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Research Trends in Mathematical Modeling Applied to Pandemic Cases: A Bibliometric Analysis

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Abstract

The disease caused by the virus has caused a continuous pandemic worldwide since 2012. In order to slow down the rapid spread of the virus, many countries have taken recovery measures. This paper aims to analyze the trends of modeling pandemic cases in Scopus-indexed journals. The research method is a literature review using a bibliometric analysis approach starting from defining the keywords modeling' and 'pandemic' in the Publish or Perish application with Google Scholar as the database. After narrowing the results by selecting the topic of modeling the pandemic problem it consisted of 200 articles in total. After that, the metadata was compiled using the Mendeley application, the VosViewer application was used to create a research trend visualization. The results obtained by bibliometric analysis show that the number of publications continues to increase. Which journals are published, which organizations and countries publish the most, how the evolution of perspective has changed since 2012, and which articles are most cited. We conclude that since the pandemic, there is a possibility of an evolution in the quality of publications.
Keywords: bibliometric analysis; pandemic; mathematical model; Mendeley; Publish or Perish; Vosviewer.

Abstrak

Penyakit yang diakibatkan dari virus telah menyebabkan pandemi berkelanjutan di seluruh dunia sejak 2012. Untuk memperlambat penyebaran virus yang cepat, banyak negara telah mengambil langkah pemulihan. Tulisan ini bertujuan untuk menganalisis tren pemodelan kasus pandemi di jurnal terindeks Scopus. *Metode penelitian adalah kajian pustaka dengan pendekatan analisis bibliometrik dimulai dari pendefinisian kata kunci 'pemodelan' dan 'pandemi' pada aplikasi* Publish or Perish *dengan database* Google Scholar. *Setelah dilakukan penyempitan hasil dengan pemilihan topik pemodelan masalah pandemi maka total artikel menjadi 200 artikel. Setelah itu dilakukan kompilasi metadata menggunakan aplikasi* Mendeley*, aplikasi* VosViewer *digunakan untuk membuat visualisasi trend penelitian. Hasil yang diperoleh dengan analisis bibliometrik menunjukkan bahwa jumlah publikasi terus meningkat. Jurnal mana yang diterbitkan, organisasi dan negara mana yang paling banyak menerbitkan, bagaimana evolusi perspektif telah berubah sejak 2012, dan artikel mana yang paling banyak dikutip. Kami menyimpulkan bahwa sejak pandemi, ada kemungkinan terjadi evolusi kualitas publikasi.*
Kata Kunci: *analisis bibliometrik*; *pandemi*; *model matematika*; Mendeley; Publish or Perish; Vosviewer.

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1. INTRODUCTION

Pandemic and epidemic are two terms used to denote global and region-specific outbreaks of disease. In the past, the world has witnessed several episodes classified as pandemics or epidemics. A

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list of pandemics includes Influenza, Sars-Cov, and COVID-19. Although the world has seen and survived many pandemics and epidemics in the past, the challenges posed by Sars-Cov, and COVID-19 are unparalleled and unprecedented. The main cause for concern is its spread, not its death. As per the latest report (22 June 2020), this virus has affected around nine million lives globally, with traces on every continent [1].

Epidemiologists use statistical models to estimate the spread of epidemics and suggest containment measures. However, the model relies heavily on available data and is subject to some randomness. At the same time, the mathematical model is more accurate and rigorous. Mathematical models can help and understand infections when they are removed or resumed. Currently, Sars-Cov and COVID-19 are of great concern for researchers, governments, and everyone because of the high rate of spread of infection and the significant number of deaths. In December 2019, the coronavirus was first reported in Wuhan, China, as an infectious disease caused by the newly discovered coronavirus. The virus that causes COVID-19 is primarily transmitted through droplets produced when an infected person coughs, sneezes, or exhales. These droplets are too heavy to hang in the air and quickly fall to the floor or other surfaces. Confirmed cases of coronavirus have reached nearly four million in 187 countries, and around 295,000 people have lost their lives to the virus [2].

Researchers have tracked the spread of the virus, mobilized the pace of innovative diagnostics, and are working on several vaccines to protect against Sars-Cov and COVID-19. Unfortunately, the expected death toll for the coronavirus was much higher than expected on 10 February 2020, as 12,289 new cases (not previously included in the official count) were added two days later. Currently, there are no licensed vaccines or therapeutic agents for the prevention or treatment of coronavirus, although research studies on potential antiviral and vaccine candidates are ongoing in several countries. Vaccine testing, development, and distribution are typically a much longer process than drug development, and, most likely, a vaccine for Sars-Cov, COVID-19 is not ready before 2021 because the virus can quickly spread in crowded places. Social distancing or low contact levels refer to steps taken to increase physical distancing between people to slow the spread of the virus. Batista [3] studied a logistic growth regression model used to estimate the final size of the virus epidemic. Several researchers are developing different models of and studying dynamic behavior (see, for example [4]).

Further research should focus on updating predictions using current data and more complex mathematical models. The mathematical modeling faced by the world's problem solvers is the process of applying mathematics to real problems to understand them. It does not only apply mathematics to real-world problems but also after finding a solution, the original question is no longer considered but rather checking whether the answer makes sense. With mathematical modeling, mathematics is used to learn more about real-world problems/situations [5].

Bibliometric citation analysis allows one to measurably evaluate major and keyword journal titles and stream publications in an academic context in a more coordinated manner. Among other relevant data relating to literary societies, interactions between writers from various universities, institutions, and countries can be visualized. For example, certain research phenomena can be assessed and investigated in a variety of fields, from the field of social sciences [6][7], to science and technology [8] [9], manipulation [10], and education [11][12]. Currently, there is no research that has mapped the distribution of certain international publications (indexed by Scopus) related to mathematical models for pandemics.

Therefore, this research was conducted to find trends in developing articles on mathematical models for the pandemic using the Scopus database from 2012 to 2021. The analysis carried out included citation analysis, authors, theme classification, theme clustering, author network, research

depth, and areas of research that are still rarely done. This study aims to analyze trends in the development of mathematical models in pandemic research publications published in Scopus-indexed scientific journals, review citation analysis, and examine author trend analysis of keyword terms.

The questions, along with the purpose of the review, desired results, and intended audience, determine how data is identified, collected, and presented. Several questions are intended to be answered in this paper. The first question is how is the evolution of publishing articles in quality journals related to mathematical modeling for pandemics. The next question is what are the characteristics of journals with more publications related to the subject. Finally, the last question is what are the most cited articles in the last two years.

2. METHODS

The term bibliometrics was first used in 1969 by Alan Pritchard, hoping that the term would be used explicitly in all studies that attempted to measure the writing process and would soon be accepted in information science [13]. Moed mentioned the potential of this type of study to reveal the great potential of quantitative bibliometric analysis of the scientific literature for a deeper understanding of intellectual activity and performance and highlights their policy relevance [14]. In scientific research, it is important to gain a broader perspective from research that has been carried out on relevant subjects and profile bibliometric analyses on research trajectories and dynamics of research activities around the world. This bibliometric review analyzes the literature systematically using articles indexed in Elsevier's Scopus (Scopus) and Clarivate Analytics Web of Science (WoS) databases. This study conducted a bibliometric analysis on international journal papers which is intended to provide valuable references for future fieldwork [15][16]. We exported all data to Microsoft Excel for statistical analysis and ranking of various bibliometric indices, including the most cited documents, countries, institutions, and journals. We use Publish or Perish to illustrate the distribution of papers. In addition, a worldwide VOSviewer software (version 1.6.18) is used to visualize research trends between terms, keywords, countries, and rainbow density maps combining bibliographies and journal writing [17]. The search strategy is

Title: “Covid-19 pandemic mathematical modeling”
Title-Abstract-keywords: “mathematics' OR "pandemic"
DocType: Article OR Review
PURYEAR: <2022

3. RESULTS AND DISCUSSIONS

The results of data collection and analysis related to the pandemic model can be seen in Figure 1, a comprehensive search yielded 200 articles. The first article on Scopus was published in 2012. Evolution of the annual publication in Scopus-indexed journals already had ten articles (4 articles in 2012 and 6 articles in 2013). In general, research articles on the pandemic model published in Scopus are experiencing growth. Figure 1 illustrates that the publication rate growth is increasing every year (except 2014, 2017, and 2021): 10 in 2013 (5%), 1 in 2014 (0.5%), 8 in 2015-2016 (4%), 4 in 2016 - 2017 (2%), 126 in 2018-2020 (63%) and 51 in 2021 (25.5%).

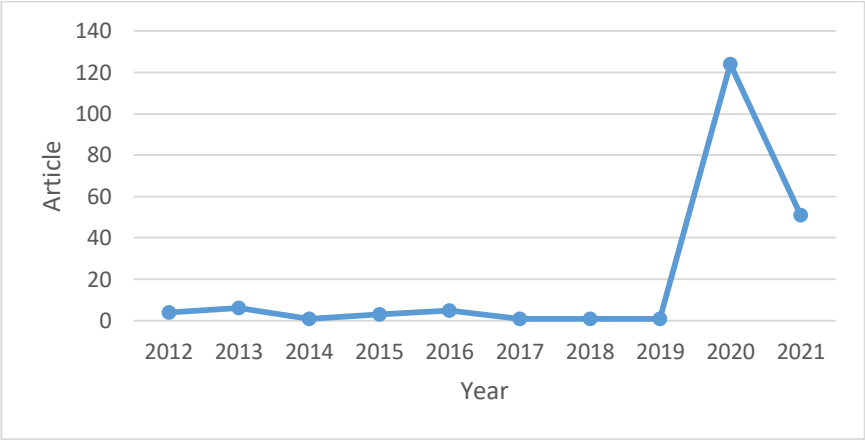

Figure 1. Annual evolution publishes papers.

Papers were published in international journals i.e. the International Journal of Environmental Research and Public Health published 18 articles; the International Journal of Healthcare Management published 6 articles; The International Journal of Infectious Diseases published 8 articles, and the International Journal of Mental Health and Addiction published 3 articles published in the UK and the US. Journal of Infection and International Journal of Antimicrobial Agents were best journals according to CiteScore in 2021 (CiteScore measures the average citations received per document published in serial), i.e., 27.5 and 16.1, respectively. The Journal of Infection and the European Journal of Epidemiology were the best journals according to SCImago Journal Rank (SJR) in 2021 (SJR measures the weight of received citations by series), 5.03 and 3.92, respectively. The European Journal of Operational Research received the best Source Normalized Impact per Paper (SNIP) in 2021. The most common WoS category is Health (Social Science). Most of these journals are ranked in the first quartile in the Journal of Citation Reports.

Table 1. Journal information based on citation rating.

Journal	#	Country	Quote Score 2021	SR 2021	SNIP 2021	Subject Wos (Category)	Q	Journal Index
Infection Journal	8	United Kingdom	27.5	5.03	1.92	Epidemiology	Q1	119
International Journal of Antimicrobial Agents	5	Netherlands	16.1	2.12	1.44	Pharmacology (medical)	Q1	137
Journal of Pharmaceutical Analysis	3	China	13.1	1.39	1.52	Pharmacy	Q1	38
European Journal of Epidemiology	21	Netherlands	12.1	3.92	2.73	Epidemiology	Q1	120
Journal of Medical Virology	11	United States of America	11.6	2.66	2.75	Infectious diseases	Q1	137

Table 1. Continued.

Journal	#	Country	Quote Score 2021	SR 2021	SNIP 2021	Subject Wos (Category)	Q	Journal Index
Journal of Molecular Biology	10	United States of America	10,.2	2.59	1.36	Biophysics	Q1	269
British Journal of Surgery	1	United Kingdom	9.60	2.48	2.44	Operation	Q1	210
European Journal of Operational Research	20	Netherlands	9.5	2.53	2.81	Modeling and Simulation	Q1	274
International Journal of Physical Distribution and Logistics Management	18	United Kingdom	9.1	1.95	1.88	Technology and Innovation Management	Q1	117
American Journal of Epidemiology	4	United Kingdom	8.1	1.83	1.81	Epidemiology	Q1	267
Journal of Epidemiology and Public Health	22	United Kingdom	7.2	1.67	1.76	Public Health, Environment, and Occupational Health	Q1	178
American Journal of Ophthalmology	17	United States of America	7.1	2,3	1.75	Ophthalmology	Q1	194
International Journal of Infectious Diseases	2	Netherlands	7	2.43	2.49	Infectious diseases	Q1	104
Journal of Medical Internet Research	6	Canada	6.9	1.74	2.70	Health Informatics	Q1	158
Journal of the American Planning Association	9	United Kingdom	6.6	1.84	2.37	Development	Q1	104
European Physical Journal Plus	19	United States of America	5.1	0.61	1,13	Physics and Astronomy	Q2	67
Journal of Biomolecular Structure and Dynamics	13	United Kingdom	5	0.56	0.98	Molecular Biology	Q2	73
International Journal of Oral and Maxillofacial Surgery	27	United States of America	3.9	0.98	1.71	Otorhinolaryngology	Q1	105
Simulation Journal	14	United Kingdom	3.5	0.87	0.63	Industrial and Manufacturing Engineering	Q1	26
Journal of Public Health	23	Netherlands	3	0.89	1.02	Health (Social Science)	Q1	69

Among the 200 articles, 51 keywords were found. Sars Cov (23 keywords), modeling (16 keywords), discovery (7 keywords), and influenza (5 keywords) were the most common keywords as shown in Figure 2. If we consider papers published until 2012, production between 2012 and 2019, and from 2020 to 2021, 5 keywords are most used in all three groups: Sars Cov, Modeling, and Influenza. Some of the keywords only exist in all 20 productions of 2021: Covid and Sars Cov. (Figure 3).

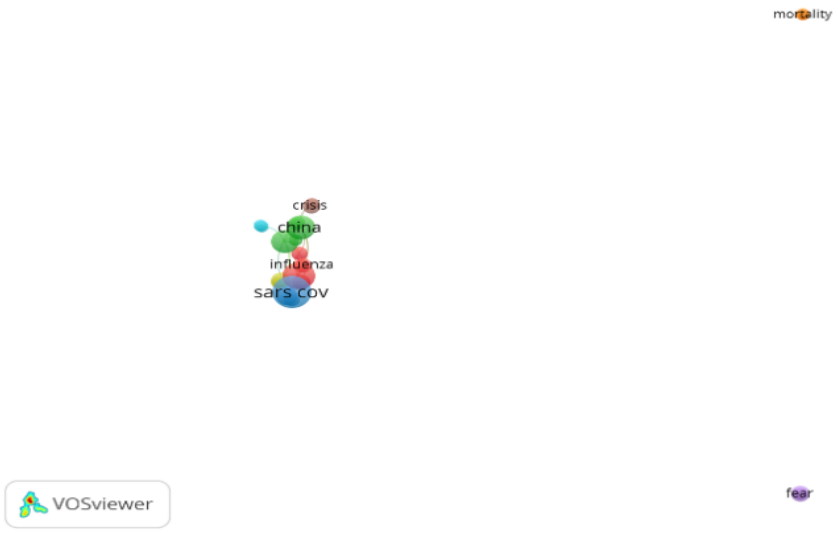

Figure 2. The most common keywords.

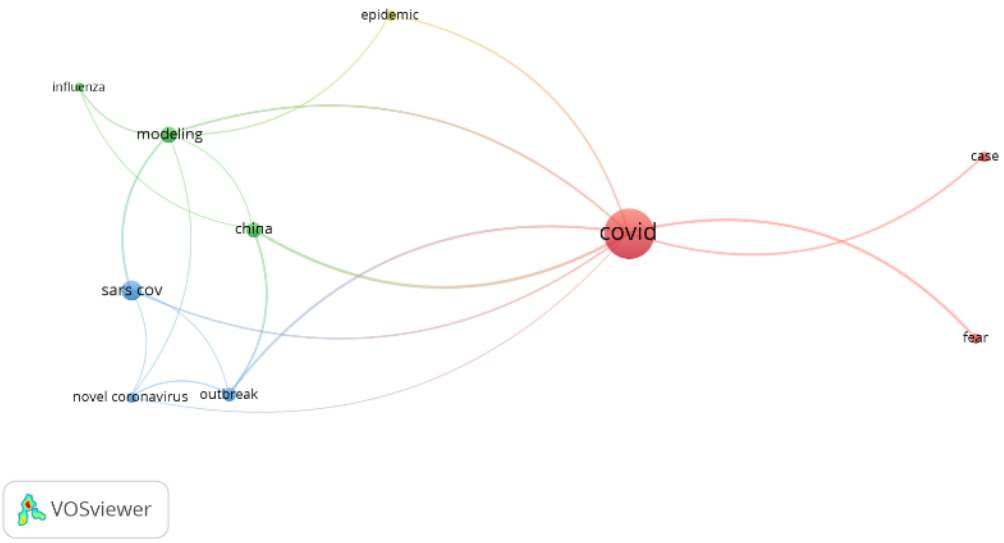

Figure 3. Network visualization, keywords, more quoted.

This list of most cited articles would not be complete if we did not include the most awarded articles in recent years. We considered articles published since 2012 for proposals. Below are some of the most cited articles:

The first article is from D. Nepogodiev et al. (2020); Optional surgery cancellation due to the COVID-19 pandemic: global predictive modelling to inform surgery recovery plans: A case study of current surgical cancellation options around the world [11],[12]. Few countries have access to real-time data, and even those that do may experience delays in releasing this information due to pressure on health systems. Estimating country-level estimates will provide the best basis for informing post-

pandemic surgical recovery planning. This study aimed to assess the number of elective surgeries that were cancelled or postponed worldwide during the 12-week peak of hospital disruption due to COVID-19 [18].

The subsequent article is from Q. Lin et al. (2020); Conceptual model for coronavirus disease 2019 (COVID-19): an outbreak in Wuhan, China with individual reactions and government actions: The ongoing outbreak of the coronavirus disease 2019 (COVID-19), which emerged in Wuhan, China in late 2019, has claimed more than 2,600 lives as of 24 February 2020, and constituted a significant threat to global public health. The Chinese government has implemented countermeasures, including setting up special hospitals and travel restrictions to reduce the spread. We propose a conceptual model for the COVID-19 outbreak in Wuhan taking into account individual behavioral reactions and government actions [19].

The third article comes from M. Tahir ul Qamar, (2020); Structural basis of pro- and anti-COVID-19 SARS-CoV-2 3CL drugs from medicinal plants: The recent coronavirus disease 2019 (COVID-19) pandemic caused by SARS -CoV-2 has caused a global health concern. The viral enzyme 3-chymotrypsin-like cysteine protease (3CLpro) controls the replication of the coronavirus and is essential for its life cycle. 3CLpro is a proven drug discovery target in cases of severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV). The aim was to analyze the 3CLpro sequence and screen a medicinal plant library containing 32,297 potent anti-viral phytochemicals/traditional Chinese therapeutic compounds. The analysis reveals that the top nine hits may serve as potential anti-SARS-CoV-2 key molecules for further optimization and drug development to combat COVID-19 [20].

The fourth article is by A. Cori (2013); New framework and software for estimating time-varying reproduction numbers during epidemics; a ready-made tool for assessing the R of a time series of events, implemented in popular software including Microsoft Excel (Microsoft Corporation, Redmond, Washington). This tool generates a new statistically robust analytical estimate of R. It incorporates uncertainty in the distribution of serial intervals (the time between another set of symptoms in primary cases and another set of symptoms in secondary patients) [21].

The last article is from J. Fantini (2020); Structural and molecular modeling studies reveal new mechanisms of action of chloroquine and hydroxychloroquine against SARS-CoV-2 infection; This study shows that chloroquine (CLQ), one of the drugs currently being researched for the treatment of SARS-CoV-2, binds sialic acid and gangliosides with high affinity. In the presence of CLQ [or its more active derivative, hydroxychloroquine (CLQ-OH)], the viral S protein can no longer bind to gangliosides. Identifying this new mechanism of CLQ and CLQ-OH supports the use of this repositioned drug to treat patients infected with SARS-CoV-2. The in-silico approach used in this study can also assess the efficiency of various drug candidates that are repositioned and loaded prior to field clinical evaluation [22].

The articles above were the most cited articles in 2012-2021. In the following table (most cited papers 2012-2021), we list the most awarded articles in 2012-2021.

Table 2. Most cited papers by a number of citations in 2012-2021.

Author	Year	Title	Journal	Quoted
D. Nepogodiev	2020	Cancellation of elective surgeries due to the COVID-19 pandemic: global predictive modeling to inform surgical recovery plans	British Journal of Surgery	634
Q. Lin	2020	Conceptual model for the coronavirus disease 2019 (COVID-19) outbreak in Wuhan, China with individual reactions and government actions	International Journal of Infectious Diseases	560
M. Tahir ul Qamar	2020	The structural basis for the discovery of the drug SARS-CoV-2 3Clpro and anti-COVID-19 from medicinal plants	Journal of Pharmaceutical Analysis	527
A. Cori	2013	New framework and software for estimating time-varying reproduction numbers during epidemics	American Journal of Epidemiology	513
J. Fantini	2020	Structural and molecular modeling studies reveal new mechanisms of action of chloroquine and hydroxychloroquine against SARS-CoV-2 infection	International Journal of Antimicrobial Agents	333
A. Abd-Alrazaq	2020	Top Tweeters' concern during the COVID-19 Pandemic: A surveillance study	Journal of Medical Internet Research	324
S. Arshad	2020	Treatment with hydroxychloroquine, azithromycin, and combination in hospitalized COVID-19 patients	International Journal of Infectious Diseases	303
IM Ibrahim	2020	Prediction of COVID-19 GRP78 host cell receptor binding sites	Infection Journal	279
S. Hamidi	2020	Has Overcrowding Made the COVID-19 Pandemic Worse? Preliminary Findings and Lessons for Planners	Journal of the American Planning Association	265
JA Jaimes	2020	Phylogenetic Analysis and Structural Modeling of the SARS-CoV-2 Spike Protein Reveals Evolutionarily Distinct and Proteolytically Sensitive Activation Cycles	Journal of Molecular Biology	237

4. CONCLUSIONS

This paper aims to analyze the research trend in mathematical modeling applied to epidemics in Elsevier Scopus-indexed journals. The sample consists of 200 articles. The results of the bibliometric analysis show that the publication rate continues to increase: 10 in 2013 (5%), 1 in 2014 (0.5%), 8 in 2015-2016 (4%), 4 in 2016-2017 (2%), 126 in 2018-2020 (63%) and 51 in 2021 (25.5%). The 200 papers were published in 50 international journals. Four out of ten journals were from the first quartile. The most common WoS category is Health (Social Science). The most cited articles in the last two

years were by D. Nepogodiev (2020) with the title "Cancellation of elective surgery due to COVID-19 pandemic: Surgery" cited 634 times ad Q. Lin (2020) with the title "Conceptual model for coronavirus disease 2019 (COVID-19): Infectious Disease" cited 560 times. The bibliometric results show that m-Learning in tertiary institutions is still a topic with a tendency to increase the number and quality of scientific production.

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