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Global trends on Covid-19 and food security research: A scientometric study

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1. Introduction

Coronavirus disease 2019 (Covid-19), one of the most popular publication topics in the recent years, has transformed global research publishing (Else, 2020). Publisher of Elsevier's journals alone received 58% of total submission on Covid-19 related papers (around 270,000) between February and May 2020 when compared with the same period in 2019 (Squazzoni et al., 2020). It is well-known that the disease is a novel coronavirus SARS-CoV-2 which started in China in December 2019 and has spread across the globe; the disease was named COronaVIrus Disease 2019, or Covid-19, by the World Health Organization (WHO). The same organization also declared a global health emergency at the end of January 2020. As of December 31, 2019, they started to record the global cases, daily, and by December 27, 2020 (almost 1 year later) the cases had reached cumulative numbers of more than 79 million reported cases and more than 1.7 million deaths globally since the start of the pandemic (WHO, 2020). Reported cases have doubled in the last 6 months (as of June 1, 2021) at 170 million cases with more than 3.5 million total deaths. Based on the continents and regions, the Americas had the highest number of cases, followed by the European regions and South-East Asia. By country, the USA, India, and Brazil had the highest numbers of confirmed cases, and also the highest numbers of total deaths.

Studies related to Covid-19 have emerged recently due to the diseases importance to human health, as well as given that most academics were forced to work and teach from home, to reduce the rate of infection. It is not enough to study Covid-19 from a health perspective; thus it is important to explore any impact of Covid-19 to others' discipline of study. For example, Covid-19 has been related to other subjects of the study such as social sciences (Lake et al., 2021; Zhou and Guo, 2021), computer science (Oliveira et al., 2021; Rahman et al., 2021), environmental sciences (Sharif et al., 2021; Tarazona et al., 2021; Vale et al., 2021), and energy (Gerald et al., 2021; Szczygielski et al., 2021). The Covid-19 pandemic also has links to other global issues and problems such as poverty (Brum and

Rosa, 2021; Tavares and Betti, 2021), climate change (Bhat et al., 2021; Rosenbloom and Markard, 2020), anthropogenic stressor (Sarà et al., 2021), and food security (Nchanji and Lutomia, 2021; Nechifor et al., 2021; Shupler et al., 2021).

Food security is popularly known as nutrition security, food availability, food utilization, access to food, food insecurity, and food safety. The Food and Agriculture Organization of the United Nations (FAO) defines food security^a as “a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” According to the FAO’s terminology, food security is associated with organic agriculture, economics and development, politics, sociology, aquaculture, fisheries, right to food, and indigenous peoples. Food security also appears to be the most frequent keyword among the top 50 key phrases in the United Nations Sustainable Development Goals (UN SDGs) 2 (Zero hunger) related research.^b The data were generated from the Elsevier products of Scopus or SciVal, within a period of 5 years (from 2015 until 2020). It shows that food security has become a worldwide concern for the most of the world’s various stakeholders, including academia.

Food as a necessity for human survival is always a timely issue and has been considered as one of the most popular topics in the last decades (Azra et al., 2021a). The concern of the twin problems between population and food is popularly known as the Malthusian theory (i.e., Malthusian theory is about two problems of growing population and food security problems occurred at the same time). In his theory, Malthus foresaw a human population always hungry and therefore malnourished. Current food production technologies enable us to tackle the problems (i.e., theory). However, an increasing world population drove the need to increase food production efficiency even further. Recently, with the global population projected at 10 billion by 2050, this might worsen the food security challenges in the 21st century (e.g., exploitation and pressure on natural resources) (Abdullah et al., 2019; Ahmed et al., 2020; Ashraf et al., 2021; Fraser, 2020; Fróna et al., 2019; Niva et al., 2020; Rasul and Neupane, 2021; Trottet et al., 2021). Any research relates to food security issue(s),

^a <http://www.fao.org/faoterm/en/>.

^b <https://www.elsevier.com/research-intelligence/societal-impact-and-sdg-guide/goal-2-research-highlights>.

especially the importance of global food security to the world population is highly required. Currently, most of the problems relating to malnutrition and undernourishment in food security are noticeable in most countries in Africa, South-East Asia, and West Asia (Biswas et al., 2021; Dizon et al., 2021; Nasrudin et al., 2020; NOE et al., 2020; Prosekov and Ivanova, 2018).

Based on the recent literature, the Covid-19 global pandemic is among the most important issues that have been correlated with food security problems (O'Hara and Toussaint, 2021; Pakravan-Charvadeh et al., 2021; Rivera-Ferre et al., 2021). Covid-19 has shown serious negative impacts on the four pillars of food security: food availability, food stability, food accessibility, and food utilization (Aday and Aday, 2020; Erokhin and Gao, 2020; Lugo-Morin, 2020; Mardones et al., 2020). Global food security issues arising from Covid-19-related situation include supply chain disruption and trade restrictions due to lockdown and border closure (Galanakis, 2020; Laborde et al., 2020), reduced production due to social distancing (Bassett et al., 2021; Seleiman et al., 2020), and limited workforce due to movement control orders (Azra et al., 2021b). Thus, such studies identifying any global pattern, trends, and the impacts of Covid-19 on food security issues or related topics can be carried out through various analyses, one of which is scientometric analysis.

The first definition of scientometrics was introduced by Nalimov and Mulcjenko, 1971, as "the quantitative methods of the research on the development of science as an informational process." Scientometrics is also known for its systematic, continuous, and comprehensive assessment of quantitative study on patterns of science, technology, and innovation. Informetrics, bibliometrics, scientometrics, cybermetrics, and webometrics are domains in metrics science (Bar-Ilan, 2008; Hood and Wilson, 2001; Martín-Martín et al., 2018). Various tools can be used to analyze the various thematic issues such as CiteSpace, VOSviewer, HistCite, SciTools, SciMAT, CitNetExplorer, BiblioMaps, and dynamic topic modeling (Azam et al., 2021; Chatterjee and Dethlefs, 2021; Kim and Zhu, 2018; Zhou and Song, 2021). Scientometrics techniques help us measure scholar and publication impacts to specific articles or papers, journal or publication, institutional hotspot, and country. In scientometrics analysis, comprehensive assessment requires accurate sources of citation data such as two traditional and popular sources of scientometrics exercise: Web of Science (WoS) and Scopus.

Other databases that can also be used for scientometrics assessments are MEDLINE/PubMed, Google Scholar, Crossref (includes OpenCitations' COCI—CrossRef open DOI-to-DOI citations), Microsoft Academic, and Dimensions.

Scientometrics has become an essential tool for analyzing and assessing researchers research and development, their production, and collaboration between institution and academic quality (Moral-Muñoz et al., 2020). This information helps the scientific community to update the progress of the related information and knowledge over time, the connection between various disciplines (especially focusing on Covid-19 and food securities issues), and the intellectual turning point of the specialty (Chen, 2017). Due to the availability of large databases corporation (e.g., Scopus, Web of Science, PubMed) and visualization and text mining of software packages (i.e., tools) (Andriaanse and Rensleigh, 2013; Bar-Ilan, 2008; Martín-Martín et al., 2018; Xu et al., 2021), scientometrics analysis has been chosen for the proposed study. The visualized result through the scientometrics study can provide rational and detailed analysis results by reducing human bias (Chen et al., 2010; Chen and Leydesdorff, 2014; Xu et al., 2021). In addition, given the increasing popularity of Covid-19-related publication topics and the food-related disciplines, a systematic-based scientometrics investigation is needed to identify not only the emerging patterns but also current challenges and pivotal changing points in focus research objective. It also can contribute to policymakers and researchers efforts in identifying the new developments of problems and issues of Covid-19 and food security, especially at the global level.

Scientometric analysis has been done on the food safety associated with the literature on coronaviruses and Covid-19 (Haghani et al., 2020); however, to our knowledge, no study has yet scientometrically evaluated the association of the food security issue with the Covid-19 global pandemic. Therefore, it is important to investigate and assess the recent literature pattern on food security during Covid-19. The objectives of the present study are: (i) to map out the scientific contribution made for food security and Covid-19 research, and determine the link to various disciplines focusing on it; and (ii) to determine the most influential countries, journals, authors, and publications on both issues of Covid-19 and food security research. This chapter is organized as follows: after the introduction (Section 1), the methodology is presented and explained in Section 2. Section 3 conducts the

scientometric analysis and discusses the important findings, hot research themes, and evolution trends from the theme perspective. [Section 4](#) summarizes the conclusions and proposes suggestions for future research.



2. Materials and methods

This study uses scientometric methods to analyze the scientific network for food security and Covid-19 research worldwide. The scientometric method can examine the structure of a research area, the performance of countries, institutions, journals, authors, and identified top research disciplines ([Hood and Wilson, 2001](#); [Chen, 2006](#); [Lin and Su, 2020](#)).

2.1 Inclusion and exclusion criteria

Several inclusion and exclusion criteria were applied in the literature search. Literature use in this study is restricted to articles published between 1st January 2019 and 30th April 2021 (during the Covid-19 pandemic years). Only original research articles are included in the research; commentaries, short communications, books and book chapters, protocol papers, and editorials were excluded.

2.2 Search strategy

A structured and systematic search strategy was conducted using Web of Science (WoS) Core Collection databases. The literature search was conducted using specific keywords commonly used to refer to Covid-19 and a food security search code. A WoS search was put on “TS,” where the title of the manuscripts, abstract, keywords, author, and Keyword Plus included in the search code are shown. The search strategy and keywords used are shown in the study flowchart in [Fig. 1](#).

2.3 Data analysis

The visualization and information graph research in this research was created with CiteSpace tools. CiteSpace is a software program created by [Chen \(2004, 2006\)](#) that provides a detailed set of tools for creating multiple bibliometric networks and performing multiple types of analysis. This study used a network analysis to look at the interdomain specialization to specialty patterns (dual-map overlay) that connect research focus on food security and Covid-19. The literature was divided into two main categories

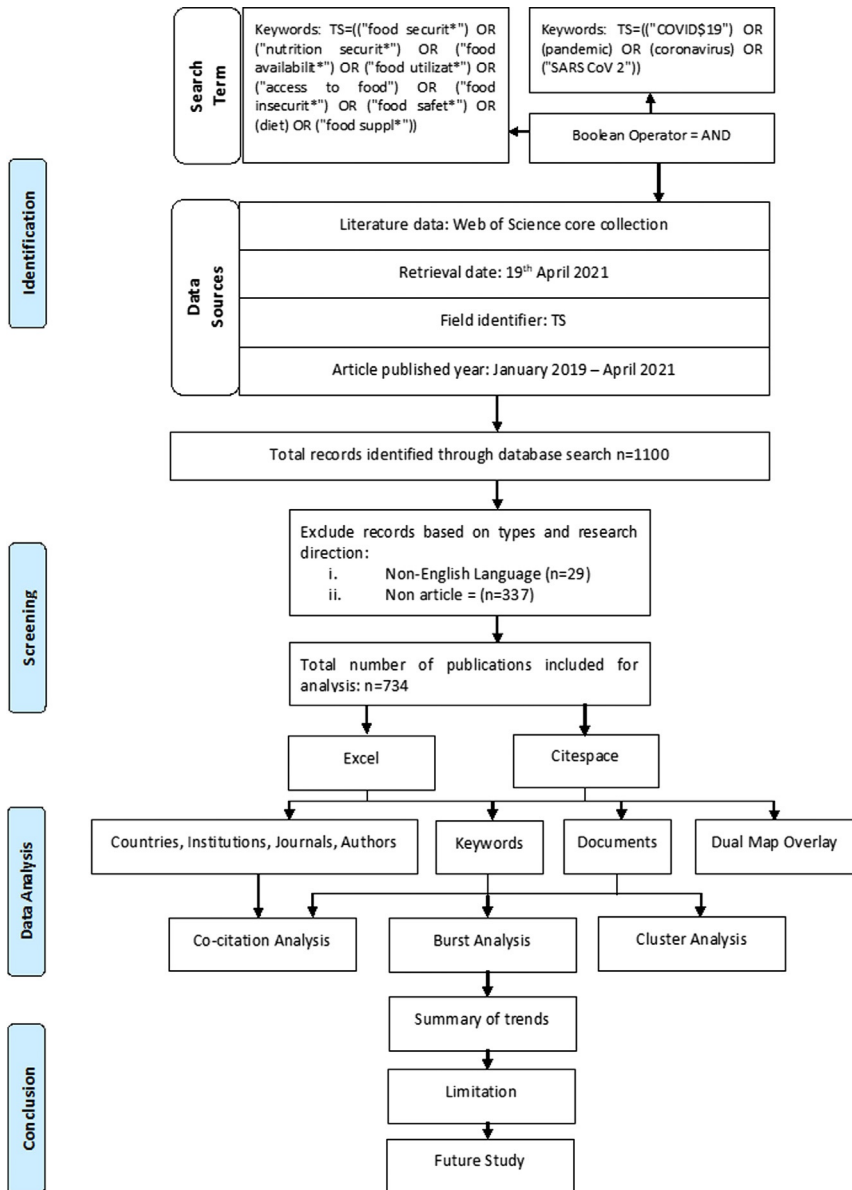


Fig. 1 Detailed retrieval strategy for the present study.

by the dual-map overlay: (1) referenced journals and (2) citing journals (i.e., the latter cited its references from the former). The frequency of these groups' relationships was physically depicted and calculated (Chen and Leydesdorff, 2014; Dahlui et al., 2020).

CiteSpace can create a variety of bibliometric networks (Chen, 2004; Chen and Leydesdorff, 2014). In this analysis, two approaches were used: (i) cocitation analysis, in which two references are quoted together, such as when nation A cites nation B or when literature A cites literature B; and (ii) cluster analysis, in which text cocitation tests are carried out to obtain a cluster of cociting articles. CiteSpace's input data came from WoS, as previously stated. Threshold settings are necessary to allow article selection to create an individual network. The Top N per slice procedure was used, which picked the most cited items from each slice to form a network based on the user-determined input value and node sort. For this analysis, a value of 50 was selected, and various node forms were used, so the top 50 most cited items were shown and ranked accordingly. The "Time Slicing" was set to 2019–2021, and the "Years per Slice" was set to 1 year. The created network was also pruned, and the "Pruning" parameter was used to do so.

For cluster recognition, a multidimensional clustering approach was used. The cluster mark was immediately extracted using the log-likelihood ratio (LLR). In terms of uniqueness and coverage, this approach was found to be the most efficient. The thesis employs a timeline and cluster view of document cocitation analyses to visualize the network's shape and structure. The timeline view is made up of a series of vertical lines arranged from left to right to represent time zones in chronological order, which is from left to right. The DCA view cluster created color-coded and automatically labeled spatial network representations in a landscape format. A 64-bit Windows CiteSpace V version 5.2.R 2.3.26.2018 was utilized in this study. The period for the time slicing was 2019 to 2021, with the parameter of slicing variable timed as one (1). All term sources, including title, abstract, author keywords, and keywords plus, were chosen during text processing.

2.3.1 Quality control and impacts

The modularity Q index, the average silhouette metric, and betweenness centrality were used to assess the quality and homogeneity of the study and observed clusters. The modularity Q index varies from 0 to 1, with higher indices showing more trustworthiness. The typical silhouette metric varies from -1 to 1, with higher values indicating greater homogeneity (Chen and Leydesdorff, 2014; Chen, 2016; Chen et al., 2009, 2010). Betweenness is a metric of impact that indicates how close articles or papers are to one another. Since they link more publications or journals and, as a result, more knowledge and pathways flow through them, publications with a higher betweenness will have a greater impact on the network (Chen, 2014, 2016; Chen et al., 2009, 2010).



3. Results and discussion

3.1 Description of the study

This section shows results based on 734 publications retrieved from January 2019 to April 2021 on food security and Covid-19 research worldwide. Based on the research design of Fig. 1, descriptive analysis is performed and then the scientometric analysis result is shown to enhance the understanding of the topic study. The h-index value is derived as at 27. It means that 27 publications have received a minimum of 27 citations each. A mean of 4.66 citations per item (i.e., paper) reasonably justifies the influence of the paper. The 734 publication has received a sum of 3241 citations (2906 citations without the self-citation).

3.2 Evolution of published studies

The analysis was focused on the scientific publications between 2019 and 2021. During this period, a total of 734 articles were gathered. The present study has considered this period (2019 until 2021) to focus on the knowledge outburst of the scientific publication of Covid-19 global health emergency which has been started from the given period of time. Table 1 shows the growth of scientific publication information of Covid-19 and food security issues with their publication years, total publication number and percentage, times cited, and h-index.

3.3 Dual map overlay

Fig. 2 is a dual-map overlay of food security and Covid-19 research articles between 2019 and 2021. Dual-map overlay detects the most productive discipline that conducts focus research and the intellectual basics of this domain. The nodes on the left are citing articles, which also determine the hotspot discipline for focus research. The nodes on the right are cited articles and discipline, which means the foundation of research of food security and Covid-19. The curve between two nodes indicates the relationship between

Table 1 Growth of publication related to the Covid-19 and food security

Publication years	Total publication (TP)	%	Times cited (CT)	TC/P	h-index
2021	242	33	116	0.48	5
2020	453	62	2935	6.48	25
2019	39	5	373	9.56	7

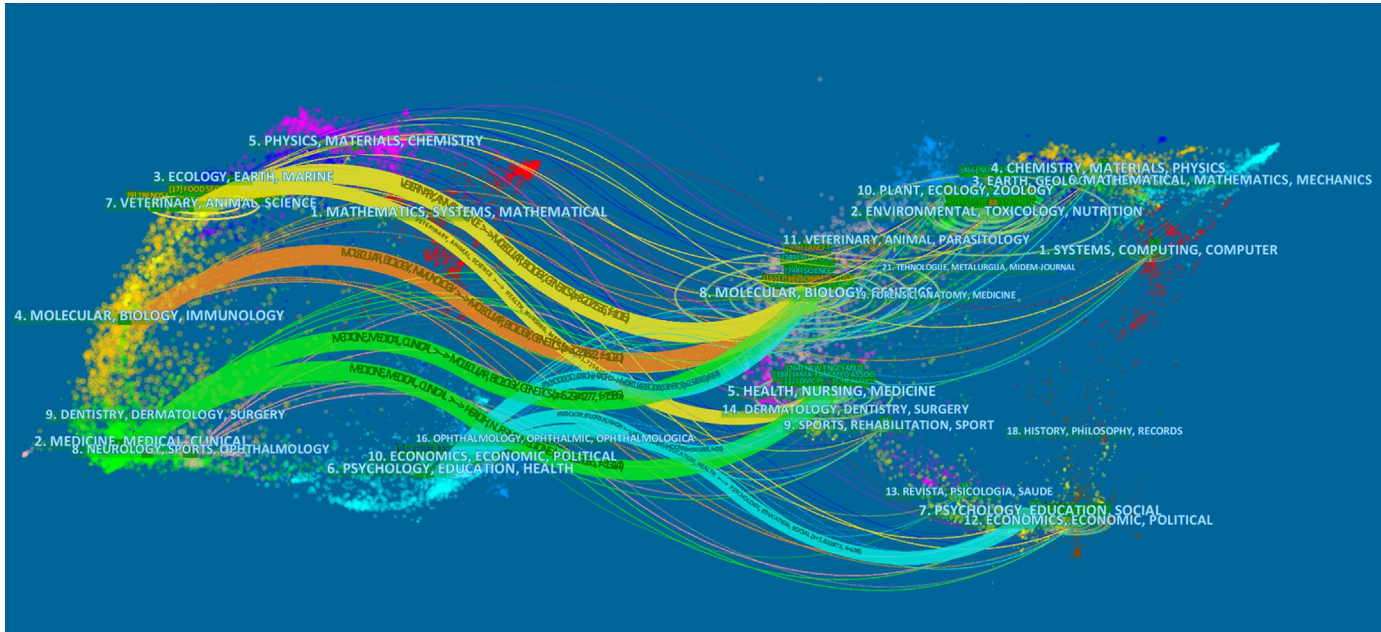


Fig. 2 Dual-map overlay on Covid-19 and food security research.

citations and the strength of the curves (after weight of z-score) is based on the number of citations (the thicker the line, the higher the number of citations). The ovals in the map indicate clusters of highly active citing and cited journals.

The results show that “Veterinary, Animal, Science,” “Molecular, Biology, Immunology,” and “Medicine, Medical, Clinical” are the disciplines that have the most publications on food security and Covid-19 research. Publications in “Ecology, Earth, Marine” mostly cited references from two types of discipline: (i) “Molecular, Biology, Genetics” and (ii) “Health, Nursing, Medicine.” These two disciplines can be considered as the intellectual basis for research focused on “Ecology, Earth, Marine” with a z-score of 3.2 and 1.7, respectively. The discipline of “Molecular, Biology, Immunology” cited articles also mostly from the “Molecular, Biology, Genetics” discipline (z-score = 3.2), while publications from “Medicine, Medical, Clinical” cited from “Medicine, Medical, Clinical” (z-score = 5.2) and “Health, Nursing, Medicine” (z-score = 4.6). Based on these results, the research areas for this topic are interdisciplinary in nature as there are many activities shown happening in the map between each discipline and research cluster.

3.4 Countries contributions and networks

The top 10 countries with the highest numbers of publications are listed in [Table 2](#). A total of 105 countries have contributed to publishing in this domain, with the United States of America (USA) accounting for 30.52% of the total publications. The USA also showed the greatest counts of publication among all countries as well as the highest h-index (16), and Italy lead the average citation per publication with 12.14, which means that each paper received at least 12 citations. [Table 2](#) and [Fig. 3](#) illustrate that the USA and England made the majority of contributions, with the USA leading in terms of total publication and citation. Tunisia, however, is shown to be having the highest influence between countries that focus research field (i.e., Covid-19 and food security), followed by Slovenia, England, Portugal, and Zambia. This is based on the centrality score of 0.37. In addition, to obtain a more comprehensive analysis of countries distribution and cooperation in the field of food security and Covid-19 scientific research, a network of coauthors based on countries is also shown in [Fig. 2](#). Each node represents a country, and the yellow line represents the cooperation of each country. The size of the nodes reflects the centrality score of the country and only

Table 2 Top 10 countries by distribution of publications.

Countries	TP	NCA	TC	TC/TP	TC/NCA	h-index
United States of America	224	1186	1333	5.95	1.12	16
England	78	505	525	6.73	1.04	11
China	68	197	207	3.04	1.05	8
India	67	294	316	4.72	1.07	9
Italy	66	627	801	12.14	1.28	12
Canada	59	325	345	5.85	1.06	10
Brazil	46	193	199	4.33	1.03	6
Spain	40	210	246	6.15	1.17	9
Australia	39	217	219	5.62	1.01	7
South Africa	27	131	133	4.93	1.02	6

Notes: TP = total number of publications; NCA = number of cited articles; TC = total citations; TC/TP = average citation per publications.

**Fig. 3** Network of countries cocitation.

country names with centrality scores greater than 0.1 are shown in Fig. 3. Based on Fig. 2, to improve the centrality score as well as to gain the highest number of citations, the present research areas should improve the quality of the publications and strengthen cooperation with other related countries.

3.5 Institution contribution and network

The top 10 institutions were ranked by the number of total articles, as shown in Table 3. Research on this area has seen contributions from 1774 organizations worldwide. Among the top 10 institutions, six were from the United States of America. The leading institution is the University of Minnesota, with 12 articles and an h-index of 4. The highest average citation rate per publication was gained by Johns Hopkins University, with almost 30; the second highest average citation was received by the Harvard T.H (Tseng-Hsi) Chan School of Public Health with 12.86 citations.

Analysis of institution distribution and cooperation in the field of focus research is shown in Fig. 4. Each node represents an institution, and the yellow line represents the cooperation of each institution. The top five

Table 3 Top 10 institutions by distribution of publications

Institution/Organization	Country	TP	NCA	TC	TC/TP	TC/NCA	h-index
University of Minnesota	U.S.A	12	31	33	2.75	1.06	3
Johns Hopkins University	U.S.A	11	329	329	29.91	1.00	4
University of Oxford	England	10	87	90	9.00	1.03	4
The London School of Hygiene & Tropical Medicine	England	8	13	13	1.63	1.00	2
National University of Singapore	Singapore	8	26	26	3.25	1.00	3
University of Michigan	U.S.A	8	53	54	6.75	1.02	3
University of North Carolina at Chapel Hill	U.S.A	8	41	41	5.13	1.00	3
Cornell University	U.S.A	7	27	27	3.86	1.00	3
Harvard T.H Chan School of Public Health	U.S.A	7	89	90	12.86	1.01	3
University of British Columbia	Canada	7	31	31	4.43	1.00	3

Notes: TP=total number of publications; NCA=number of cited articles; TC=total citations; TC/TP=average citation per publications.

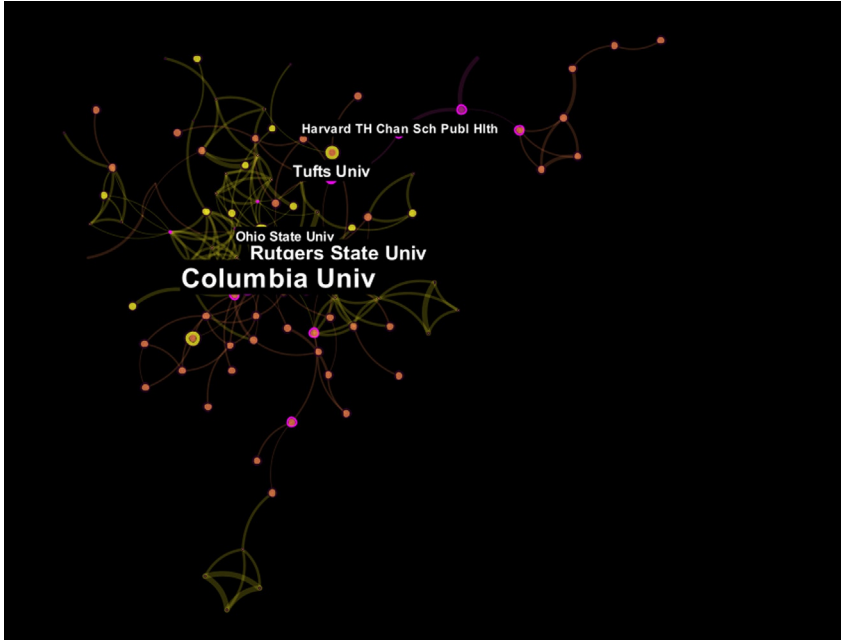


Fig. 4 Network of institutions cocitation.

institutions with the highest centrality scores are shown in this figure. Columbia University (USA) has the highest centrality score, followed by Rutgers State University (USA) and Tufts University (USA). The centrality scores are 0.37, 0.29, and 0.23, respectively. The results showed a high contrast between most published institutions and most centralized institutions. The majority of most centralized institutions published on average five publications.

3.6 Journal contribution and network

The articles were published in 409 journals. Table 4 shows the top 10 most productive journals with h-index, impact factor, and publisher. The journals publishing the most papers are *Nutrients* ($n=35$), *International Journal of Environmental Research and Public Health* ($n=28$), and *Food Security* ($n=17$). The results also showed that the highest citation received per publication is the *Nutrients* journal, published by MDPI, followed by the *Diabetes Metabolic Syndrome Clinical Research Reviews* journal.

Table 4 Top 10 productive journals.

Sources titles	TP	NCA	TC	TC/TP	TC/NCA	h-index	IF	Publisher
<i>Nutrients</i>	35	184	227	6.49	1.23	9	5.089	MDPI
<i>International Journal of Environmental Research and Public Health</i>	28	106	115	4.11	1.08	7	3.127	MDPI
<i>Food Security</i>	17	64	79	4.65	1.23	6	3.285	Springer
<i>Sustainability</i>	15	27	28	1.87	1.04	3	2.798	MDPI
<i>World Development</i>	12	38	38	3.17	1.00	4	4.749	Pergamon-Elsevier
<i>Diabetes Metabolic Syndrome Clinical Research Reviews</i>	11	78	65	5.91	0.83	4	N/A	N/A
<i>Applied Economic Perspectives and Policy</i>	9	15	16	1.78	1.07	2	2.611	Wiley
<i>Frontiers in Nutrition</i>	9	4	4	0.44	1.00	1	3.365	Frontiers Media SA
<i>PLOS One</i>	9	8	8	0.89	1.00	2	3.227	Public Library Science
<i>Trends in Food Science Technology</i>	9	14	14	1.56	100	N/A	11.39	Elsevier

Notes: TP=total number of publications; NCA=number of cited articles; TC=total citations; TC/TP=average citation per publications; IF=impact factor for 5 years; N/A=not available.

The journal cocitation results are shown in Fig. 5. The journal with a centrality score of more than 0.1 is shown by name. A “central” journal acts as the mediating role of literature in the topic being studied. *Nature* (IF: 46.488; Q1) is the most influential journal in the focus field research with a score of 0.52. This is followed by *Lancet* (IF: 59.345; Q1) and *Nutrients* (IF: 5.089; Q1), with centrality scores of 0.51 and 0.41, respectively.

The analysis of high-impact journals in the field showed that most of the journals are included in the first and second quartile of the Journal Citation Reports. Based on the impact factor and centrality score, this topic has received attention from some of the best journals in the fields of forestry, economics, and material sciences.

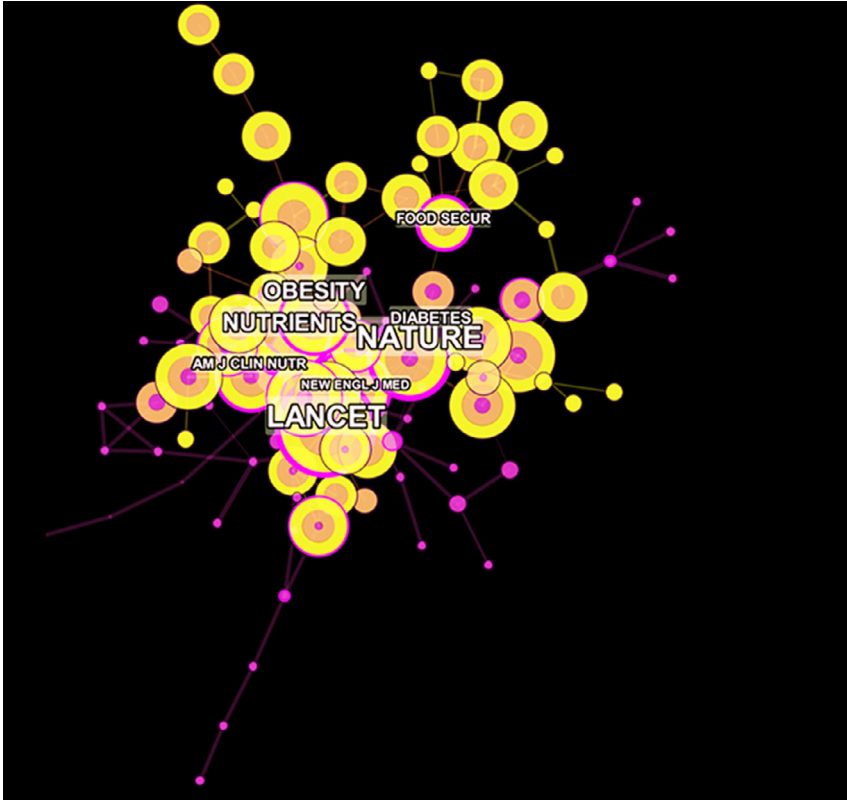


Fig. 5 Network of journal cocitation.

3.7 Author contribution and network

The 734 articles published in this area involve 4179 authors. The top 10 most productive authors are shown in Table 5. The author with the highest number of publications is Jie Li, with five publications with 60 citations and an h-index of 3. Since the publications are related to the Covid-19 global pandemic, which started at the end of 2019, there is no related network for determining the most influential journal for the study area. The most cited author with the highest average citation per publication is Alberto Davalos.

3.8 Publication analysis and network

The top 10 articles with highest citation in the focus areas are shown in Table 6. A total of 1064 citations (covering more than 30% of the whole citation received by the research area) were received by the top 10 most cited articles in the area of food security and Covid-19 research.

Table 5 Top 10 most productive authors.

Authors	TP	NCA	TC	TC/TP	TC/NCA	h-index
Jie Li	5	60	60	12.00	1.00	3
Jian Zhang	4	19	19	4.75	1.00	2
Karen Austrian	3	2	2	0.67	1.00	1
Alberto Davalos	3	53	57	19.00	1.08	3
Grant Drawve	3	29	31	10.33	1.07	3
Caroline Glagola Dunn	3	6	7	2.33	1.17	2
Kevin M. Fitzpatrick	3	29	31	10.33	1.07	3
Sheila Fleischacker	3	5	7	2.33	1.40	2
Casey Harris	3	29	31	10.33	1.07	3
Jody Harris	3	15	16	5.33	1.07	2

Notes: TP=total number of publications; NCA=number of cited articles; TC=total citations; TC/TP=average citation per publications.

The most cited paper was on the indirect effects of the Covid-19 pandemic on maternal and child mortality by [Robertson et al. \(2020\)](#). They found that Covid-19 indirectly collapsed the related health system and decreased access to food (global pandemic shock and intentional choices made in responding to the pandemic) for children under 5 years old. The second most impactful article in terms of citation received is from the study by [Renzo et al. \(2020\)](#) on the Italians eating habits and lifestyle during the Covid-19 lockdown. According to their survey on 3533 Italian respondents aged between 12 and 86 years old, Renzo et al. found that the younger population (18–30 years) had a higher adherence to the traditional healthy living diets (i.e., Mediterranean diet), and weight gain was observed by almost half of the respondents.

The fourth most cited article, by [Pietrobelli et al. \(2020\)](#), is also about the Italian-related eating lifestyle, after the article entitled “Comorbid diabetes results in immune dysregulation and enhanced disease severity following MERS-CoV infection” by [Kulcsar et al. \(2019\)](#). The study by [Pietrobelli et al. \(2020\)](#) found that intake of nonhealthy foods such as potato chips and sugary drinks increased significantly during the lockdown period. The early assessment by [Hobbs \(2020\)](#) on food supply chains at the Canada–US border was conducted during the early stages of the global Covid-19 pandemic in 2020 and is the fifth most cited article. The article found that food distribution through the expansion of online grocery shops

Table 6 Top 10 highly cited publications

Article title	Authors	Source title	Total citation
Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a modelling study	Roberton et al. (2020)	<i>Lancet Global Health</i>	176
Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey	Renzo et al. (2020)	<i>Journal of Translational Medicine</i>	163
Comorbid diabetes results in immune dysregulation and enhanced disease severity following MERS-CoV infection	Kulcsar et al. (2019)	<i>JCI Insight</i>	128
Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study	Pietrobelli et al. (2020)	<i>Obesity</i>	109
Food supply chains during the COVID-19 pandemic	Hobbs (2020)	<i>Canadian Journal of Agricultural Economics</i>	105
The food systems in the era of the Coronavirus (COVID-19) pandemic crisis	Galanakis (2020)	<i>Foods</i>	105
Global patterns in excess body weight and the associated cancer burden	Sung et al. (2019)	<i>CA: A Cancer Journal for Clinicians</i>	78
Slum health: arresting COVID-19 and improving well-being in urban informal settlements	Corburn et al. (2020)	<i>Journal of Urban Health</i>	73
Nutrition amid the COVID-19 pandemic: a multi-level framework for action	Naja and Hamadeh (2020)	<i>European Journal of Clinical Nutrition</i>	64
Early nutritional supplementation in non-critically ill patients hospitalized for the 2019 novel coronavirus disease (COVID-19): Rationale and feasibility of a shared pragmatic protocol	Caccialanza et al. (2020)	<i>Nutrition</i>	63

was the most significant change during the Covid-19 lockdown. The study also found that consumer panic buying behaviors and the sudden change in consumption patterns were the most shocking scenarios from the Covid-19 lockdown. Labor shortages and disruptions to transportation networks are the most disruptive to food supply chains.

Galanakis (2020) is the sixth most referred article in the area of food security and Covid-19 research. The study highlights the importance of the bioactive ingredients of foods and herbs in supporting the human immune system. The study by Sung et al. (2019), published in the *CA: a Cancer Journal for Clinicians* journal, provides the global patterns in excess body weight and the associated cancer burden, and is the seventh most cited article. Meanwhile, Corburn et al. (2020), Naja and Hamadeh (2020) and Caccialanza et al. (2020) are the eighth, ninth, and tenth most referenced articles, respectively. Naja and Hamadeh (2020) identified that Covid-19 has affected various levels of ecological health and behavior models, including individual (through food utilization, eating pattern), community (through food availability and accessibility, social support), national (through food security, healthy food, policies, marketing and media), and global (trade agreement, food distribution and shipping, capacity building, commodity pricing).

3.9 Cluster network

The modularity Q index and the average silhouette metric for the document cocitation network were 0.7846 and 0.9205, respectively, suggesting a high level of reliability and homogeneity for the network. A total of six cocitation clusters emerged from the analysis and two largest clusters are summarized below. Fig. 6 presents the top six clusters in the data on a horizontal line with the cluster label appearing on the right side and Fig. 6 shows the network of the whole articles. The cluster were numbered and ranked in terms of size, starting with #1 as the largest cluster. The circle showed the magnitude of the publication's influence where a large circle indicates a high citation for the publication. The purple rings indicated the centrality of the articles; high centrality articles indicated a strategic position and ability to bridge between different articles in the DCA networks. The yellow line in each line represents the lifetime of the cluster.

The top 10 articles with the most influential publication, based on the centrality score, are shown in Fig. 7. Cluster labels were generated by text

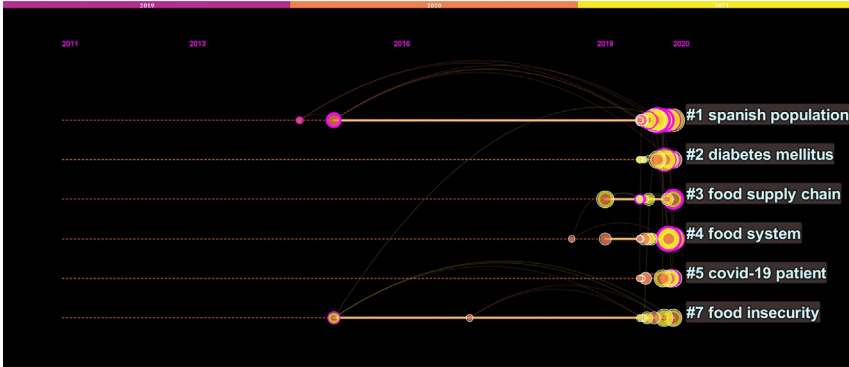


Fig. 6 Timeline view of the document cocitation network.

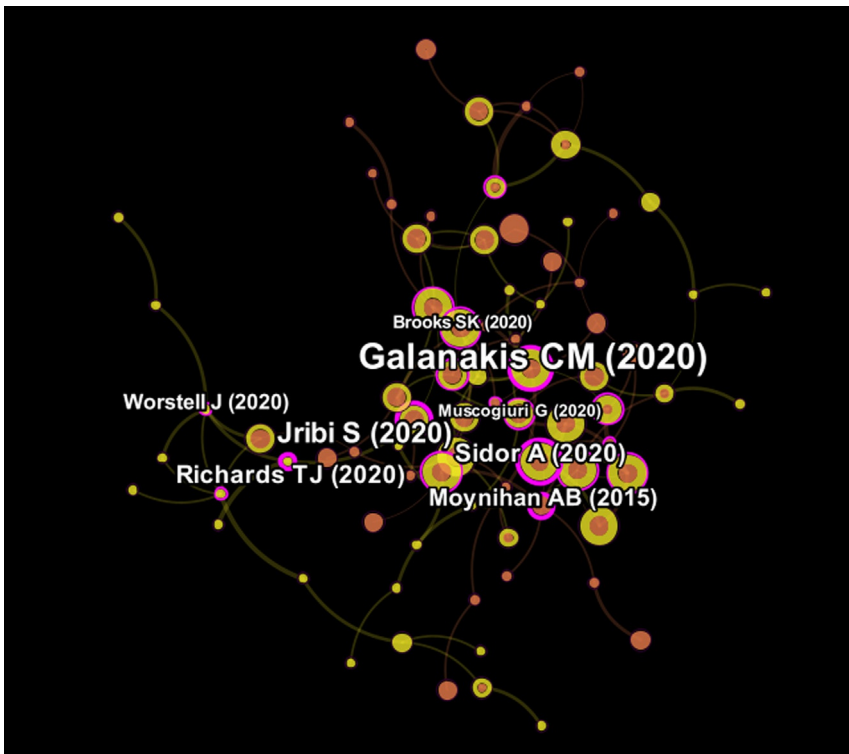


Fig. 7 Cluster view of document cocitation network (top 10 articles with highest citation shown based on the centrality score).

mining and keyword analysis algorithms in CiteSpace software. These clusters were given names according to four methods: latent semantic indexing (LSI); term frequency * inverted document frequency (TF*IDF); log-likelihood ratio (LLR); and mutual information (MI). Based on a study

by [Chen \(2010\)](#), this paper reports the cluster based on log-likelihood ratio (LLR) as the outputs of each method were not always logical.

[Table 7](#) shows the most influential publication (publications with a centrality score greater than 1); the most influential article is by [Galanakis \(2020\)](#), followed by the paper from [Jibri et al. \(2020\)](#). The third most impactful article in the area of food security and Covid-19 is a study from Poland, authored by [Sidor and Rzymiski \(2020\)](#), followed by an article from [Richards and Rickard \(2020\)](#). A previous article by [Moynihan et al. \(2015\)](#) is the last most influential paper, published by *Frontiers in Psychology*.

[Galanakis \(2020\)](#) found the possibility of certain herbs containing the potential bioactive ingredients to encounter infections such as Covid-19. The author also discussed the possibility of Covid-19 transmission through the various food chains. Meanwhile, the study by [Jibri et al. \(2020\)](#) showed the impact of the Covid-19 lockdown on 284 respondents regarding Tunisian consumer awareness, attitudes, and behavior related to food wastage. Most respondents agreed that Covid-19 lockdown impacted their socio-economical context such as food availability, loss of income, and restricted movement, compared to the pro-environmental concern. A study on cross-sectional online survey of Polands population during the quarantine period found that eating behavior and dietary habits were affected under Covid-19 lockdown ([Sidor and Rzymiski, 2020](#)). Meanwhile, growers

Table 7 Top five most influential publications (centrality score > 0.1).

Title	Authors	Sources title	Centrality score
The food systems in the era of the Coronavirus (COVID-19) pandemic crisis	Galanakis (2020)	<i>Foods</i>	0.31
COVID-19 virus outbreak lockdown: What impacts on household food wastage?	Jibri et al. (2020)	<i>Environment, Development and Sustainability</i>	0.25
Dietary choices and habits during COVID-19 lockdown: Experience from Poland	Sidor and Rzymiski (2020)	<i>Nutrients</i>	0.22
COVID-19 impact on fruit and vegetable markets	Richards and Rickard (2020)	<i>Canadian Journal of Agricultural Economics</i>	0.22
Eaten up by boredom: consuming food to escape awareness of the bored self	Moynihan et al. (2015)	<i>Frontiers in Psychology</i>	0.22

and distributors in Canadian fruit and vegetable markets were significantly impacted by the Covid-19 lockdown (closure of restaurants, bars, and school) (Richards and Rickard, 2020).

3.10 Cluster characteristics

Table 8 presents the top two major clusters that emerged from DCA analysis. Each cluster represents a research topic in the research areas. The size of the cluster indicates the number of publications it has. The two clusters have 16 and 15 publications, respectively. The silhouette score is 0.946 for cluster #1 and 0.798 for cluster #2. This indicates a high homogeneity between publications in each cluster (silhouette score ranges from -1 to 1 , with scores higher than 0 seen as homogenous). The publications were placed in each type of cluster because they were cited by a similar group of publications, thus representing a cocitation relationship. The top two clusters are described in Table 8.

Table 9 shows the top five most influential publications in cluster #1 (Spanish population) with a centrality score greater than 0.1 . This cluster contains 16 publications with a silhouette of 0.946 and a mean year 2019. The top publication of the article in this cluster is from Sidor and Rzymiski (2020) on the impact of the Covid-19 lockdown from 1097 respondents regarding Poland's food consumption behavior. The second most influential publication under the cluster of the Spanish population is on eating behavior as a function of boredom by Moynihan et al. (2015). This is followed by a publication from Brooks et al. (2020) on the negative physiological impact of the Covid-19 lockdown. The fourth impactful article from this cluster #1 is from a study by Wang et al. (2020) on the immediate psychological responses and associated factors during the early stages of the Covid-19 pandemic, followed by a study by Rodríguez-Pérez et al. (2020) on the dietary changes among the Spanish population during the home confinement caused by Covid-19.

Table 10 shows the top three most influential publications in cluster #2 (Diabetes mellitus) with centrality scores greater than 0.1 . Cluster #2 contain 15 publications with a silhouette value 0.798 and a mean year 2020.

Table 8 Top two clusters within the Covid-19 and food security research area

Cluster ID	Size	Silhouette	Mean year	Cluster label
1.	16	0.946	2019	Spanish population
2.	15	0.798	2020	Diabetes mellitus

Table 9 Cluster #1: Spanish population (top five most influential publications in cluster #1 with centrality scores >0.1)

Title	Authors	Sources title	Centrality score
Dietary choices and habits during COVID-19 lockdown: Experience from Poland	Sidor and Rzymiski (2020)	<i>Nutrients</i>	0.22
Eaten up by boredom: consuming food to escape awareness of the bored self	Moynihan et al. (2015)	<i>Frontiers in Psychology</i>	0.22
The psychological impact of quarantine and how to reduce it: rapid review of the evidence	Brooks et al. (2020)	<i>The Lancet</i>	0.16
Immediate psychological responses and associated factors during the initial stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the general population in China	Wang et al. (2020)	<i>International Journal of Environmental Research and Public Health</i>	0.14
Changes in dietary behaviors during the COVID-19 outbreak confinement in the Spanish COVIDiet study	Rodríguez-Pérez et al. (2020)	<i>Nutrients</i>	0.13

Table 10 Cluster #2: Diabetes mellitus (top three most influential publications in cluster #2 with centrality scores >0.1).

Title	Authors	Sources title	Centrality score
Nutritional recommendations for CoVID-19 quarantine	Muscogiuri et al. (2020)	<i>European Journal of Clinical Nutrition</i>	0.15
COVID-19 confinement and changes of adolescent’s dietary trends in Italy, Spain, Chile, Colombia and Brazil	Ruiz-Roso et al. (2020)	<i>Nutrients</i>	0.14
Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study	Pietrobelli et al. (2020)	<i>Obesity</i>	0.10

The most influential article in cluster #2 is from the study by [Muscogiuri et al. \(2020\)](#), about the positive impact of carbohydrate-rich foods as one of the ways to self-medicate stress. The study also found that unhealthy food leads to developing obesity, complications to heart and lung disease, and indirectly increases Covid-19 complications. [Ruiz-Roso et al. \(2020\)](#) in their study identified that home confinement (due to movement control order) risked degenerative diseases such as obesity through poor dietary habits. Thus, they proposed that the modification of nutritional diets during Covid-19 home quarantine may have influenced changes among the 820 adolescents from Spain, Italy, Brazil, Colombia, and Chile. [Pietrobelli et al. \(2020\)](#) provided the third most influential article in cluster #2, in which they assessed the impact of 3 weeks of Covid-19 lockdown on the lifestyle information (such as diet, activity, and sleep behaviors) of 41 children in Verona, Italy. Their study found that there are no changes in reported vegetable intake; however, there was slightly increased fruit intake among the children. The authors also emphasized that the lockdown period may have a lasting impact on a child's or adolescent's adult adiposity level ([Pietrobelli et al., 2020](#)).

3.11 Overall publication trends

This study aimed to perform a scientometric study on food security and Covid-19 research to obtain the current status of this study areas and detect its research trends. This study focuses on scientific publications between January 2019 and April 2021, with a total of 734 publications being produced. Even though the timeframe is only 2 years and 4 months, the high number of publications show that this issue has received high interest from researchers worldwide. As the pandemic issues are still far from over, our forecast is that this topic of study will have high numbers of researchers involved and publications will continue to increase in the near future.

Based on the results, “Veterinary, Animal, Science,” “Molecular, Biology, Immunology,” and “Medicine, Medical, Clinical” are the main disciplines that focus on these areas. This area has proven to be interdisciplinary, where most of the publications cited from discipline are different than their own. Most of the publications are from applied science areas and there are few to no publications from social science. This is the gap that we found from the analysis, and future research might focus on this issue. Some of the issues that might be of interest for new focus is this area include poverty, women and children, and governance.

The USA is the most productive countries in this focus area. With 224 publications and an h-index of 16, this country accounts for 30.52% of total publications that focus on this issue. However, in terms of centrality, Tunisia is shown to be the country with the highest influence on this topic. With high influence of publication, most of the studies follow the information cited from Tunisia. This shows that studies based on Tunisia might influence the trajectory of this research area in the future. The leading institution in terms of total publications is the University of Minnesota in the USA, and in terms of influence it is Columbia University, again in the USA. Based on country and institution analysis, this area of research has been dominated by researchers from the USA. This is in line with other scientometric results, as the USA is one of the leading countries in terms of research capability.

The analysis on journals in the field has shown that food security and Covid-19 research is a multidisciplinary focus research. The area has seen publications from some of the highest-impact journals in the fields of health, environment, and food security. The journal publishing the most papers is *Nutrients* with 35 publications, and the most influential journal is *Nature* with a centrality score of 0.52. Each journal is located in quartile 1 in the Web of Sciences database and has a high impact factor. This shows that this research area has been important in the current situation and the research done is of high quality.

The article with the highest number of citations is from [Roberton et al. \(2020\)](#), “Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a modelling study,” with 176 citations overall and 88 citations on average per year. They found that the Covid-19 indirectly collapsed the related health system and decreased access to food (global pandemic shock and intentional choices made in responding to the pandemic) for children under 5 years old.

The most influential publication in this area is a publication by [Galanakis \(2020\)](#). This paper found the possibility of certain herbs containing the potential bioactive ingredients to encounter infections such as Covid-19. The author also discussed the possibility of Covid-19 transmission through the various food chains. This paper has a centrality score of 0.31 and 105 citations for 3 years.

Both articles discuss at length the impact of Covid-19 on food security. However, the gap found in the most cited and most influential articles is the lack of qualitative study in this area. Most articles focus on the macro site of

the situations and show a lack of micro understanding. This can be further explored by other researchers in future studies.

A total of six cocitation clusters emerged from the analysis with the top two clusters, as explained in the study. The cluster were numbered and ranked in terms of size, starting with #1 as the largest cluster. The silhouette scores for clusters ranged from 0.7846 to 0.9205. This indicates a high homogeneity between publications in each cluster (silhouette score ranges from -1 to 1 , with scores higher than 0 seen as homogenous). The clusters were labeled as “Spanish population” and “Diabetes mellitus” by using the log-likelihood ratio (LLR) method. The top publication of the article in this cluster was from [Sidor and Rzymiski \(2020\)](#) on the impact of Covid-19 lockdown from 1097 respondents regarding Poland’s food consumption behavior.

The most influential study in cluster #2 is a study by [Muscogiuri et al. \(2020\)](#), about the positive impact of carbohydrate-rich foods as one of the ways to self-medicate stress. The study also found that unhealthy food leads to developing obesity, complications to heart and lung disease, and indirectly increases Covid-19 complications.

3.12 Limitations of the study

Although we consider that the findings from the present study provided insight into the scientific framework and network, the study has its limitations, like other scientometric studies. Firstly, this study considered only scholarly articles relating to Covid-19 and food security research, as reflected in WoS (core collection only); other large databases such as Scopus and PubMed were not included. Previous studies found that different databases (i.e., Scopus versus WoS) have their own bias in terms of update entries and choice of sources ([Pal, 2021](#)). Secondly, this study also only includes articles in the English language. Thirdly, as mentioned earlier, the food security terms are associated with other terms such as aquaculture, fisheries, right to food, etc. However, for the present study, we used the most representative keywords to label the topic, especially the food security topic, which is the most frequent term (i.e., nutrition security, food availability, food utilization, food safety, etc.), but the subjects of others associated with food security or closely aligned are not allowed. Finally, the datasets (publication and trends) were identified using computer software of CiteSpace, rather than being selected manually, as manual selection is required for more detailed systematic reviews.

WoS is deemed better for investigating as its database is geared toward hard science and social sciences, and gives its wider databases and scope compared with other available datasets (Andriaanse and Rensleigh, 2013; Bar-Ilan, 2008). Future research could compare other sets of databases with WoS for mapping photovoice method research around the world.

The other restriction is the use of CiteSpace software to mine the publication (collected automatically). The dataset might be subject to bias due to the chance of including irrelevant subjects. The decision to balance between stringent criteria and overexcluding certain studies is a challenge. Future researchers who aim for high precision can consider using more stringent keyword searches to reduce the likelihood of irrelevant studies. Lastly, only the names of the principal (first) authors were used in the cocitation analyses performed in this study. Databases of cited publications downloaded from WoS did not include the names of other contributing authors even though citing publications did not possess such restrictions. If additional author names were made available by these databases, the cocitation analysis might yield different results.



4. Conclusion and recommendations

In the present scientometric study, we identified a great number of peer-reviewed articles (734) in the research field (Covid-19 and food security), with the United State leading the field and Tunisia having the highest influence between countries. *Nutrients* (published by MDPI) was the core journal with most publications, but *Nature* is the most influential in terms of cocitation, and Jie Li was the most active author. Accordingly, studies on Covid-19 and food security research have been published in more than 409 journals, contributed by more than 1700 organizations worldwide. Surprisingly, more than 4000 authors were involved in this research area, which took less than 2 years to produce with such a huge number of authors. The results may be useful for early career researchers who are interested in this research domain of Covid-19 and food security, which assists academic and researchers in teaching or research purposes. The results may also be useful for journal editors to identify hot topics for special issues in the future. Further works on systematic literature review can be directed to better understand the development of the focus area. Example research questions include how knowledge of the latter impact of Covid-19 can be used to establish sustainable food security, and how Covid-19 and food security research will help stakeholders to draft decision-making processes in the future.

Future in-depth research such as a systematic literature review (SLR) on Covid-19's impacts on food security are truly needed to understand further the thematic issues within the proposed research area. The RepORting standards for Systematic Evidence Syntheses (ROSES) and Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) can be used to assess any research gaps and problems for the Covid-19 and food security issue.

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