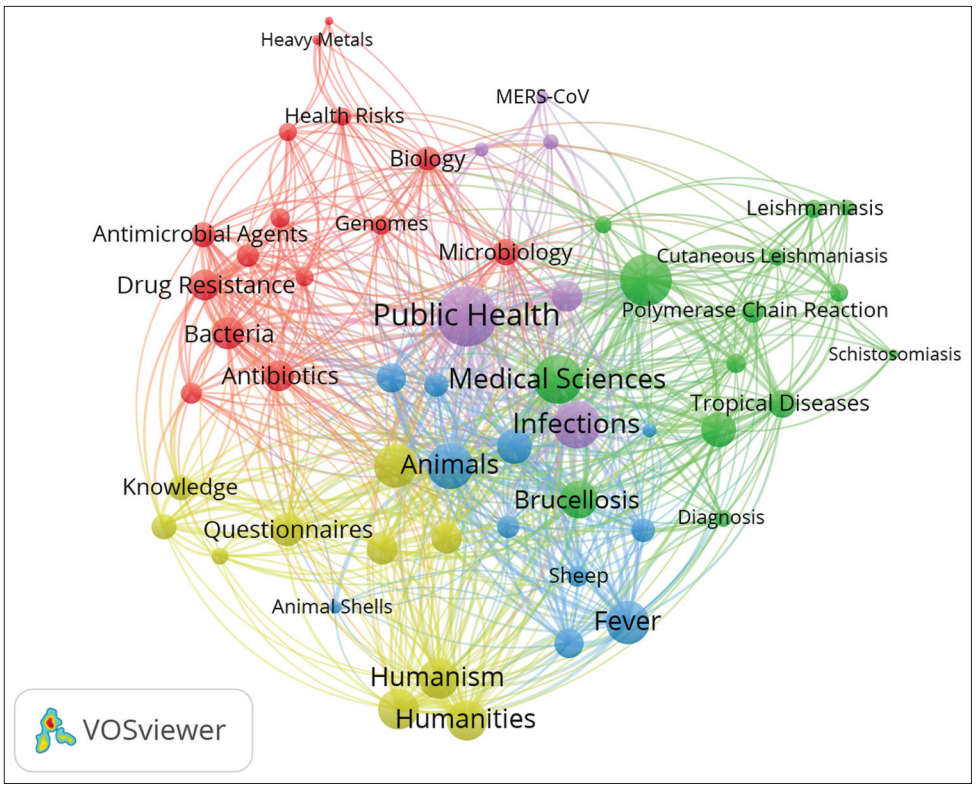

Figure 6: Keyword co-occurrences of thematic clustering and interconnections topics within the One Health domain in Saudi Arabia.

were carried out to establish the perceptions, behaviors, practices, and knowledge produced by the public about health practices.

DISCUSSION

This bibliometric analysis identifies core themes, key research contributors, and articles in the OH domain of Saudi Arabia. The Kingdom of Saudi Arabia provides a proper context for OH research because of its specific environmental and epidemiological challenges [17]. The population density of large livestock raised in various ecosystems in Saudi Arabia is an area of great research concerning the relationship between human, animal, and environmental health [18]. The country has a population of 1. 8 million camels, which are used in various capacities, including racing, meat, and camel milk production [19]. The presence of camel-borne emerging zoonotic viruses, such as MERS-CoV, demonstrates the risks associated with interactions between humans and animals [20].

The national collaboration resulted in higher research output, highlighting a major potential for Saudi Arabia to improve its engagement in OH implementation by promoting national partnerships to develop research capabilities to improve the contribution to the OH strategy [8]. The study findings by Prince Naif Center for Health Research [21] and King Saud University [22, 23] showed that the major institutions that supported OH research were King Saud University, the Ministry of Health, and King Abdulaziz University. King Saud University outperforms all other institutions with 61 publications and 1768 cites, which account for the university's research power and ability to advance scientific study in this area. The Ministry's emphasis on developing policy- and practice-based research guarantees adequate management of essential health problems. Their citation records indicate worldwide recognition and have significantly contributed to the development of public health strategies [24, 25]. Another important contributor is King Abdulaziz University. The great infrastructure and commitment of these universities contribute to the fostering of interdisciplinary research [26, 27]. These institutions produce a large amount of research output and publish highly cited papers that underscore the international perspective of their work. The research outputs generated by these institutions are diverse and cut across areas such as infectious diseases, environmental issues, and zoonotic diseases, providing a holistic perspective on the identified health challenges [24, 28]. Such institutions support interdisciplinary research and cooperation, which improves the concept of OH and significantly contributes to health security at the national and international levels [29].

In addition to universities, Saudi Arabia's historical policies have managed zoonotic diseases through national-level plans for prevention and control. A comprehensive multi-sectoral engagement includes exchanging information and collaborating with all stakeholders between the Ministry of Health, the Ministry of Municipalities and Rural Affairs, the Ministry

of Interior, the Saudi Wildlife Commission, the Saudi Food and Drug Authority, the Saudi Center for Diseases Control, and Saudi Customs. However, a considerable need remains to enhance the OH system to guide progressive development approaches as part of more extensive efforts by Saudi Arabia [30]. In 2020, Weqaa Center was established as the National Center for the Prevention and Control of Plant Pests and Animal Diseases linked to the Ministry of Environment, Water, and Agriculture by the board of directors' representatives from various ministries, government authorities, and private sector experts, reflecting a collaborative, multisectoral approach to health governance [31, 32]. Weqaa manages disease early detection and spread control of plant and animal diseases through enhanced disease reporting systems and adequate veterinary awareness and education [31]. On its part, Weqaya (National Center for Disease Prevention and Control) has aligned human health promotion and disease prevention and control programs with veterinary and ecological health, thereby affecting human health [33]. Such partnerships, capacity, and disease elimination are indications of healthcare delivery that cuts across humans, animals, and the environment in Saudi Arabia. These efforts demonstrate an understanding of the Kingdom of Saudi Arabia's organic growth and development with the human community, animals, and environment harmonious for steady growth plans of coordination and exchange services [31–35].

Regarding individual contributions, Ziad A. Memish contributed the most to the literature (NP = 13), receiving 482 citations (TC) for an ACPP of 37.08 and an h-index of 8. This research productivity reflected his influence on academic, public health, and biomedical research [9]. The other authors are Abdullah D. Alanazi and Jaffar A. Al-Tawfiq, who published fewer articles but maintained a high citation rate. Among the top 10 self-cited authors, Osama B. Mohammed has the highest average citation count per publication, indicating the impact of his work in molecular parasitology on OH [8]. The other authors with high research activity affiliated with the Ministry of Health are Abdullah M. Assiri and Rafat F. Alhakeem, who focused on public health and infectious diseases, demonstrating the essential government involvement in weaving OH principles into public health policies [10, 24]. At an international level, Alimuddin Zumla from the United Kingdom offers an international perspective on the research, confirming the intersectoral cooperation component of the OH literature [9]. Most of the authors in the selected articles are from infectious diseases, virology, parasitology, and public health fields, which underscores the OH focus [6, 9]. This list shows that researchers from different fields actively contribute to the understanding and realization of OH to incorporate interdisciplinary coordinated relations between human, animal, and environmental health in the research community [4–6].

The analysis reveals that the Saudi Arabian provinces significantly differ in research output and citation rates. The contribution of Riyadh, with higher numbers of publications and citation rates, clearly highlights the city as a research hub that facilitates funding resources and better collaboration opportunities [24, 28]. The Eastern Province or Makkah may not receive the same attention from other scholars as those in other regions. These marked differences in ACPP may indicate that some provinces may be constrained by challenges in increasing research profile and influence, mainly due to a lack of research materials, funding, or network connections regarding OH studies by Uddin and Alharbi [9] and Alotaibi *et al.* [24]. The decrease in the productivity of some scholarly output in Jazan and Al-Jouf may indicate low activity in the overall academic environment, where the citations might point toward a scholarly activity in the development process or existing concerns regarding the effective sharing of research findings by Alotaibi *et al.* [24] and Alshahrani *et al.* [28].

It is crucial to recognize that articles published in high-quality journals often have a high citation count, which acknowledges the contributions of these journals to the scientific community [36, 37]. These journals play an important role in disseminating and enhancing the knowledge of OH applications through interdisciplinary studies on human health, animals, and the environment. The increased awareness of journals makes them more accessible to the international community and contributes to the sharing of information and collaboration [36, 37]. This highlights the ability of journals to inform local and international health policies and practices to promote OH security.

National, regional, and international cooperation supports information exchange, skills, and equipment to tackle health issues [38]. This enhances the research capability of Saudi institutions by implementing global approaches and methodologies, and the engagement of premier international universities and organizations enriches the programmer with different perspectives and research to help generate better research outcomes [38]. The dynamic collaboration in OH research between national, regional, and international levels has provided more opportunities regarding technologies, analytical instruments, and other resources to enable researchers to conduct more complex and comprehensive studies by Hooper *et al.* [39], Gök and Karaulova [40], Aksnes and Sivertsen [41] and Dusdal and Powell [42]. Collaborations are influenced by the quality of partnership, knowledge exchange, and commitment. Inequality in the distribution of resources and differences in objectives may hamper outcomes. Collaboration can be improved through the adoption of visible frameworks, equitable relationships, and alignment with Saudi Arabia's health priorities and OH goals and needs [39–42].

The keyword network visualization revealed strong interconnections between public health, zoonotic diseases, and AMR in OH research in Saudi Arabia. The findings also reveal that researchers and collaborating sections have devoted more attention and joint efforts to brucellosis, MERS-CoV, and drug resistance. Saudi Arabian studies on health trends have successfully countered ailments, emerging infectious diseases, zoonotic diseases, and environmental and ecological health hazards through several papers and international partnerships [38, 39]. Disease surveillance has been improved through collaboration across different fields of medicine and innovation by leading organizations that focus on emerging infection prevention strategies and global public health policies [32]. Strengthening infrastructure and capacity while promoting regional international collaboration is necessary to increase community awareness about incorporating sustainable practices that guarantee long-term wellness across species [42].

The study has some limitations regarding the h-index, citation counts differed from one field to another, and the results may not reflect the quality. This is especially true in OH research, where citation practices can result in the oversampling of certain content. Several directions of OH research in Saudi Arabia remain under-represented. There is a need to improve collaboration and cooperation between human and animal health sectors. System-level studies on the description and functionality of OH systems are also lacking. Limited linking of research outputs with practical implementations in disease surveillance, AMR control, or public awareness campaigns in the OH domain. These outlines can inform the research agendas in Saudi Arabia and the national health plan to support the devolvement of sustainable OH practices in Saudi Arabia.

CONCLUSION

This bibliometric analysis provides a comprehensive overview of OH research in Saudi Arabia, highlighting significant progress, key contributors, and thematic trends. The findings underscore the pivotal roles of leading institutions such as King Saud University, the Ministry of Health, and King Abdulaziz University, whose outputs significantly shape the OH research landscape. The analysis identifies critical themes, including zoonotic diseases, antimicrobial resistance, and environmental health, which have been instrumental in addressing public health challenges. Notably, the Saudi Medical Journal and Saudi Journal of Biological Sciences emerged as vital dissemination platforms, reflecting the domestic and international relevance of this research.

The study's strength lies in its systematic approach, leveraging advanced bibliometric tools such as VOSviewer and Biblioshiny to uncover collaboration networks, research productivity, and thematic evolution. It emphasizes the role of domestic partnerships, which outperform regional and international collaborations in volume while acknowledging the superior citation impact of international partnerships. Furthermore, the study reveals the dominance of Riyadh as a research hub, while other regions remain underrepresented, signaling a need for more equitable resource allocation.

Despite these achievements, the study identifies several gaps, such as the limited integration of research outputs into practical applications, including disease surveillance, antimicrobial resistance management, and public awareness campaigns. The low representation of certain regions and the need for enhanced interdisciplinary collaborations are also areas requiring attention.

To advance OH research in Saudi Arabia, there is a need for robust policy frameworks that promote cross-sectoral collaborations between human, animal, and environmental health sectors. Expanding research efforts to underrepresented regions and fostering international partnerships can further elevate the country's contribution to the global OH movement. In addition, integrating research findings into actionable public health interventions, such as disease surveillance systems and educational programs, will enhance the practical impact of OH initiatives. Future studies should also explore qualitative aspects of OH research to gain deeper insights into stakeholder perspectives and implementation challenges.

By addressing these areas, Saudi Arabia can strengthen its role as a leader in OH research and contribute to the development of sustainable, globally relevant health strategies that benefit humans, animals, and the environment.

AUTHORS' CONTRIBUTIONS

HIAS: Conceived and designed the study and oversaw the overall execution. HIAS and SA: Data collection, processing, and analysis. HIAS: Interpreted the results and drafted the manuscript. SB and AA: Interpreted the results, critical revisions, and played key roles in final preparation and editing, ensuring the manuscript's accuracy and clarity. All authors have read and approved the final manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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