

## Review

# The Evolution of Zoonosis-Related Studies in Indonesia, 1977-2023: Bibliometric Analysis Concepts

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**Abstract.** Various zoonotic diseases have been reported as epidemics throughout the world, including in Indonesia. Various studies have been conducted related to gaps in knowledge, especially on disease distribution, etiology, pathogens, hosts, vector biology, dynamics, cycle of transmission, predisposing factors, and risk factors. To find out the dynamics of zoonotic disease study and research in Indonesia, a study was conducted to report a literature analysis that focused on bibliometric analysis of the Scopus database and VOSviewer software to create a visualization map that identified how the evolution of zoonotic diseases studies from 1977-2023 in Indonesia. In co-occurrence analysis, two units of analysis are used, namely "author keywords" and "index keywords" in VOSviewer. It showed that studies related to zoonoses in Indonesia tend to increase every year with a significant increase in 2020 and 2022. Document types are dominated by articles (72%) with subjects or research areas related to "medicine" (29%). From the "author keywords" analysis unit, the words "zoonosis" and "Indonesia" were the words that appeared the most. Meanwhile, from "index keywords" six clusters were found with the word "human" "animals", and "zoonosis" being the word that appears the most in the analysis of the studies conducted.

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## 1. Introduction

Indonesia is a country with the fourth largest human population in the world with diversity of flora and fauna. Humans, animals and the environment form an important interaction that plays a role in the transmission of a disease, especially zoonotic diseases [1]. According to the World Health Organization (WHO), zoonotic diseases are correlated with diseases that can be transmitted from vertebrate animals to humans and vice versa with more than 250 diseases reported. Zoonotic diseases contribute 60% of diseases in humans and 75% of emerging infectious diseases [2]. Zoonotic diseases can be classified based on the type of pathogens, transmissions, animal sources, host organ system, and ecosystem. Based on the etiological agent, zoonotic diseases can be caused by viruses, parasites, bacteria, fungi, yeast and can be transmitted by intermediate host either vertebrate or invertebrates. In addition, it can be transmitted directly by close contact with infected animals or their secretions (blood, urine, faeces, body fluids) or indirectly via environment or fomites [3].

The interaction between humans and animals is the highest risk factor in the transmission of zoonotic diseases [4]. Companion animals, livestock, poultry, and wild animals can be the reservoir of zoonotic disease [5-6]. Currently, wildlife animals are reported to be the reservoir of several zoonotic diseases that caused outbreak or pandemic situation throughout the world [7-8]. Bats, the only mammals that can fly, are reported to carry many viruses in their bodies. Due to their specific immune system, bats do not show clinical symptoms of disease but can spread the disease to other animals or humans who come into close contact with them or their environment [9]. Moreover, land deforestation has caused many wild animals, including bats, to lose food and habitation, so that they invade environments close to humans. Apart from that, some people believe that eating wild animal meat (bushmeat) can cure several diseases such as asthma and allergies [10-11].

When killing animals and processing wild animal meat, the potential for splashing the animal's body fluids is very high so that infection can easily occur [12]. Bushmeat is reported to be one of the vectors that transmits Ebola disease to humans. This disease is known to be carried by fruit bats and then transmitted to intermediate hosts, namely primates. Wild animal meat that was not cooked properly was the cause of the Ebola outbreak in West Africa in 2014 [13]. Apart from bushmeat, traditional animal markets found in various developing countries are also reported to be one of the meeting points for the transmission of zoonotic diseases. This traditional market sells many species of animals kept in cages close together, with varying ages and different origins of the animals. In addition, several traditional markets also sell various live animals, meat, and processed meat products in the same location [14]. Some markets have slaughterhouses in which the blood, feces and internal organs are disposed of in the area surrounding the market. The transmission of various zoonotic diseases in this market environment has also been widely reported by researchers throughout the world [15-16].

Currently, various zoonotic diseases have been reported as epidemics throughout the world, including the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) that infected humans in 2002/2003 and the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in 2012 [17-18]. Then in late 2019, a new respiratory disease called Coronavirus Disease 19 (COVID-19) emerged in China. This disease is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) which is currently still being debated due to its zoonotic nature [19]. Besides coronavirus, various other infectious agents have also been reported as etiology of zoonotic diseases including avian influenza virus, salmonella, West Nile virus, rabies, brucella, etc., [20].

Burden cause by zoonotic diseases arise due to high morbidity and mortality rates, followed by significant economic losses from various sectors [21]. After various zoonotic diseases were reported and caused pandemic outbreaks throughout the world with high mortality rates, zoonotic diseases are still predicted to cause epidemics or pandemic threats in the future [22]. Indonesia is the country with the highest human mortality rate for avian influenza virus subtype H5N1 to date. Various zoonotic diseases are also found in Indonesia, including rabies, avian influenza, leptospirosis, anthrax, and various parasitic zoonotic diseases [23-25]. To date, zoonotic diseases are still being public health

problem globally, including in Indonesia. Various studies have been conducted related to gaps in knowledge, especially on disease distribution, etiology, pathogens, hosts, vector biology, dynamics, cycle of transmission, predisposing factors, and risk factors [8]. To find out the dynamics of zoonotic disease study and research in Indonesia, a study was conducted to report a literature analysis that focused on bibliometric study of the Scopus database and VOSviewer software to create a visualization map that identified how the evolution of zoonotic diseases studies from 1977-2023 in Indonesia.

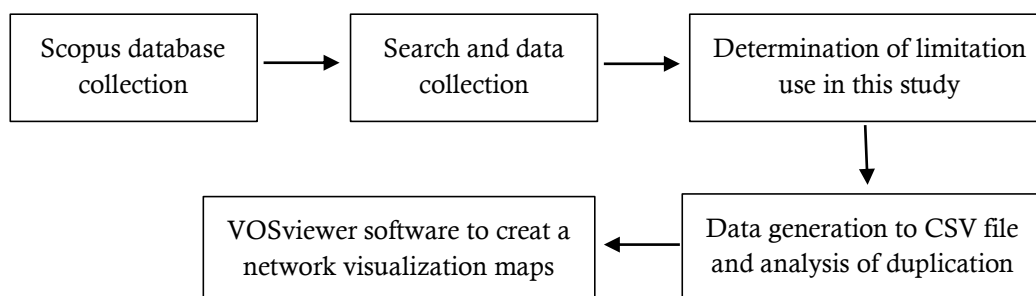
## 2. Experimental Section

### 2.1. Materials and Methods

In this research, a bibliometric study was conducted with the focus to find out the evolution related to study of zoonotic diseases in Indonesia during 1977-2023. The data was obtained from the Scopus database (<https://www.scopus.com/>) which has comprehensive data from all disciplines including science, technology, medical, veterinary and socio-economic, including PubMed, The National Center for Biotechnology Information (NCBI) [26]. The Scopus database also indexes many components of publications such as title, abstract and author name [27].

After selecting the database, the data collected was used in the research. The data was searched in the "search documents" column with the keyword "zoonosis" which included "article title, abstract and keywords". The search found 40,217 data/documents which were then limited to "country/territory" by selecting studies in "Indonesia" as the focus of the current study. The search results yielded 188 documents. Furthermore, limitations are made on "languages" by selecting documents that have languages other than English, hence the total analysis documents are 186 document data.

The data obtained was then exported into a CSV file extension and tabulated in Microsoft excel to eliminate the possibility of duplication. The data in the CSV file is then visualized by mapping on the VOSviewer software to create a network visualization map (<https://app.vosviewer.com/>) [28]. VOSviewer is a program developed for creating and viewing bibliometric maps. VOSviewer can be used to create "authors" or "journal" maps based on co-citation data or to create keyword maps based on co-occurrence data. The program offers a viewer tool that allows bibliometric maps to be examined in detail. VOSviewer can display maps in several different ways, each emphasizing a different aspect of the map. VOSviewer has functions for zooming, scrolling and searching, which facilitate detailed inspection of the map [28]. An overview of the workflow carried out in this study is shown in Figure 1. In the network visualization map, node size is proportional to the number of occurrences while the distance between terms measures the strength of the relationship between terms with closer distances implying a stronger relationship.



**Figure 1.** Workflow of bibliometric analysis carried out in this study.

### 3. Results and Discussion

Zoonoses are diseases that are naturally transmitted from animals to humans and vice versa. This disease accounts for >60% of emerging infectious diseases in humans. Zoonoses can be caused by various agents such as viruses, bacteria, yeast, fungi, and parasites [29]. Zoonotic infectious agents are also often found to be the etiological agent of pandemic events throughout the world which result in high rates of mortality and morbidity, including pandemics of Influenza, SARS, MERS, Nipah, Rabies, etc.

In recent years, the incidence of pandemics has been reported to have increased around the world. These conditions are followed by an increase in global travel, urbanization, changes in land use, and excessive exploitation of nature. Apart from that, social and cultural conditions also influence the occurrence of pandemic events such as the bushmeat tradition. Consuming and handling animals infected with zoonotic diseases can potentially transmit disease to humans, especially if the animals are consumed in raw conditions and lack hygiene. In addition, the potential for transmission of zoonotic diseases is also found in livestock and pets apart from the wild animals previously described. Exposure to these zoonotic agents will increase along with the increase in the frequency of interactions between humans and animals [10], [30].

Zoonotic agents vary in their ability to survive and transmit. There are at least five stages in how zoonotic agents can cross the host barrier [31]. However, with their ability to pass the stage 3, zoonotic agents are considered capable of adapting to humans and have the potential to cause wide geographic transmission between humans without being limited to transmission from animals. This inter-species transmission is then referred to as "host jump", "cross-species transmission", "zoonotic transfer", "pathogen spillover", or "zoonotic spillover". However, it should be remembered that this condition is a complex condition involving the host, microorganisms, and the environment condition. The ability of zoonotic agents to transmit is also very varied, some zoonotic agents are capable of directly transmitting to humans, but some of them require hosts, either vertebrates or vertebrates, and others require environmental media through contamination that occurs in the environment [3].

Pigs are one of the intermediate hosts for the transmission of zoonotic viruses, including the influenza virus which became pandemic in 2009 caused by the H1N1pdm09 virus. Pigs have both avian-type and human-type receptors for influenza, therefore referred to as mixing vessels [32]. Its nature as a mixing vessel allows pigs to be infected with avian and human influenza viruses at the same time, potentially causing co-infection. Co-infection is a condition when different virus strains infect the same cell.

Influenza viruses that have eight gene segments have the potential to undergo reassortment under these conditions. Reassortment or exchange of gene segments in influenza viruses can produce novel viruses that are different from their ancestors, in which these viruses may have higher pathogenicity and cross-species transmission capabilities [33]. This condition occurs in the H1N1pdm09 virus which is a reassortant virus with the PB2 and PA genes originating from avian viruses, the PB1 gene originating from a human virus and other gene segments originating from two pig virus lineages [34].

Apart from pigs, bats are also reported as hosts of many zoonotic viruses [9]. Due to the destruction of agricultural land and hunting for this animal, which is considered a traditional medicine for asthma, many bats have left their habitat and are approaching human residential areas. Several bat species were also found to have habitats close to the human environment, thus becoming a factor that could facilitate the spillover of zoonotic agents from bats to humans. However, their ability to resist diseases caused by pathogens in the body is currently still being researched, although the current hypothesis stated that their ability is resulted from special immune system due to its body temperature and metabolism [35].

Currently, various zoonotic diseases that cause pandemics have been reported in various parts of the world, including coronaviruses, Marburg viruses, Ebola viruses, variola viruses (i.e., smallpox), human immunodeficiency viruses (HIVs), Zika viruses, measles viruses and several subtypes of

influenza viruses. Viruses are thought to be able to evolve to maintain their ability to infect and transmit. For example, the coronavirus that causes the Covid-19 pandemic evolved by undergoes mutation in the spike protein (D614 to G614) resulting in a higher viral load. With these aminonacid exchange, coronavirus is considered to have higher infectivity. However, the D614 mutation also results in milder disease, shorter incubation period and greater transmission among community populations [36].

Excessive use of antimicrobials also results in the spread of various zoonotic diseases caused by viruses and bacteria. The influenza virus has certain mutations in the neuraminidase protein which makes the influenza virus resistant to oseltamivir class drugs. This mutation occurred in the seasonal influenza A H1N1 (A/Brisbane/59/2007-like) strain in 2007 and then in the 2009 H1N1 pdm09 [37]. This also occurs in zoonotic diseases caused by bacteria, in which the extensive use of antimicrobials in the veterinary field causes an increase in resistance to zoonotic bacterial pathogens, especially bacteria from the Salmonella, Campylobacter, Shigella, Yersinia, Listeria, and Enterococcus genera, including E. coli species. Besides, antibiotic resistance is also found in aquatic environments [38].

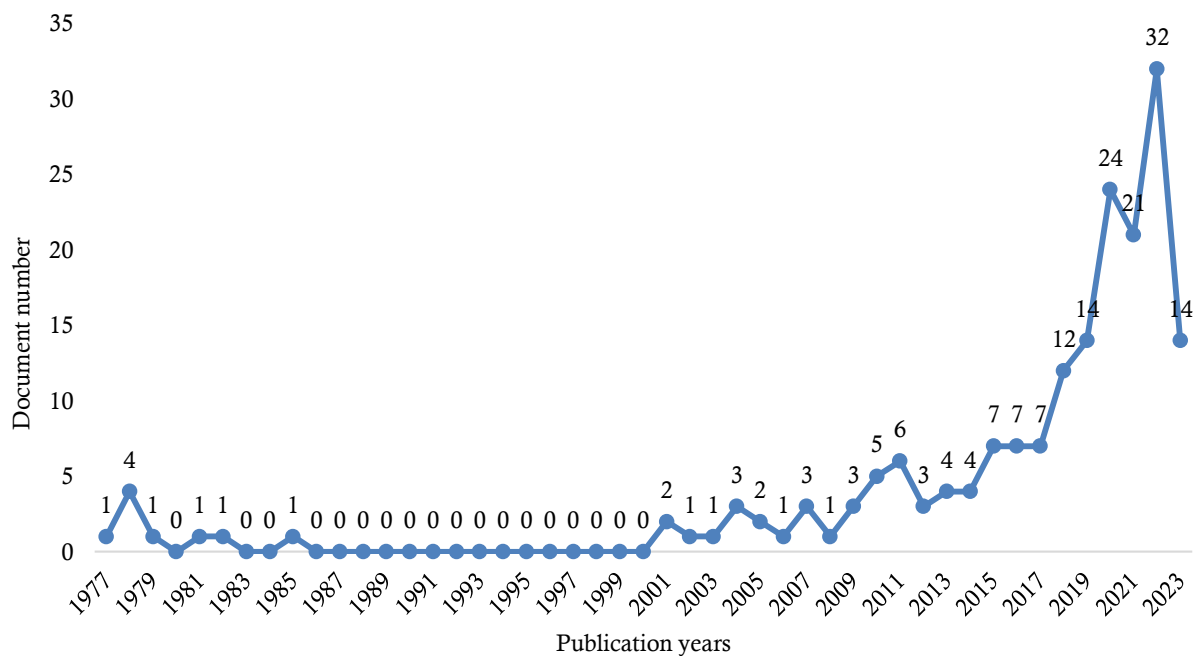
Wild animals that have previously been described as reservoirs for various zoonotic viruses have also been reported to be reservoirs for various zoonotic parasitic agents. Various human activities that cause close contact with animals are one aspect that facilitates the transmission of many parasites from animals to humans. Climate change is also an aspect that has a big impact on the transmission and distribution of parasites, especially parasites that require vectors in their life cycle [39]. Various zoonotic diseases are also found in Indonesia, including rabies, avian influenza, leptospirosis, anthrax, and various parasitic zoonotic diseases. In addition, Indonesia is the country with the highest human mortality rate for the H5N1 subtype avian influenza virus disease to date [25], [40].

With reports of various zoonotic diseases in the world, including in Indonesia, the focus on zoonotic disease research is also predicted to increase in the future. Various research agencies have focused on zoonotic diseases research with the hope of providing an early warning system to policy makers and the public regarding the possibility of zoonotic diseases emerging in the future [41], [42]. Surveillance for zoonotic diseases continues to be carried out, followed by characterization of various microbes that cause zoonotic diseases. The development of new vaccines and drugs is also ongoing against new, mutating or resistance microbes [43-45]. Thus, an analysis of the development of zoonotic disease research in Indonesia may need to be carried out to see the current state of research and possible gaps that can be found as a basis for future research.

In this study, results obtained in the search for "article title, abstract and keywords" with the keyword "zoonosis" obtained as many as 40,217 documents. Furthermore, limitations were made on "country" with the limitation "Indonesia" and "languages" with the document limitation "English" hence 186 documents were obtained for the final analysis. Of the 186 data, tabulation was carried out on Microsoft Excel and checked for data duplication. As a result, no duplication data was found hence 186 data will be continued in further analysis.

### 3.1 Documents by Year of Publication

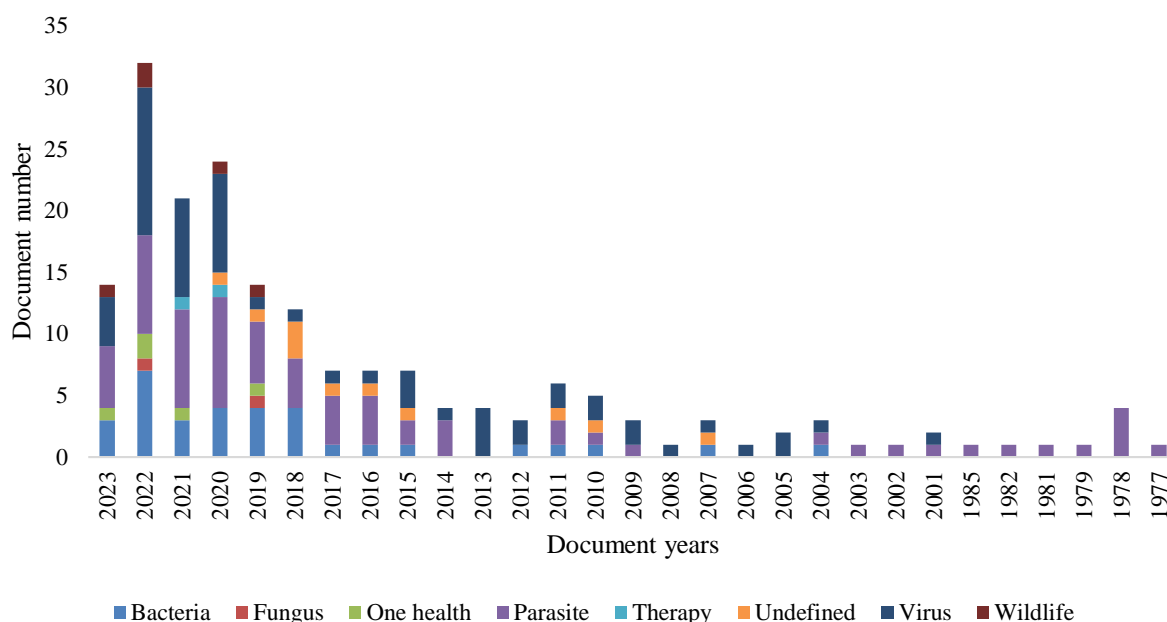
Based on the analysis of the "year of publication" of the documents each year, it appears that the number of publications from 1977-2017 has not increased significantly compared to 2018-2023 (Figure 2). The number of publications in 2018 showed a significant increase, especially in 2020 with 24 documents and 2022 with the highest number of documents, namely 32. Whereas in 2023 the number of documents tends to decrease. This may be due to the fact that the analysis in 2023 is only carried out in the middle of the year, so there is a possibility that there will be an increase in the number of documents at the end of the year.



**Figure 2.** Number of documents by publication year

Even though the number of publications per year increased during the SARS-CoV2 pandemic, the research objects were found to be quite diverse (Figure 3). In this study, eight terms will be used to define the theme of research objects including viruses, bacteria, parasites, fungi, one health, wildlife, therapy, and undefined. Undefined describes a research object that is quite broad, includes more than two research objects or does not fall into the seven groups of research objects previously mentioned. From the results of the analysis, it was shown that the research area of researchers in Indonesia related to zoonoses was quite extensive and seemed to have an increasing trend from year to year. This increase may be associated with an increase in the number, frequency and diversity of zoonotic disease outbreaks that occur as a result of climate change [46], globalization, economic growth, urbanization, deforestation, etc. thereby increasing contact either directly or indirectly between animals and humans [47].

On the other hand, based on the research area, the "virus" research area tends to increase and almost dominated in the 2020-2023 research year. This may be related to the increase in outbreaks caused by viruses, including the SARS-CoV-2 virus, which began to spread at the end of 2019 as well as monkeypox, which became epidemic in 2022 [48, 49]. Apart from viruses, the parasite research area also seems to dominate at the beginning of the 1977-2004 research year and the end of the 2014-2023 research year (Figure 3).



**Figure 3.** Overview of the dominating zoonotic research study areas based on documents each year

The increasing of zoonotic studies in Indonesia nowadays is related to the fact that at least 60% of human infectious diseases and 75% of emerging infectious diseases originate from zoonotic agents [2]. Various zoonotic diseases have occurred, namely rabies, ebola, Middle East respiratory syndrome (MERS), highly pathogenic avian influenza (HPAI), severe acute respiratory syndrome (SARS), monkeypox, to SARS-CoV-2, which is still being debated [50-51]. These diseases can cause high mortality and morbidity in humans and animals, disrupt global economic stability, and become a problem in the national public health system [50].

In addition, the World Health Organization (WHO) has focused on global strategies to prevent and control zoonotic pathogens through research. This needs to be supported by carrying out various coordination, cooperation and research study, especially in the relationship between humans-animals-environment which can then be implemented at the national, regional, and global levels through the implementation of appropriate policies.

### 3.2 Document Based on Publishers

From the results of document analysis, it is shown that as many as 111 journal publishers play a role in the dissemination of research results related to zoonotic studies in Indonesia. Out of 111 publishers, Veterinary World became the publisher with the most documents with 9 documents and was followed by the Southeast Asian Journal of Tropical Medicine and Public Health with 6 documents each and Biodiversity, Iop Conference Series Earth and Environmental Science, Parasites and Vectors, Plos One and Zoonoses and Public Health, each of which issued 5 documents (Table 1).

**Table 1.** List of publishers in this study

Publishers	Number Of Issued Documents	Publishers	Number Of Issued Documents
Veterinary World	9	Hayati Journal of Biosciences	1
Southeast Asian Journal of Tropical Medicine and Public Health	6	Heart International	1
Biodiversitas	5	Human Ecology	1
Iop Conference Series Earth and Environmental Science	5	Human Vaccines and Immunotherapeutics	1
Parasites And Vectors	5	Ilmu Kelautan Indonesian Journal of Marine Sciences	1
Plos One	5	Indian Journal of Public Health Research and Development	1
Zoonoses And Public Health	5	Indian Veterinary Journal	1
Aip Conference Proceedings	4	Infection And Drug Resistance	1
American Journal of Primatology	4	Influenza And Other Respiratory Viruses	1
Journal Of Medical Virology	4	International Journal for Parasitology Parasites and Wildlife	1
Plos Neglected Tropical Diseases	4	International Journal of Medical Engineering and Informatics	1
Acta Tropica	3	International Journal of One Health	1
Advances In Parasitology	3	International Journal of Surgery	1
Emerging Infectious Diseases	3	Iraqi Journal of Veterinary Sciences	1
Journal Of Advanced Veterinary and Animal Research	3	Japanese Journal of Infectious Diseases	1
Malaria Journal	3	Jordan Journal of Biological Sciences	1
African Journal of Infectious Diseases	2	Journal Of Engineering Science and Technology	1
Indian Journal of Forensic Medicine and Toxicology	2	Journal Of Helminthology	1
Infectious Disease Reports	2	Journal Of Parasitology	1
Journal Of Veterinary Parasitology	2	Journal Of Pharmaceutical Sciences and Research	1
Journal Of Veterinary Science	2	Journal Of Physics Conference Series	1
One Health	2	Journal Of Pure and Applied Microbiology	1
Systematic Reviews in Pharmacy	2	Journal Of Veterinary Medical Science	1
Transactions Of the Royal Society of Tropical Medicine and Hygiene	2	Jurnal Ilmu Ternak Dan Veteriner	1
Transboundary And Emerging Diseases	2	Kesmas	1
Travel Medicine and Infectious Disease	2	Korean Journal of Parasitology	1
Tropical Medicine and International Health	2	Lancet	1
Vector Borne and Zoonotic Diseases	2	Mammal Review	1
Viruses	2	Mbio	1
ACS Applied Materials and Interfaces	1	Medical Journal of Indonesia	1



Aacl Bioflux	1	Microbiology And Immunology	1
Acta Parasitologica	1	Microbiology Research	1
Advances In Animal and Veterinary Sciences	1	Nigerian Journal of Clinical Practice	1
African Health Sciences	1	OIE Revue Scientifique Et Technique	1
Agricultural Systems	1	Open Access Macedonian Journal of Medical Sciences	1
Annals Of Tropical Medicine and Public Health	1	Open Veterinary Journal	1
Applied Biosafety	1	Parasitology	1
Asian Pacific Journal of Tropical Biomedicine	1	Parasitology International	1
BMC Veterinary Research	1	Peerj	1
Bali Medical Journal	1	Plos Pathogens	1
Biological Conservation	1	Radiology Case Reports	1
Communications Biology	1	Recent Patents on Anti Infective Drug Discovery	1
Comparative Immunology Microbiology and Infectious Diseases	1	Revista Electronica De Veterinaria	1
Critical Reviews in Microbiology	1	Sains Malaysiana	1
Disaster Medicine and Public Health Preparedness	1	Science Of the Total Environment	1
E3s Web of Conferences	1	Scientific Reports	1
Ecohealth	1	Tohoku Journal of Experimental Medicine	1
Environmental Research Letters	1	Trends In Ecology and Evolution	1
Epidemiology And Infection	1	Tropical And Geographical Medicine	1
Ethnobiology And Conservation	1	Tropical Medicine and Infectious Disease	1
F1000research	1	Veterinary Parasitology Regional Studies and Reports	1
Frontiers In Ecology and Evolution	1	Veterinary Practitioner	1
Frontiers In Veterinary Science	1	Virologica Sinica	1
Gaceta Medica De Caracas	1	Virology	1
Hasanuddin Law Review	1	Virology Journal	1
		World S Veterinary Journal	1

Although “Veterinary World” is the publisher with the most issued documents, “the Southeast Asian Journal of Tropical Medicine and Public Health” is the earliest journal publisher to report the subject area of zoonotic research reported from 1977 to 2016. On the other hand, in this study, Veterinary World, according to the results of the analysis of this study, began to publish the documents related to zoonoses in 2017-2023 with a number that fluctuated each year with a total of 1 document in 2017, 2020 and 2023, and 2 documents in 2019, 2021 and 2022 respectively. Interestingly, the publishers of “the journal Biodiversity” have a sharp increase in the number of documents published in 2023 related to the study of parasites. The top 10 prolific journals of zoonotic diseases in Indonesia are shown in Table 2. It can be shown that half of the publications have Q1 rank based on SJR in 2022. One of the journals from Indonesia, namely Biodiversitas, published by Sebelas Maret University, Surakarta, is one of the journals in the top 10 journals that are of interest to researchers in publishing their research related to zoonotic diseases.

**Table 2.** The top 10 prolific publication from 1977 to mid 2023

Rank	Source Title	Frequency	Publisher	SJR (2022)	Country	Citescore (2022)	H-Index (2022)	Document Type
1	Veterinary World	9	Veterinary World	0.43 Q2	India	3.2	41	Journal
2	Southeast Asian Journal of Tropical Medicine and Public Health	6	Southeast Asian Ministers of Education Organisation	0.13 Q4	Thailand	0.5	57	Journal
3	Biodiversitas	5	Biology department, Sebelas Maret University Surakarta	0.327 Q3	Indonesia	2.2	22	Journal
4	IOP Conference Series Earth and Environmental Science	5	IOP Publishing Ltd.	0.197 (NA)	United Kingdom	0.8	41	Conference Proceeding
5	Parasites And Vectors	5	Springer Nature	0.961 Q1	United Kingdom	6.6	102	Journal
6	Plos One	5	Public Library of Science	0.885 Q1	United States	6	404	Journal
7	Zoonoses And Public Health	5	Wiley-Blackwell	0.676 Q1	Germany	5.1	72	Journal
8	AIP Conference Proceedings	4	American Institute of Physics	0.164 (NA)	United States	0.7	80	Conference Proceeding
9	American Journal of Primatology	4	Wiley-Blackwell	0.868 Q1	United States	4.6	90	Journal
10	Journal of Medical Virology	4	Wiley-Blackwell	1.957 Q1	United States	23.4	145	Journal

\*SJR : SCImago Journal Rank

\*N/A : Not available

### 3.3 Document Based on Affiliate and Author

As many as 160 affiliates of researchers play a role in resulting documents related to zoonotic diseases in Indonesia. The top ten affiliations can be seen in table 3. Gadjah Mada University is the affiliate that produces the most documents in this research, followed by Airlangga University in 2nd place and Bogor Agricultural University (IPB) in 3rd place. Interestingly, in the results of this study, the top seven affiliate that produced the most documents related to zoonotic studies came from universities, in which 6 universities came from Indonesia and another university from Thailand, namely Mahidol University, while others are from Ministries or Agencies.

**Table 3.** The most productive affiliation contributors

Ranks	Affiliates	Number of documents
Ranks 1	Universitas Gadjah Mada	29
Ranks 2	Universitas Airlangga	27
Ranks 3	IPB University	22
Ranks 4	Universitas Indonesia	12
Ranks 5	Universitas Udayana	12
Ranks 6	Hasanuddin University	9
Ranks 7	Mahidol University	8
Ranks 8	Ministry of Health, Republic of Indonesia	8
Ranks 9	Badan Penelitian Dan Pengembangan Kesehatan, Kementerian Kesehatan Republik Indonesia	8
Ranks 10	Oxford University Clinical Research Unit	8

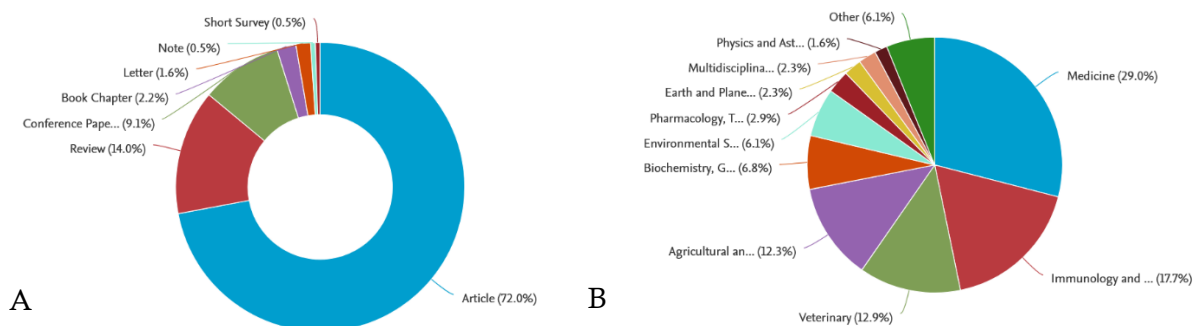
Meanwhile, from the side of the authors or researchers (author or co-author), as many as 160 authors were involved in the publication of documents related to zoonoses in Indonesia with the top 10 author or co-author is shown in Table 4. From the results obtained, it can be seen that more than half of the authors come from Indonesia and the majority are lecturers at universities in Indonesia.

**Table 4.** The most prolific authors

Rank	Author Name	Frequency	Affiliation	Citations	Documents	H-Index
1	Wandra, Toni	8	Universitas Sari Mutiara, Sari, Indonesia	1.398	48	22
2	Effendi, Mustofa Helmi	7	Universitas Airlangga, Surabaya, Indonesia	967	113	22
3	Ito, Akira	7	Asahikawa Medical University, Asahikawa, Japan	11.798	349	57
4	Okamoto, Munehiro	6	Kyoto University, Kyoto, Japan	3.517	144	31
5	Artama, Wayan Tunas	5	Universitas Gadjah Mada, Yogyakarta, Indonesia	375	53	11
6	Hadi, Upik Kesumawati	5	IPB University, Bogor, Indonesia	258	45	9
7	Satrija, Fadjar	5	IPB University, Bogor, Indonesia	467	38	10
8	Asih, Puji Budi Setia	4	Badan Riset dan Inovasi Nasional, Central Jakarta, Indonesia	1.394	81	21
9	Engel, Gregory A.	4	Samuel Simmonds Memorial Hospital, Barrow, United States	1.215	40	19
10	Jones-Engel, Lisa E.	4	President of People for the Ethical Treatment of Animals (PETA), Norfolk, United States	2.318	84	29

### 3.4 Documents Based on Document Types and Research Areas

From the results of the analysis based on the type of document, there are 10 types of document types used for analysis including: Article, Review, Conference Paper, Book Chapter, Letter, Note, and Short Survey. Articles were the highest number of documents, namely 134 out of 186 documents in analysis (72%), followed by Review and Conference Papers with 26 (14%) and 17 (9.1%) documents, respectively (Figure 6A). Meanwhile, in terms of research areas, there were 18 subjects or research areas in the analysis, with the top five ranking being Medicine with 90 documents (29%), Immunology and Microbiology with 55 documents (17.7%), Veterinary with 40 documents (12.9%), Agricultural and Biological Sciences with 38 documents (12.3%), and Biochemistry, Genetics and Molecular Biology with 21 documents (6.8%) (Figure 6B).



**Figure 6.** (A) An overview of the most common types of documents found in the analysis and (B) the most common research subject area in the analysis

Of the various articles written by researchers related to zoonotic diseases in Indonesia, the highest number of citations was obtained with 224 citations from articles in 2014. The second highest article was obtained with 212 citations related to the H5N1 avian influenza virus. The development of the evolution of the H5N1 subtype avian influenza virus in Indonesia is quite interesting. The virus, which was first reported in 2003/2004, is still endemic in poultry in Indonesia today [52-57]. Interestingly, this virus can infect humans and the highest mortality rate is reported in Indonesia. Currently, antigenic drift and antigenic shift continue to be reported in Indonesia. Thus, this virus is still the focus of research around the world because of its potential to cause pandemics in the future [58-59].

Meanwhile, the article with the third highest number of citations with 106 citations was obtained from researchers from the University of Indonesia with a publication year of 2022 related to One Health. One health is an integrated approach that aims to balance human, animal, and environmental health. This approach is needed to prevent and control various zoonotic diseases throughout the world with collaboration from various sectors [60]. With One Health, it is expected to increase the ability to prevent, detect and respond to various zoonotic diseases, especially prioritized zoonotic diseases [61].

In Indonesia, this approach has been carried out and applied. However, implementation in Indonesia is not yet optimal, especially in implementation in the wide community, so that various research related to the One Health implementation system is still being carried out to find the optimal situation and system that can be applied in Indonesia [62]. Thus, it is not surprising that articles related to One Health received the third highest attention in this study.

**Table 5.** The most cited documents by authors

Rank	First author	Title	Year	Journal	Cited by	Document type	Affiliation of first author
1	Aplin, Ken P.	Multiple geographic origins of commensalism and complex dispersal history of black rats	2011	PLoS ONE	224	Article	Western Australian Museum, Perth, Australia
2	Smith, Gavin J.	Evolution and adaptation of H5N1 influenza virus in avian and human hosts in Indonesia and Vietnam	2006	Virology	212	Article	Duke-NUS Medical School, Singapore City, Singapore
3	Adisasmito, Wiku B.	One Health: A new definition for a sustainable and healthy future	2022	PLoS Pathogens	106	Article	Universitas Indonesia, Depok, Indonesia
4	Jost, Christine C.	Participatory epidemiology in disease surveillance and research	2007	OIE Revue Scientifique et Technique	97	Review	United States Agency for International Development, Washington, D.C., United States
5	Putra, Anak Agung Gde	Response to a rabies epidemic, Bali, Indonesia, 2008-2011	2013	Emerging Infectious Diseases	94	Article	Denpasar Disease Investigation Center, Denpasar, Indonesia
6	Jones-Engel, Lisa E.	Diverse contexts of zoonotic transmission of simian foamy viruses in Asia	2008	Emerging Infectious Diseases	94	Article	President of People for the Ethical Treatment of Animals (PETA), Norfolk, United States
7	Townsend, Sunny E.	Surveillance guidelines for disease elimination: A case study of canine rabies	2013	Comparative Immunology, Microbiology and Infectious Diseases	74	Article	University of Glasgow, Glasgow, United Kingdom

8	Jones-Engel, Lisa E.	Detection of antibodies to selected human pathogens among wild and pet macaques ( <i>Macaca tonkeana</i> ) in Sulawesi, Indonesia	2001	American Journal of Primatology	72	Article	President of People for the Ethical Treatment of Animals (PETA), Norfolk, United States
9	van Vliet, Nathalie	Bushmeat and human health: Assessing the evidence in tropical and sub-tropical forests	2017	Ethnobiology and Conservation	70	Article	Center for International Forestry Research–World Agroforestry (CIFOR-ICRAF)
10	Moyes, Catherine L.	Defining the Geographical Range of the <i>Plasmodium knowlesi</i> Reservoir	2014	PLoS Neglected Tropical Diseases	69	Review	Nuffield Department of Medicine, Oxford, United Kingdom

### 3.5 Co-Occurrence Analysis

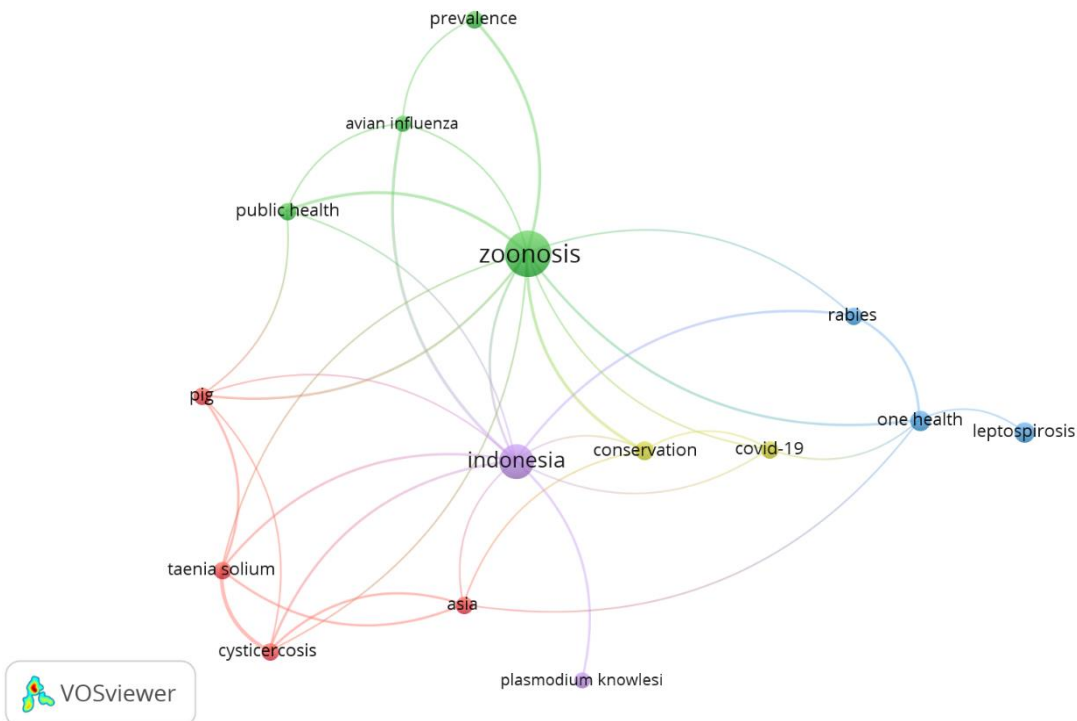
In co-occurrence analysis, two units of analysis are used, namely "author keywords" and "index keywords" in VOSviewer. In the VOSviewer analysis, select author keywords by setting the minimum number of occurrences of keywords to five and 17 results meet the threshold of 519 keywords. Of the 17 keywords, two duplicate words were found so that after removing the two keywords, there were 15 author keywords used in the further analysis. From the results of the analysis, it was found that the words "zoonosis" and "Indonesia" were the words used most by researchers in their publications related to zoonotic studies in Indonesia (Table 6).

In line with previous research results, One Health is still the highest research focus and is ranked third in the top 15 author keywords. Apart from that, various infectious agents are included in the top author keywords, such as viruses, bacteria, and parasites, which are still problems faced by people in Indonesia. This is in line with various studies that show various infectious agents and diseases that are still a problem in Indonesia, such as Leptospirosis, *Taenia solium*, Rabies, Cysticercosis, Covid-19, Avian influenza, and *Plasmodium knowlesi* [63-69]. Moreover, Covid-19 occurred in 2019 and became a pandemic throughout the world, including in Indonesia [70].

**Table 6.** The list of top 15 author keywords

Rank	Keywords	Occurrences	Total Link Strength
1	<i>Zoonosis</i>	38	20
2	<i>Indonesia</i>	21	22
3	<i>One Health</i>	8	10
4	<i>Leptospirosis</i>	8	1
5	<i>Conservation</i>	7	10
6	<i>Taenia solium</i>	6	12
7	<i>Asia</i>	6	10
8	<i>Pig</i>	6	9
9	<i>Rabies</i>	6	7
10	<i>Public health</i>	6	6
11	<i>Covid-19</i>	6	5
12	<i>Prevalence</i>	6	4
13	<i>Cysticercosis</i>	6	11
14	<i>Avian influenza</i>	5	6
15	<i>Plasmodium knowlesi</i>	5	2

In the analysis at VOSviewer, five clusters were identified including (a) green cluster containing four terms namely zoonoses, public health, avian influenza and prevalence; (b) red cluster consisting of four terms namely Asia, cysticercosis, *Taenia solium* and pig; (c) blue cluster containing 3 terms namely rabies, one health, and leptospirosis, (d) purple cluster consisting of two terms namely Indonesia and *Plasmodium knowlesi*, and (e) yellow cluster containing two items namely Covid-19 and conservation. This result is in line with the author keywords results previously explained. Which underlines that research related to this term has currently been carried out and continues to be carried out to this day in Indonesia.



**Figure 7.** VOSviewer visualization of author keywords

In VOSviewer's analysis of index keywords, by setting the lowest number of occurrences of keywords to 5, 174 terms out of 1940 keywords were obtained that met the threshold. Of the 174 keywords, duplicate or identical words were excluded hence 166 keywords were obtained which were then used for further analysis. From the results of the analysis, there were six clusters (Table 7), with the words "human" "animals" and "zoonosis" being the words that appeared the most in the analysis of the studies conducted.

**Table 7.** Index of keywords that appear the most for each cluster based on total link strength (TLS).

Cluster 1 (Red)				Cluster 2 (Violet)			
No	Keywords	TLS	Occ	No	Keywords	TLS	Occ
1	<i>swine</i>	301	13	1	<i>phylogeny</i>	456	24
2	<i>china</i>	280	13	2	<i>genetics</i>	449	22
3	<i>classification</i>	279	13	3	<i>priority journal</i>	331	19
4	<i>enzyme linked immunosorbent assay</i>	255	13	4	<i>virus transmission</i>	295	15
5	<i>pig</i>	236	12	5	<i>epidemic</i>	291	19
6	<i>thailand</i>	235	10	6	<i>virology</i>	275	14
7	<i>risk factor</i>	226	15	7	<i>avian influenza</i>	242	12
8	<i>viet nam</i>	214	8	8	<i>influenza a virus, h5n1 subtype</i>	229	10
9	<i>taenia</i>	210	10	9	<i>influenza in birds</i>	229	10
10	<i>taenia solium</i>	210	9	10	<i>disease outbreaks</i>	219	13
Cluster 3 (Yellow)				Cluster 4 (Green)			
No	Keywords	TLS	Occ	No	Keywords	TLS	Occ
1	<i>animals</i>	1234	82	1	<i>human</i>	130	90
2	<i>indonesia</i>	1076	72	2	<i>zoonosis</i>	123	94
3	<i>geographic distribution</i>	365	22	3	<i>disease transmission</i>	302	22
4	<i>isolation and purification</i>	320	15	4	<i>review</i>	234	18
5	<i>parasitology</i>	310	17	5	<i>vaccination</i>	155	11
6	<i>southeast asia</i>	256	13	6	<i>malaria</i>	149	10
7	<i>dog</i>	168	10	7	<i>public health</i>	145	13
8	<i>animals, domestic</i>	153	8	8	<i>disease surveillance</i>	144	9
9	<i>animal model</i>	147	8	9	<i>plasmodium knowlesi</i>	130	8
10	<i>cross-sectional study</i>	144	9	10	<i>leptospirosis</i>	109	11
Cluster 5 (Blue)				Cluster 6 (Light Blue)			
No	Keywords	TLS	Occ	No	Keywords	TLS	Occ
1	<i>article</i>	1225	87	1	<i>male</i>	538	31
2	<i>nonhuman</i>	1204	86	2	<i>female</i>	467	29
3	<i>controlled study</i>	513	30	3	<i>adult</i>	356	21
4	<i>prevalence</i>	353	27	4	<i>middle aged</i>	216	12
5	<i>animal experiment</i>	329	19	5	<i>adolescent</i>	177	9
6	<i>polymerase chain reaction</i>	320	24	6	<i>major clinical</i>	161	8
7	<i>nucleotide sequence</i>	291	15	7	<i>reverse transcription</i>	144	9

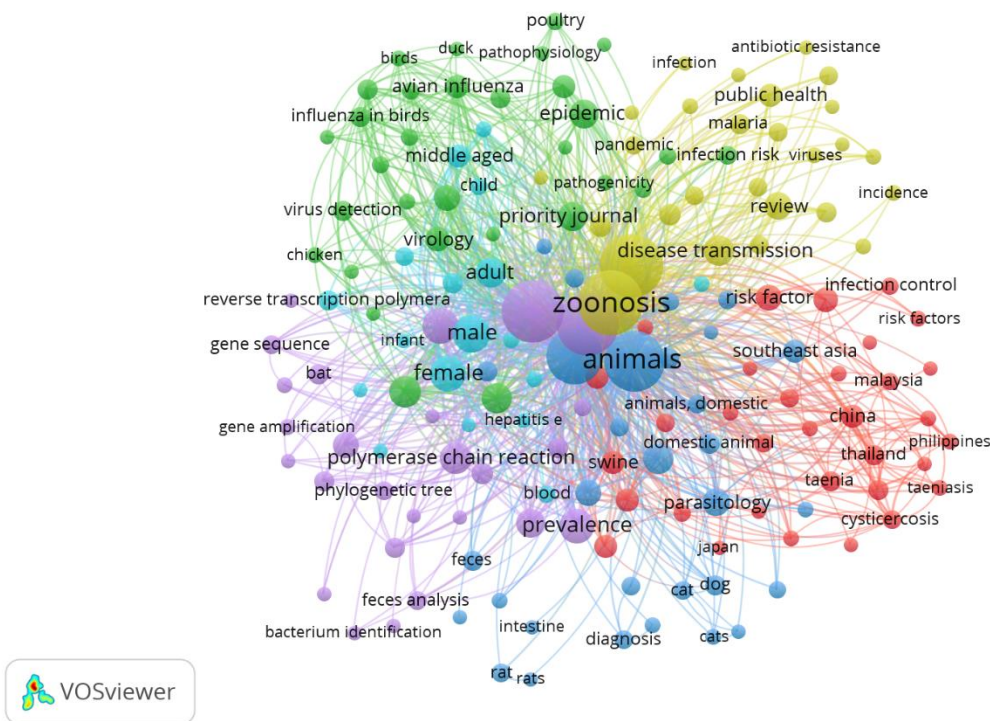
					<i>polymerase chain reaction</i>		
8	<i>genotype</i>	241	11	8	<i>virus antibody</i>	134	6
9	<i>gene sequence</i>	158	8	9	<i>hepatitis e virus</i>	126	6
10	<i>sequence analysis</i>	152	9	10	<i>child</i>	120	7

\*No : Number/Rank

\*TLS : Total link strength

\*Occ : Occurrence

The keyword index based on occurrence (nodus) performed on VOSviewer is presented in Figure 8. The results of the analysis showed that six clusters were obtained after analysis with cluster 1 shown in red with 33 items; cluster 2 with violet color consisting of 31 items; cluster 3 in yellow color with 31 items; cluster 4 shown in green with 30 items; cluster 5 with blue nodes with 28 items and cluster 6 with light blue nodes consisting of 18 items.



**Figure 8.** VOSviewer visualization of index keywords.

#### 4. Conclusion

In Indonesia, zoonotic diseases are still being major public health threat. Research related to Leptospirosis, Taenia solium, Rabies, Cysticercosis, Covid-19, Avian influenza, and Plasmodium knowlesi is still at the highest level of research in Indonesia and in the future, it can be explored further. The results of this study illustrate how zoonotic research is conducted in Indonesia from year to year and further research can be carried out with a comprehensive database in future to complete the research gaps in Indonesia



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