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Bibliometric Analysis on Mathematical Modeling Research of Dengue Disease Control with Wolbachia

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Abstract

Dengue fever is currently a global public health problem. Various strategies or efforts have been made including vaccination, fogging, use of mosquito repellent, mosquito nets, and so on. Recently, there was a new effort using Wolbachia bacteria aimed at controlling the vector of the disease, namely the Aedes Aegypti mosquito. In this paper, we focus on conducting a bibliometric analysis study of research related to the mathematical model of Wolbachia for dengue fever control using RStudio bibliometric and VosViewer. This paper aims to explore the following information: (1) trend and impact of Wolbachia model research on dengue disease control; (2) authors, countries, and sources who wrote or published a lot on this research; (3) articles that are widely cited because of their influence and impact; (4) keywords that are widely used in this research; (5) the topic of Wolbachia in Dengue which provides an opportunity for further research.

Keywords
Wolbachia, Aedes Aegypti, Leslie Matrix, Dengue and Bibliometric analysis.

1. Introduction
Dominantly, dengue fever is a disease that is transmitted by the Aedes aegypti mosquito to humans. To a lesser extent, this mosquito can also be transmitted by the Aedes albopictus mosquito. This disease is a very important health problem to be addressed in many countries. The spread of this disease is generally found in tropical areas including Southeast Asia, East Asia, namely Hong Kong, South Asia, namely India, and many more. Dengue fever with severe conditions was first recognized in 1950. Currently, dengue fever consists of four serotypes namely DENV-1, DENV-2, DENV 3, and DENV-4.

Various efforts were made to control the spread of dengue fever. These control efforts can be in the form of upstream and downstream control. Upstream control is control carried out on disease vectors, namely mosquitoes. This upstream control includes the use of mosquito repellent, insecticide, and fogging. Downstream control is control that is given directly to humans for prevention and treatment, including drugs and vaccines. However, these efforts are still not able to holistically deal with dengue fever. Recently, a new effort was made to control dengue fever using Wolbachia bacteria. The use of this bacterium is the control of dengue fever aimed at vectors.

Along with the rapid development of technology, research on bibliometric analysis is in great demand and is widely carried out. Bibliometric analysis provides information about little or much development on a research topic (Al Husaeni and Nandiyanto, 2022). In addition, bibliometric analysis has objectives including ascertaining whether the proposed topic is still relevant, trending, and influential, finding a research novelty that variables or other things have not been done on the topic, and much more that can be explored.

Bibliometric analysis research can focus on the topic being studied, the insights studied, the source database used, the limitations of the study, the software used to visualize the data and others. Some of the software used to perform bibliometric analysis include VosViewer, RStudio bibliometric, CiteSpace. Several researchers conducted bibliometric analysis studies on COVID-19 using VosViewer in cases of COVID19 research (Hamidah et al., 2020; Kaya and Erbay, 2020; Yu et al., 2020), materials research (Nandiyanto and Al Husaeni, 2021), sustainable oil and

gas production (Tamala et al., 2022) and many more. Then, there are also bibliometric analysis studies using other software including VosViewer combined with RStudio bibliometric (Guleria and Kaur, 2021; Najaf et al., 2021), VosViewer and HistCite (Li et al., 2022; Rajeswari et al., 2021; Shah et al., 2020), VosViewer and CiteSpace (Guan et al., 2021; Guo et al., 2019; Meng et al., 2020). Then, there are also studies that write clearly on the titles related to the databases used, including Scopus (Herrera-Franco et al., 2020; Nurdin et al., 2021), and Web of Science (Xie et al., 2020).

In this study, we focus on a bibliometric analysis study of the mathematical model of dengue vector control using Wolbachia. The software we use in this study is a combination of VosViewer and RStudio Bibliometrics using datasets from the Scopus database. In this paper, we focus on digging up information based on the following research questions:

1. What are the research trends and impacts on mathematical models of dengue disease control using Wolbachia?
2. Which countries and sources write or publish a lot of research related to mathematical models on dengue disease control using Wolbachia?
3. Who is the author who has written a lot of articles and cited a lot of research related to the mathematical model of dengue disease control using Wolbachia?
4. Which articles have been cited the most due to their influence and impact on research on mathematical models of dengue disease control using Wolbachia?
5. What are the keywords that are widely used in research on mathematical models of dengue disease control using Wolbachia?
6. What is the topic of the mathematical model of dengue disease control using Wolbachia that provides an opportunity for further research?

2. Methodology

This research begins by collecting article data from the Scopus database. The Scopus database has the advantage of having complete metadata that makes it possible to dig up a lot of information on a topic with the help of powerful software.

Table 1. Criteria for data collection

Keyword	"Wolbachia" AND "Dengue" AND ("Math" OR "Mathematical Model")
Database	Scopus
Timespan	2005-2022
Document Type	Article
Source Type	Journal
Publication Stage	Publication Stage
Language	English

Data collection in this study was limited by several criteria in the Scopus database. The keywords we use in this bibliometric analysis are "Wolbachia" AND "Dengue" AND ("Math" OR "Mathematical Model"). These keywords are considered capable of digging up topic information regarding research on mathematical modeling from Wolbachia in controlling Dengue. In the Scopus search column, data collection with the categories "title, abstract, and keywords" is applied. Timespans available in the Scopus database from 2005 to 2022 are classified as not very long ranges. Therefore, the timespan for this bibliometric analysis study was taken according to the one in the Scopus database, namely 2005-2022. Then, we limit the bibliometric analysis to document types in the form of articles written in English and have final conditions. These criteria are briefly presented in Table 1.

Data collection in this study was carried out on July 6, 2022. From data collection in the Scopus database, we obtained 395 papers. Then, this data will be the source of this research to be explored based on the research question.

3. Results and Discussion

In this section, we present and discuss the results of a biblimometric analysis of 395 articles obtained from the Scopus database. The bibliometric analysis was carried out with two software that can be said to be quite widely used, namely

RStudio with a bibliometric package and VosViewer. Both of these software are open source software which certainly has advantages and disadvantages. More information is obtained on RStudio bibliometrics than on VosViewer. However, VosViewer's visualization image quality is better than RStudio.

3.1 Main Information Dataset

The first thing that can be explored in the paper obtained from the Scopus database is the main information from the data. Main information is obtained through RStudio bibliometrics. Some of the important information that we obtained regarding the main information from the data is presented in Table 2.

Table 2. Main Informations of Dataset

Keywords Plus (ID)	2476
Author's Keywords (DE)	909
Authors	1375
Authors of single-authored documents	15
Authors of multi-authored documents	1360
Single-authored documents	18
Documents per Author	0.287
Authors per Document	3.48
Authors per Document	4.74

In Table 2, information is presented in several categories, including keywords, authors, and documents. The things discussed, include: (1) the number of plus keywords; (2) the number of author keywords; (3) the number of authors who write singly; (4) the number of authors who write collaboratively; (5) the number of articles written singly; (6) comparison of the number of documents produced with the number of authors; (7) comparison of the number of authors with the number of documents; (8) comparison of the number of co-authors with the number of documents.

3.2 Annual Scientific Production dan Average Article Citation per Year

This section presents the annual scientific production and the average article citation in one year. Annual scientific production is information on the development of the number of articles produced per year on related topics. Then, the average article citation is information about the development of the average article citation on the related topic. These two things are presented to answer whether the topic we are studying is in a trending and impactful position based on the visualization results from RStudio bibliometrics.

The graph of the annual scientific production in this study is presented in Figure 1. It can be seen in Figure 1 that the development of the annual scientific production graph sometimes goes up and sometimes down. However, if you pay attention to the trend of this research topic, which is shown in Figure 1, the trend looks up. In 2021, 56 articles were produced, while in 2022, 42 papers were produced. The average number of articles produced is around 25 papers, where since 2015 the papers produced are above the average, except for 2017 there are 17 articles. Then, we estimate in 2022 with 6 months remaining from the time of data collection that this topic still has a chance to be researched.

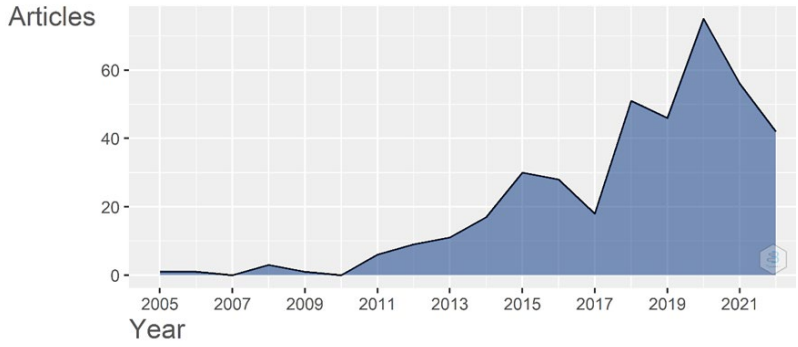

Figure 1. Annual scientific production.

The graph of average article citation in this study is presented in Figure 2. In 2005-2007 and 2009, the average was relatively low compared to other years. Then, 2022 has the highest average compared to other years, meaning this topic has a big impact.

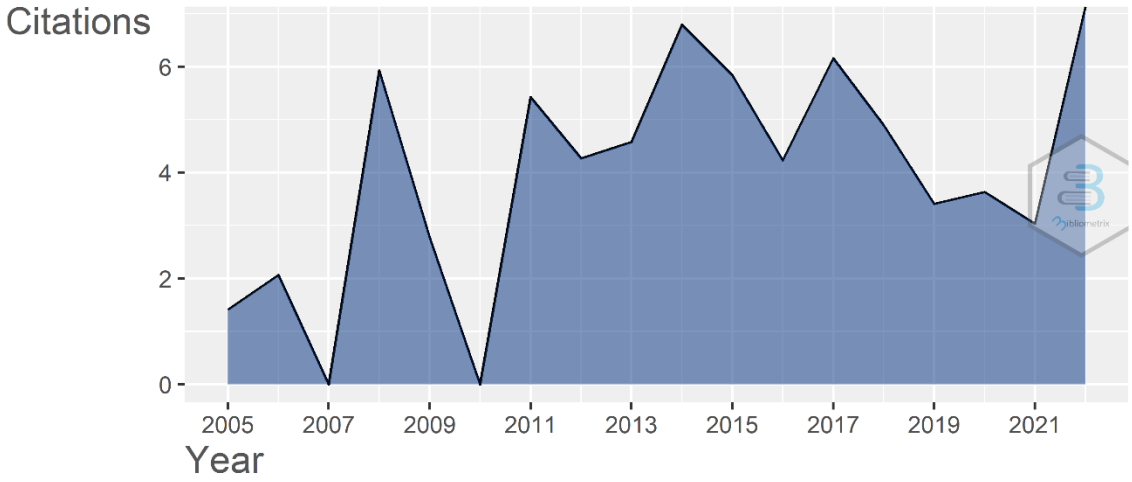

Figure 2. Average citations per year.

3.3 Country Scientific Production, Overlay Visualisation of Countries, Relevant Sources, and Local Cited Sources

In this section, information is presented about countries and sources that play a role in the topics carried out in this research. In this case, we present country information and relevant sources using both RStudio bibliometric software and VosViewer. The items presented include country scientific production, overlay visualization of countries, and top 10 relevant sources. These three things are intended to dig up information and answer the second research question related to countries and sources that play a role in related topics.

Country scientific production is the number of documents produced by the country. Studies on country scientific production are presented in Figure 3. In Figure 3, 5 color categories are given based on the number of articles produced by each country. Based on the 5 categories in Figure 3 the bluer the color of a country, the more it produces with the largest number of 337 articles by the USA. Then, the top 10 countries that produce the most articles are presented in Table 3.

Overlay Visualization of Countries is a visualization that provides information about which countries play a role annually, categorized by color. Overlay Visualization of Countries is presented in Figure 4. On the other hand, Figure 4 also supports Figure 3 and Table 3 regarding the top 10 countries. Based on Figure 4, the color of the blue nodes in

the figure shows the countries involved in 2016. Then, the more nodes point to the yellow color of the nodes, the more recent countries in the related topic are. Countries classified as having a role in 2019-2022 include Colombia, South Africa, Indonesia, Thailand, China, Saudi Arabia, and so on.

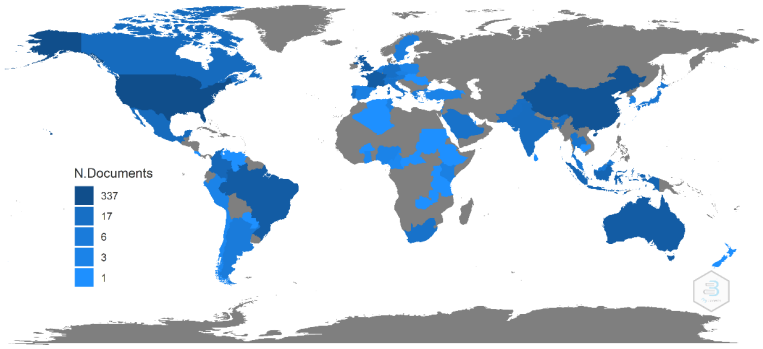

Figure 3. Country Scientific Production.

Table 3. Top 10 Country Scientific Production.

Countries	Number of Articles
USA	337
CHINA	192
UK	107
FRANCE	95
AUSTRALIA	91
BRAZIL	89
INDONESIA	43
COLOMBIA	33
MEXICO	25
CANADA	24

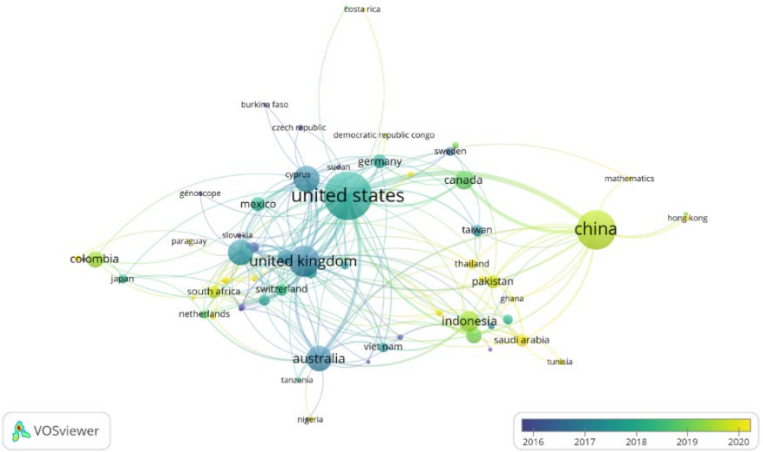

Figure 4. Overlay Visualisation of Countries.

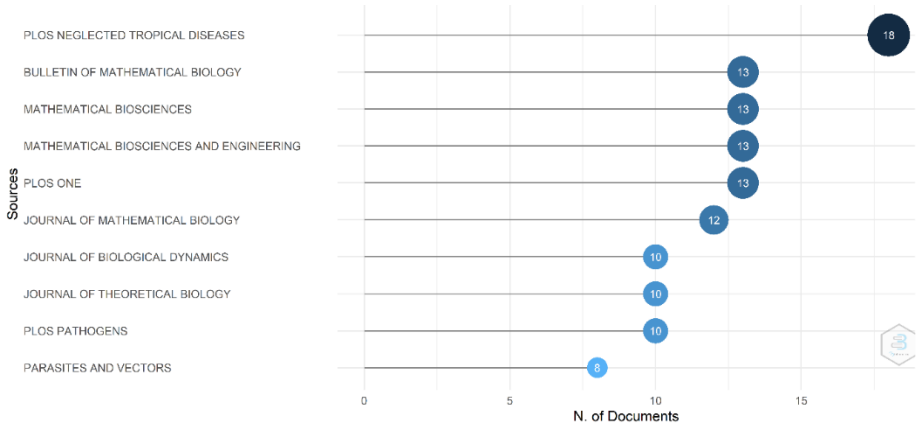

Figure 5. Top 10 Relevant Sources.

In Figure 5, we present the top 10 relevant sources. The study of relevant sources aims to examine information sources that are most widely published on related topics. Then, in Figure 6 we present the top 10 local cited sources. The study of local cited sources is aimed at finding out the sources that have been most cited from the data with the criteria in Table 1. Figure 5 and Figure 6 can answer sources that have many publications as well as many citations.

3.4 Relevant and Local Cited Authors

In this study, we present two bibliometric indicators to analyze the most relevant authors, namely based on the number of articles and author citations presented in Table 4 and Table 5. Relevant cited authors are information on authors who are widely cited globally (excluding datasets) on topics that are studied. Then, the local cited author is information about the author that is widely cited locally (in the dataset) on the topic being studied.

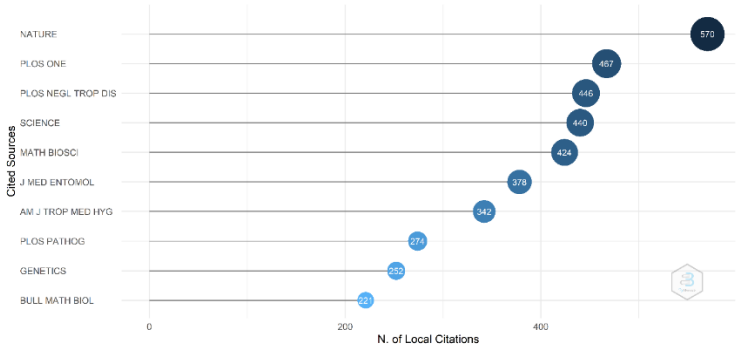

Figure 6. Top 10 Local Cited Sources.

Table 4. Top 10 Relevant Authors.

Authors	Number of Articles
Yu, Jianshe	22
Ndii, Meksianis Z	16
Zheng, Bo	16
Hu, Linchao	9
Li, Jia	9
Vasilieva, Olga	9
Tang, Moxun	8
Teixeira, Luis	8

Ritchie, Scott Alex	7
Vauchelet, Nicolas	7

Based on Table 4, the author who has the highest number of articles is Jianhe Yu who has written 22 articles. Followed by Mexianists Z. Ndi and Bo Zheng who wrote 16 articles, Jia Li, Olga Vasieva, and Moxun Tang who wrote 9 articles.

Meanwhile, based on Table 5, the most influential writer according to the number of citations is Olga who has been quoted 41 times. Then there are the writers Jianshe Yu, who has been quoted 23 times, and Bo Zheng, who has been quoted 23 times. Authors who have several related articles and citations. This can be seen from the names of the authors in Table 4 and Table 5 which are not much different.

3.4 Global and Local Cited Articles

This section discusses the top 10 global and local cited articles. Global cited articles are articles that are cited outside of the articles in the dataset from Table 1. Meanwhile, local cited articles are articles that are cited based on the articles in the dataset from Table 2.

In Table 6, the article with the most citations globally entitled Malaria published in 2017 was 249 citations, then the article Global temperature constraints on Aedes aegypti and Ae. albopictus persistence and competence for dengue virus transmission in 2014 which was cited 197 times and followed by the article Differential Protection to Viruses in Drosophila melanogaster: A Phenotypic and Phylogenomic Analysis in 2013 with 171 citations.

Meanwhile, in Table 7, the articles that were most cited locally were the article Modeling Wolbachia spread in mosquitoes through delay differential equations published in 2014 with 38 citations, followed by the article Modeling the transmission dynamics of dengue in the presence of Wolbachia in 2015 as many as 35 citations and Modeling the Use of Wolbachia to Control Dengue Fever Transmission in 2013 were cited 33 times.

Table 5. Top 10 Local Cited Authors

Authors	Number of Articles
Yu, Jianshe	23
Zheng, Bo	17
Vasilieva, Olga	41
Li, Jia	11
Hu, Linchao	9
Vasilieva, Olga	9
Tang, Moxun	8
Teixeira, Luis	8
Ritchie, Scott Alex	7
Vauchelet, Nicolas	7

Table 6. Top 10 Local Cited Authors

No.	Title	Source	Total Citation	Total Citation Per Year
1	Malaria (Phillips et al., 2017)	Nature Reviews Disease Primers	249	41.5
2	Global temperature constraints on *Aedes aegypti* and *Ae. albopictus* persistence and competence for dengue virus transmission (Brady et al., 2014)	Parasites and Vectors	197	21.89

3	Wolbachia Variants Induce Differential Protection to Viruses in Drosophila melanogaster: A Phenotypic and Phylogenomic Analysis (Chrostek et al., 2013)	PLoS Genetics	171	17.1
4	The Zika Virus Epidemic in Brazil: From Discovery to Future Implications (Lowec et al., 2018)	International Journal of Environmental Research and Public Health	157	8.02
5	Benefits and risks of the Sanofi-Pasteur dengue vaccine: Modeling optimal deployment (Ferguson et al., 2016)	Science	155	22.14
6	Modelling the impact on virus transmission of Wolbachia-mediated blocking of dengue virus infection of *Aedes aegypti* (Ferguson et al., 2015)	Science Translational Medicine	152	19
7	Symbionts Commonly Provide Broad Spectrum Resistance to Viruses in Insects: A Comparative Analysis of Wolbachia Strains (Martinez et al., 2014)	PLoS Pathogens	151	16.78
8	Climate, environmental and socio-economic change: weighing up the balance in vector-borne disease transmission (Parham et al., 2015)	Philosophical Transactions of the Royal Society B: Biological Sciences	140	17.5
9	Modelling the control strategies against dengue in Singapore (Burattini et al., 2008)	Epidemiology and Infection	116	7.73
10	The Toll-Dorsal Pathway Is Required for Resistance to Viral Oral Infection in *Drosophila* (Ferreira et al., 2014)	PLoS Pathogens	108	12

Table 7. Top 10 Local Cited Documents.

No.	Title	Source	Local Citation	Global Citation
1	Modeling Wolbachia spread in mosquitoes through delay differential equations (Zheng et al., 2014)	SIAM Journal on Applied Mathematics	38	73
2	Modelling the transmission dynamics of dengue in the presence of Wolbachia (Ndii et al., 2015)	Mathematical Biosciences	35	63
3	Modelling the Use of Wolbachia to Control Dengue Fever Transmission (Hughes and Britton, 2013)	Bulletin of Mathematical Biology	33	69
4	Wolbachia infection dynamics by reaction-diffusion equations (Huang et al., 2015)	Science China Mathematics	31	47
5	Assessing the efficiency of Wolbachia-driven Aedes mosquito suppression by delay differential equations (Huang et al., 2018)	Journal of Theoretical Biology	25	38
6	Wolbachia spreading dynamics in mosquitoes with imperfect maternal transmission (Zheng et al., 2018)	Journal of Mathematical Biology	25	38
7	Models to assess how best to replace dengue virus vectors with Wolbachia-infected mosquito populations (Zhang et al., 2015)	Mathematical Biosciences	24	25
8	Qualitative analysis for a Wolbachia infection model with diffusion (Huang et al., 2016)	Science China Mathematics	23	33

9	Modeling the impact on virus transmission of Wolbachia-mediated blocking of dengue virus infection of *Aedes aegypti* (Ferguson et al., 2015)	Science Translational Medicine	22	152
10	Constraints on the use of lifespan-shortening Wolbachia to control dengue fever (Schraiber et al., 2012)	Journal of Theoretical Biology	18	42

3.6 Trend of Keywords

In this section, we examine the trend of keywords related to this research topic. The things studied include thematic evolution studies, co-occurrence studies based on author keywords, and word cloud studies.

Using RStudio bibliometric, we conducted an assessment related to thematic evolution on the topics in Table 1. The thematic evolution from the study of this research topic is presented in Figure 7. The thematic evolution parameters used in the field column are author keywords, the number of words column is 5000 words, the number of labels column is 2, and the number of cutting points is 2 consisting of 2018 and 2022. Based on the selected number of cutting points, RStudio Bibliometrics divides the thematic map into three-time slices, namely 2005-2018, 2018-2020, and 2020- 2022.

From Figure 7, note that only a small part of the “dengue” topic in the 2005-2018 period is connected to the “Wolbachia” topic in the 2018-2020 period. Then, there is a small part of the topic "Wolbachia" in 2018-2020 which is reconnected with "dengue" and "dengue model" in 2020-2022. The topics related to "Wolbachia" and "dengue" respectively were two topics that were widely studied in 2005-2018 but the topic of "dengue" in 2018-2020 was not widely studied anymore. In addition, the topic of "dengue" is again a topic that is widely studied in 2020-2022, while the topic of "Wolbachia" is declining.

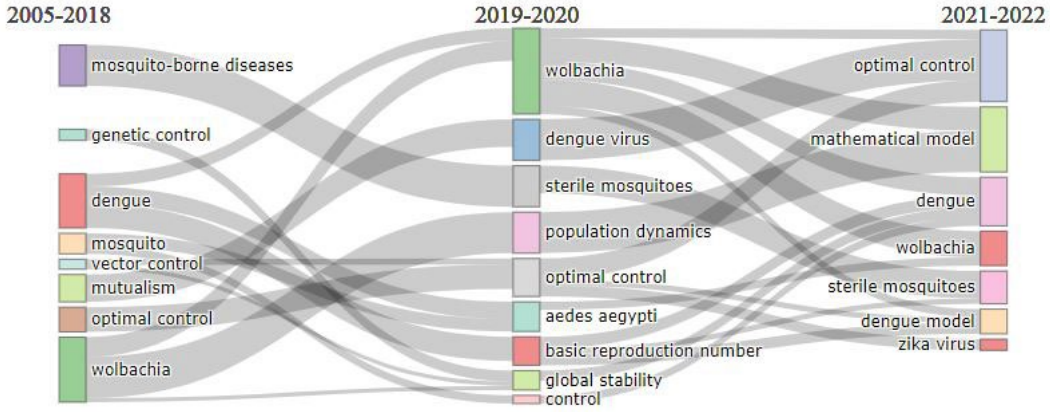

Figure 7. Thematic Evolution.

For each time slice, the thematic map is presented in Figure 8(a)-8(b) and is described using the Callon centrality method. The thematic map for each time slice is divided into four quadrants. Quadrant 1, namely the motor themes, is the quadrant with the largest centrality and density. Quadrant 1 has strong cluster connectedness both externally (another cluster) and internally (the same cluster). Quadrant 2, namely the niche themes, is a quadrant with small centrality and large density. Quadrant 2 has weak cluster connectedness externally and strong internally. Quadrant 3, namely the emerging or declining themes, is a quadrant with small centrality and low density. Quadrant 3 has weak cluster connectivity both externally and internally. Finally, quadrant 4, namely the basic themes, is a quadrant with large centrality and low density. Quadrant 4 has strong cluster connectedness externally but weak internally.

Figure 8(a)-8(c) shows that all topics are only spread out in two quadrants, namely quadrant 1 and quadrant 4. In 2005-2018, the two largest clusters namely Wolbachia and cytoplasmic incompatible, dengue and Aedes aegypti are the two clusters right in quadrant 4. Besides, Wolbachia and dengue are not in the same cluster. In 2018-2020, Wolbachia and dengue are in the same cluster and are the largest cluster in quadrant 1. In 2020-2022, Wolbachia is not in the

same cluster but only in mosquitoes that cause dengue, namely Aedes aegypti while dengue is in one cluster. with optimal control.

In Figure 8, we present an overlay visualization of co-occurrence based on author keywords using VosViewer. In the lower right corner of the figure in Figure 8, there is a range of years divided into color intervals. The year category combined with the color implies more yellow nodes, so that topic is a topic that is currently being studied a lot in 2020 and above. The topic of Wolbachia has a node color of 2019. Then, the topics of the dengue model, vaccination, optimal control, stability analysis, sterile mosquitoes, and mosquito population suppression are on nodes with colors indicating 2020 and above. This shows that there are several opportunities for the topic that I am currently trending to research, namely mathematical models on the use of Wolbachia in combination with vaccines in dengue control. In addition, things that can be studied in the combination model of Wolbachia and vaccines include optimal control and stability analysis. This statement is also supported in Figure 8 which shows the relationship between vaccination and dengue topics which is quite far from the edge that connects the two nodes.

Using RStudio bibliometrics, we also performed an analysis on the word cloud feature. The purpose of this word cloud analysis is to obtain keywords that are widely used by authors on related topics so that the keywords written are on target. Five popular keywords used in several studies for related topics include Wolbachia, dengue, Aedes aegypti, optimal control, and mathematical models. These five keywords can be seen in Figure 8, the vaccination keyword is still relatively little used in the study of the mathematical model of Wolbachia in dengue control. A new idea is to research a mathematical model of dengue disease control using a combination of Wolbachia and vaccination. These two methods have different targets in dengue disease control. Wolbachia focuses on controlling disease vectors, while vaccination focuses on preventing diseases given to humans.

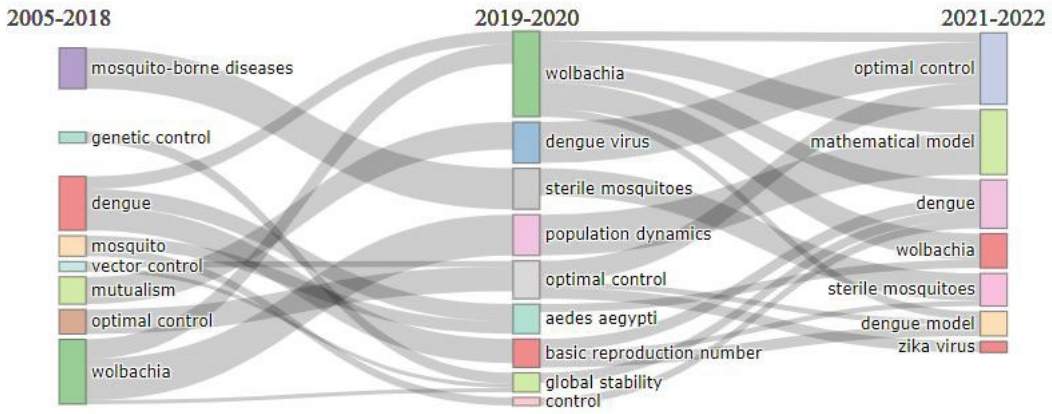

Figure 8. (a) Thematic Map For Time Slice (2005-2016), (b) Thematic Map For Time Slice (2016-2018), and (c) Thematic Map For Time Slice (2018-2022).

4. Conclusion

This study aims to examine the bibliometric literature on the mathematical model research of Wolbachia in dengue disease control. The trend of this research tends to rise and research has an impact, especially from 2021 to mid-2022 the average citation tends to rise and is even higher than the previous year.

Meanwhile, the country with the most publications related to this research from 2005 to 2022 was the USA with 337 articles, followed by China with 192 articles and the UK with 192 articles. The active author can be seen from the number of articles and citations on this topic is Jianshe Yu. Based on the results of VOSViewer analysis and mapping, malaria articles in 2017 were most cited globally and the article Modeling. Wolbachia spread in mosquitoes through delay differential equations in 2014 was cited the most locally.

VOSviewer analysis identified five keyword clusters related to the mathematical modeling research topic of dengue disease control with Wolbachia. Wolbachia, dengue, Aedes aegypti, optimal control, and mathematical models are five popular keywords used. In addition, it appears that the vaccination keyword is still relatively little used in the

study of the mathematical model of Wolbachia in dengue control. So the topic of Wolbachia in Dengue disease provides an opportunity for further research.

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