International Journal of Information Science and Management
Vol. 21, No. 2, 2023, 85-101
DOI: https://doi.org/10.22034/ijism.2023.1977814.0 / DOR: https://dorl.net/dor/20.1001.1.20088302.2023.21.2.6.8

Original Research

Bibliometric Analysis and Topic Modeling of Information Systems in Maternal Health Publications

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Received: April 26 2022
Accepted: July 06 2022

Abstract

Due to the importance of maternal health for the development of society and the role of information systems in improving healthcare, this study aims to investigate and analyze the characteristics and topics of articles published in the field of information systems in maternal health. The articles were retrieved from the Web of Science (WoS) on October 23, 2021. The bibliometric indicators included the number of documents and citations, top journals, institutes, and countries. The co-authorship collaboration network of the countries was examined using Bibliometrix 3.1 package and VOSviewer software (ver. 1.6.17). In addition to bibliometric analysis, the related topic modelling was calculated with Non-Matrix Factorization (NMF) algorithm in Python programming language. Overall, 1140 original articles were published in the selected field in the WoS database within the years 1991-2021. The results demonstrated an ascending growth in the number of publications. The "The University of London", the "London School of Hygiene Tropical Medicine", and the "World Health Organization" (WHO) contributed the most to this field orderly. Researchers from the USA with 372 (32.63%), Brazil with 267 (23.42%), and England with 150 (13.2%) documents had the most scientific collaboration on publishing in this regard. The USA and England had the most collaboration in 38 articles in the co-authorship network of countries. Based on topic modelling analysis, five topic clusters, including "maternal mortality", "child and infant mortality", "risk

factors related to pregnancy and maternal health", "Geographic Information Systems (GISs)", and "data quality in Health Information Systems (HISs)" were considered for this research. According to the research results, it can be concluded that there is a rising trend in the number of articles published in the field of information systems in maternal health. The USA, Brazil, and England have played a prominent role in scientific production in this regard. Given that this study gives a snapshot of the current status of the research topic and visualizes the collaboration between countries, the obtained results can guide future collaboration and encourage scientific institutes to expand their interactions.

Keywords: Bibliometrics, Topic Modeling, Maternal Health, Information Systems.

Introduction

Maternal healthcare is very critical in health strategies because pregnant women are vulnerable, and the fetus's survival and newborn well-being are closely related to it (Koblinsky et al., 2016; Le Meur, Gao & Bayat, 2015; Lund et al., 2012; Song, May, Vaidhyanathan, Cramer, Owais & McRoy, 2013). Annually, many women and newborns die due to pregnancy-related events. Based on the World Health Organization (WHO) reports, the global maternal mortality rate is excessively high, with around 810 maternal deaths occurring daily, 94% of the total maternal mortality in developing countries (Ahmadian, Salehi & Bahaadinbeigy, 2020; Babamohamadi, Jangjo, Nejat & Kahouei (2016).

The global strategy for women's health includes an integrated continuum of quality care with efficient pregnancy, childbirth, and postpartum interventions, leading to maternal and child survival and preventing maternal morbidity and mortality (Frøen et al., 2016). One of the main factors enhancing the health systems is using and improving the health information systems (HISs) (Kihuba et al., 2014). Information technology (IT) and HISs have transformed and advanced healthcare.

In recent years, extensive software and IT services implementation has helped health professionals improve their healthcare. These advances have allowed healthcare professionals to work more efficiently and effectively (Ahmadian et al., 2020). Whitten and Bentley (2007) defined the information system as: "An arrangement of data/information, processes, people, and information technology interacting to collect, process, store, and disseminate the information, the output needed to support the organization". Information systems and ITs in healthcare include a broad range of applications, products, and services that health providers, patients, governments, researchers, and financial organizations use (Wager, Lee & Glaser, 2017).

As previously mentioned, due to the importance of maternal health and the role of HISs in improving the quality of healthcare-related processes and facilitating information management and cost management, HISs are also widely used in maternal healthcare. This has led to the conduction of numerous studies regarding the design, use and status of information systems and IT in maternal health, implying the need for help to understand and understand the current situation in this field. On the other hand, by being aware of the current situation and the progress made in the selected subject areas, a comprehensive picture of the scientific activities of researchers, journals, countries, and institutions in that area will be obtained, which is essential for setting research policies and priorities in a thematic area, and also in a correct understanding of the past situation. Bibliometric analysis through statistical and mathematical techniques has been considered an effective and reliable approach for evaluating scientific outputs (Chen & Xie, 2020). Topic modelling is used due to the expansion of textual resources to extract knowledge from the texts and identify the main topics. The topic modelling approach uses

statistical algorithms to extract semantic information from texts. To our knowledge, no study has reviewed these studies using the topic modelling approach. Thus, the present study aimed to analyze these studies based on bibliometric indicators and topic modelling analysis. The research addresses the following questions:

1. What are the time and citation trends of publications in information systems in maternal health?
2. What are the most cited articles and the most productive countries, institutions, journals, and researchers in information systems in maternal health?
3. What is the collaboration network of countries in the field of information systems in maternal health?
4. What are the topical clusters of articles in information systems in maternal health?

Literature Review

Table 1 summarizes the methodologies and findings of some bibliometrics/scientometrics and topic modelling studies conducted about maternal and child health.

Table 1

Summary of studies conducted concerning maternal and child health

Article title	Author's name and date of publication	Methodology	Most essential results
Thyroid Diseases during Pregnancy: Bibliometric Analysis of Scientific Publications	Yuan, Wang, Li & Zhang (2022)	- Bibliometric approach - 3310 records from the Web of Science (WoS) database. - The software used in this study (VOSviewer, CiteSpace and CitNetExplorer)	- The United States had the largest number of articles and contributions. - Harvard University had the most articles and H-Index. - Thyroid Journal published most articles. - Pregnancy was the most frequent keyword.
Bibliometric Analysis of Global Research on Perinatal Palliative Care	Wang, Shan, Tian, Pu & Zhu (2021)	- Bibliometric approach - 114 records from the WoS database - The software used in this study (VOSviewer)	- The United States played the most important role in this area, with the most significant number of articles, citations, and collaborations with Canada, Portugal, and Australia. - York College of Pennsylvania was the most prolific institution. - Wool C., was the most productive author in the field. - The Journal of Palliative Medicine was the most prolific publication. - Five main topics identified by the co-occurrence network ("(i) candidates for PPC; (ii) PPC models and forms; (iii) components

Article title	Author's name and date of publication	Methodology	Most essential results
			related to the PPC framework (iv) parental perspectives and satisfaction; and (v) challenges and needs of health care providers".
Exploring the Structure and Trends of Research on Single mother: A Bibliometrics Analysis	Abdullah, Rahmat, Ariffin, Rahim, Jamalludin & Wahab (2022)	- Bibliometric approach - 836 records from the Scopus database - The software used in this study (Biblioshiny)	- The collaboration index was 1.71 - The most productive (- Author: Jones D. J - Country: The United States - Institution: The University of California) - Top frequent keywords: female, single parent, adult
Bibliometric Analysis of Research Studies Based on Federally Funded Children's Health Surveys	Lebrun-Harris et al. (2021)	- Bibliometric approach - 716 records from the WoS database - The software used in this study (VOSviewer)	- The most productive: (- Institution: the University of California System - Journal: Maternal and Child Health Journal) - Top three topics (obesity, adverse childhood experiences, autism)
Mapping Maternal Health in the New Media Environment: A Scientometric Analysis	Xie et al. (2021)	- Scientometric approach - 2270 records from the WoS database - The software used in this study (CiteSpace)	- The most productive:(- Country: The United States - Institution: University of Toronto) - Top frequent keywords: pregnancy, health, risk
Worldwide Original Research Production on Maternal Near-Miss: A 10-year Bibliometric Study	Hernández-Vásquez, Bendezu-Quispe, Comandé & Gonzales-Carillo (2020)	- Bibliometric approach - 326 records from the Scopus database - The software used in this study (VOSviewer)	- The most productive:(- Author: Ceccatti JG - Country: Brazil - Journal: BMC Pregnancy and Childbirth) - Top frequent keywords: prospective surveillance, score, primary outcome measure, mortality ratio, the case fatality rate
Worldwide Research on Fear of Childbirth: A Bibliometric Analysis	Dai, Zhang, Rong and Ouyang (2020)	- Bibliometric approach - 743 records from the WoS, PubMed, Embase and the Cochrane Library databases - The software used in this study (VOSviewer)	- The most productive:(- Country: Sweden - Institution: KarolinskaInst /Hosp - Journal: Midwifery - Author: Hildingsson, I) - Top frequent keywords: Cesarean section, experience, factor.

Article title	Author's name and date of publication	Methodology	Most essential results
Analysis of Women's Health Online News Articles Using Topic Modeling	Cho, Kim and Woo (2019)	- Topic modelling approach - 7,710 records from women's health-related online news (1993 to 2015) - Latent Dirichlet Allocation (LDA) algorithm	- In different periods, the most critical topic has been like this: - 1993-2000: "Healthcare" - 2001-2005: "Medical Services" - 2006-2010: "Skin Health" - 2011-2015: "Dietary Supplement"
Bibliometric Mapping and Clustering Analysis of Iranian Papers on Reproductive Medicine in the Scopus Database (2010-2014)	Bazm, Kalantar and Mirzaei (2016)	- Bibliometric approach and social network analysis - 3141 records from the Scopus database - The software used in this study (VOSviewer)	- The most productive:(- Author: Soleimani M - Institution: Tehran University of Medical Sciences - Journal: Iranian Journal of Reproductive Medicine)

According to Table 1, scientometric and bibliometric studies and topic analysis in the subject areas related to maternal and child health, including "Thyroid Diseases During Pregnancy", "Perinatal Palliative Car", "Single Mothe", "Maternal Near-Mis", "Children's Health", "Reproductive Medicin", "Women's Health", "Fear of Childbirth", and"Maternal Health in the New Media Environment" have been done; however, no study on information systems in maternal health has been done so far. The contribution of the present study is that in addition to investigating a different research area and using the bibliometric approach, it has also used the topic modelling approach to understand better the thematic structure and trend in this field, which has been less addressed in previous studies. For this purpose, the NMF algorithm was used, which is suitable for short texts (Chen, Zhang, Liu, Ye & Lin, 2019).

Materials and Methods

Data collection and cleaning

This applied research was conducted using the bibliometric and topic modelling approaches. A search strategy was developed for WoS to identify documents related to information systems in maternal health. The WoS database was one of the most reputable and authoritative multidisciplinary bibliographic data sources frequently used in the bibliometric and scientometric analyses that provide citation information for evaluation (Li, Rollins & Yan, 2018; Visser, van Eck, & Waltman, 2021). The search strategy is presented in Table 2. The search process and data retrieval were performed on October 23, 2021. The inclusion criteria for entering the study were all published documents related to our topic until the end of 2021

indexed in the WoS. The exclusion criteria were any document type except "Articles". The data were extracted in Tab-Delimited format.

Table 2
The search strategy used in the present study

Database name	Search string	Number of results
Web of Science™ (WoS)	((TS = (health OR hospital OR management OR "ambulatory care" OR pharmacy OR radiology) AND TS = ("information system*")) OR (TS = ("medical order entry system*" OR "decision support system*" OR "electronic health system*" OR "medical record system*" OR "medical informatics"))) AND (TS = (maternal OR perinatal OR Maternity OR prenatal OR antenatal OR postpartum OR puerperal OR reproductive) AND TS = (health OR Welfare))	1140

Data analysis

The bibliometric indicators included the number of documents, number of citations, most cited documents, number of authors, the average number of authors per document, top authors, top journals, top institutes, and countries, which were examined using the Bibliometrix 3.1 package for R (Aria & Cuccurullo, 2017) and VOSviewer software (ver. 1.6.17) (van Eck & Waltman, 2010). The topic modelling of the retrieved articles was also studied in the present research. To achieve this goal, Term Frequency-Inverse Document Frequency (TF-IDF) weighting algorithm and Non-Matrix Factorization (NMF) algorithm from the Scikit-learn package (Pedregosa et al., 2011) were used in Python Language Programming.

For the topic modelling, the "Author Keywords" and "Keyword Plus" fields were considered for each document to get a more accurate process. First, the data were preprocessed, which means doing case conversion (or converting all words letters to lowercase) for uniformity and preprocessing the text for later stages. Next, the similarity between the keywords was calculated with the help of the Fuzzy-wuzzy tool in the Python environment. For this purpose, those pairs of keywords with more than 90% similarity were selected and extracted. Then they were checked manually, and if they were correctly similar to each other due to their singular or plural form (e.g. surveillance system, surveillance systems), the difference in British or American writing (e.g. paediatrics, paediatrics), the existence of some characters like hyphen (e.g. pregnant women, pregnant women), and variation of keywords (e.g. obstetric nursing, obstetrical nursing), a thesaurus file was created order to map these keywords automatically in the corpus, help the uniformity of corpus, and reduce the vocabulary size is worth noting that if the records of both fields were empty or the number of keywords was less than two words, they were removed from the collection. Finally, 1080 records were selected for topic modelling.

Next, the TF-IDF weighting algorithm was used to determine the weighting and the importance of the words in each document and set of documents. TF-IDF is one of the most well-known weighting algorithms based on the bag of words model. In this model, the location and order of the words do not matter, and the semantic relations of the words are not considered; instead, only the occurrence of the words in each document is essential. The TF-IDF consists of two main factors: frequency of the word in a document and inverse document frequency. The occurrence of a word should not be high in any of the documents in the collection

(Manning, Raghavan & Schütze, 2008). Using the TF-IDF algorithm, the words were weighted and then the term-document matrix was given to the NMF algorithm for topic modelling.

Non-Negative Matrix Factorization (NMF) is an unsupervised method to reduce dimensions and clustering. It works by breaking a document into words and building a term-document (A) matrix. Then this matrix is decomposed into two low-rank factor matrices. NMF produces two matrices with non-negative coefficients (W and H). (W) demonstrates the topics it found, and (H) demonstrates the coefficients of these topics (Lopes & Ribeiro, 2015; Shi, Kang, Choo & Reddy, 2018). The distribution of topics in each document was determined using matrices (W), and the coefficients of each feature in all topics were determined using a matrix (H). Finally, the dominant topic of each document and the most frequent words in each topic were extracted and presented in a word-cloud diagram.

Results

Overall, 1140 original articles were published in the WoS in information systems in maternal health from 1991 to 2021. Most of the articles in this collection were written in English (n=1003, 88%), followed by Portuguese (n=108, 9.5%) and Spanish (n=15, 1.3%). Our findings demonstrated an ascending growth in the number of publications. Time trend analysis of the frequency of publications and total citations of documents in each year is presented in Figure 1.

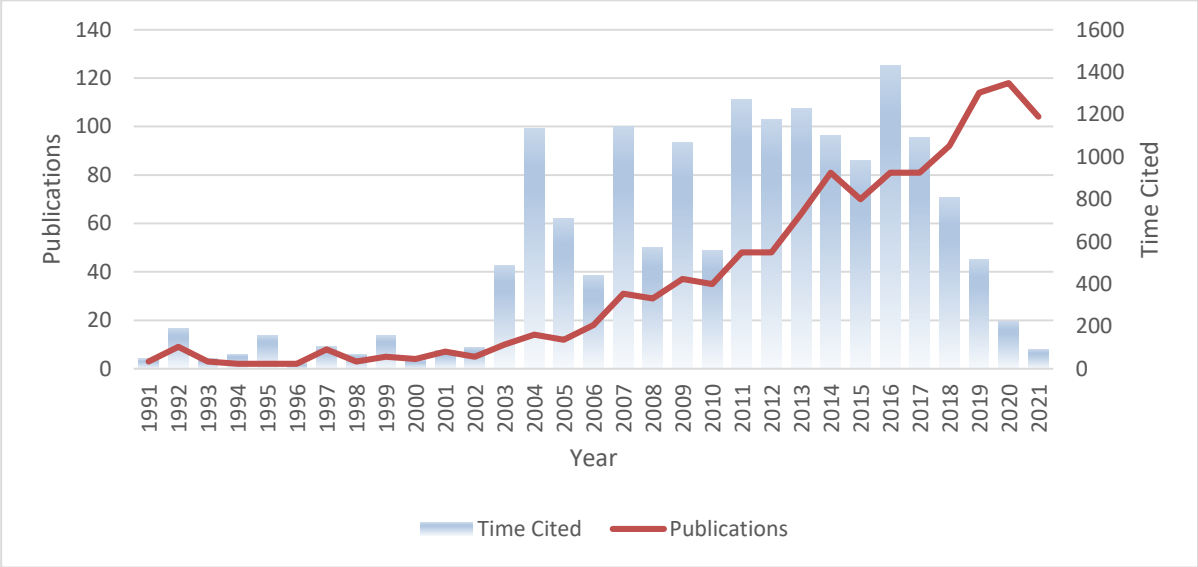

Figure 1: Frequency of publications and total citations of documents in the field of information systems in maternal health by the year of publication

Overall, information systems in maternal health documents received 17119 citations in the WoS. The average number of citations per document was 15.01. The h-index for this collection was 55, meaning there were 55 documents in our collection with 55 or more citations. The top 10 most cited documents in this field are presented in Table 3. As can be seen, the highest number of citations in the selected field belongs to the article "The future of family medicine: a collaborative project of the family medicine community", with 454 citations at the time of this study. It is worth mentioning that these top 10 articles accounted for approximately 15% of the total citations of articles in this collection.

Table 3

Top 10 most cited publications in the WoS in the field of information systems in maternal health

	Author (Date)	Title	TC	CPY	Source	IF $_{2020}$
1	Gorey TM., et al. (2004)	The future of family medicine: a collaborative project of the family medicine community	454	26.7	Annals of Family Medicine	5.166
2	Mokdad AH., et al. (2016)	Global burden of diseases, injuries, and risk factors for young people's health during 1990-2013: a systematic analysis for the global burden of disease study 2013	401	80.2	Lancet	79.321
3	Abouzahr C., (2003)	Global burden of maternal death and disability	295	16.4	British Medical Bulletin	4.291
4	Conde-agudelo A., et al. (2005)	Maternal-perinatal morbidity and mortality associated with adolescent pregnancy in Latin America: a cross-sectional study	274	17.1	American Journal of Obstetrics and Gynecology	8.661
5	Bolton-Moore C., et al. (2007)	Clinical outcomes and CD4 cell response in children receiving antiretroviral therapy at primary health care facilities in Zambia	264	18.9	JAMA-Journal of the American Medical Association	56.272
6	Patton GC., et al. (2012)	The health of the World's Adolescents: A synthesis of internationally comparable data	246	27.3	Lancet	79.321
7	Ziraba AK., et al. (2009)	The state of emergency obstetric care services in Nairobi informal settlements and environs: results from a maternity health facility survey	245	20.4	BMC Health Services Research	2.655
8	Gabrysch S., et al. (2011)	The influence of distance and level of care on delivery place in rural Zambia: a study of	205	20.5	PLOS Medicine	11.069

	Author (Date)	Title	TC	CPY	Source	IF 2020
		linked national data in a geographic information system				
9	Bliddal M., et al. (2018)	The Danish medical birth register	165	55.0	European Journal of Epidemiology	8.082
10	Slama R., et al. (2007)	Traffic-related atmospheric pollutants levels during pregnancy and offspring's term birth weight: a study relying on a land-use regression exposure model	155	11.1	Environmental Health Perspectives	9.031

***TC**: Total Citations; **CPY**: Citations Per Year*

The author-level analysis of information systems in maternal health documents demonstrated that 5426 authors, averaging 4.75 authors per paper, had participated in publishing these 1140 documents. "Lawn JE" with 13 (1.1%) and "Blank A", "Mathias TAD", and "Saraceni V" with 9 (0.8%) documents were the most prolific authors, orderly. Also, "Murray CJL" with 678, "Degenhardt L" and "Patton GC" with 647, and "Lopez AD" with 646 citations were the most cited authors in this field, orderly.

The "The University of London", the "London School of Hygiene Tropical Medicine", and the "WHO", with 79, 63, and 50 articles, respectively, contributed the most to this field, and 114 countries contributed to writing these articles. Researchers from the USA with 372 (32.63%), Brazil with 267 (23.42%), and England with 150 (13.2%) documents had the most scientific collaboration on publishing in this field of study, orderly.

Figure 2 shows the co-authorship network of countries with a threshold of at least five documents (52 countries) in the selected field. These 52 countries are divided into five clusters using VOSviewer software. In this map, the colors represent different clusters, each node represents a country, and the size of each node indicates the number of articles published by that country in the entire collection. The links between the nodes also indicate the countries" collaboration in writing articles in this collection. The thickness of the links indicates that the two countries were cooperating more with each other. The USA and England had the most collaboration in 38 articles in the co-authorship network of countries. The USA collaborated with Switzerland in 24 articles and Canada in 20. England and Sweden collaborated on 17 articles, and the USA and South Africa had 15 standard articles.

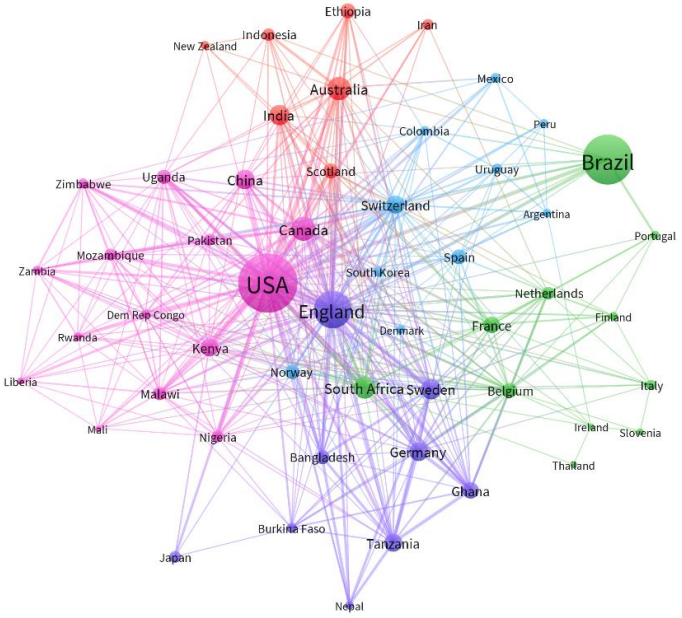

Figure 2: Co-authorship collaboration network of the world countries in information systems in maternal health

A review of the journals publishing documents in the field of information systems in maternal health revealed that the "Cadernos de SaúdePública" with 44 (3.9%), "PLOS ONE" with 42 (3.7%), and "Revista de SaúdePública" with 40 (3.5%) documents were the most prolific journals, orderly. Additionally, they have published more than 25% of the articles on information systems in maternal health. More information about the Impact Factor, number of publications, total citations, average citation per publication, journal h-index, and publication year of the first document published by a journal for each of the top 10 most prolific journals are represented in Table 4.

Table 4
Top 10 most prolific journals in the field of information systems in maternal health

	Sources	IF_{2020}	NP	TC	Avg. CPP	h-index	PY-start
1	Cadernos de Saudepublica	1.632	44	405	9.2	12	2007
2	PLOS ONE	3.240	42	595	14.2	12	2009
3	Revista de Saudepublica	2.106	40	431	10.8	12	1993
4	BMC Health Services Research	2.655	39	617	15.8	12	2006
5	BMC Pregnancy and Childbirth	3.007	27	428	15.9	12	2010
6	Epidemiologia e Servicos de Saude	1.901	24	113	4.7	5	2009
7	Global Health Action	2.640	18	189	10.5	8	2009
8	International Journal of Gynecology & Obstetrics	3.561	18	274	15.2	11	2001
9	Ciencia & Saudecoletiva	1.336	18	181	10.1	8	2011
10	BMJ Global Health	2.640	18	81	4.5	5	2018

IF: *Impact Factor;* ***NP****: Number of Publications;* ***TC****: Total Citations;* ***Avg. CPP****: Average Citations per Publication;* ***PY-start****: Publication Year (of the first document published by a journal)*

As the NMF topic modelling algorithm first needs to choose the number of topics; hence, according to the opinion of two experts in the information systems in the maternal health field, five topic clusters were considered for the present research. After performing analytical processes on the data and determining the topic clusters, 50 keywords with the highest weight in each cluster, along with ten document titles and abstracts with the most relevance in that cluster, were given to the experts. They were then asked to assign an appropriate topic label to each cluster separately; eventually, with the consensus of these experts, a topic label was considered for each cluster. Topic 1, with 154 documents, was related to "Maternal mortality"; topic 2, with 189 records, was associated with "Child and infant mortality"; topic 3, with 319 documents, belonged to the "Risk factors of pregnancy and maternal health", Topic 4 with 142 articles about "Geographic Information Systems (GISs)", and Topic 5 with 276 documents was related to "Data quality in Health Information Systems". Figure 3 displays the most important keywords of each topic cluster. In the following, the top five keywords in each topic are presented.

Topic 1 (Maternal mortality): mortality, maternal mortality, causes of death, women's health, and death

Topic 2 (Child and infant mortality): information systems, infant mortality, risk factors, maternal and child health care, and Brazil

Topic 3 (Pregnancy and maternal health): pregnancy, health, women, outcomes, and prevalence

Topic 4 (Geographic Information Systems): Geographic Information Systems (GISs), access, health care, maternal health, and accessibility

Topic 5 (Data quality in Health Information Systems): health information systems, quality, data quality, care, and antenatal-care

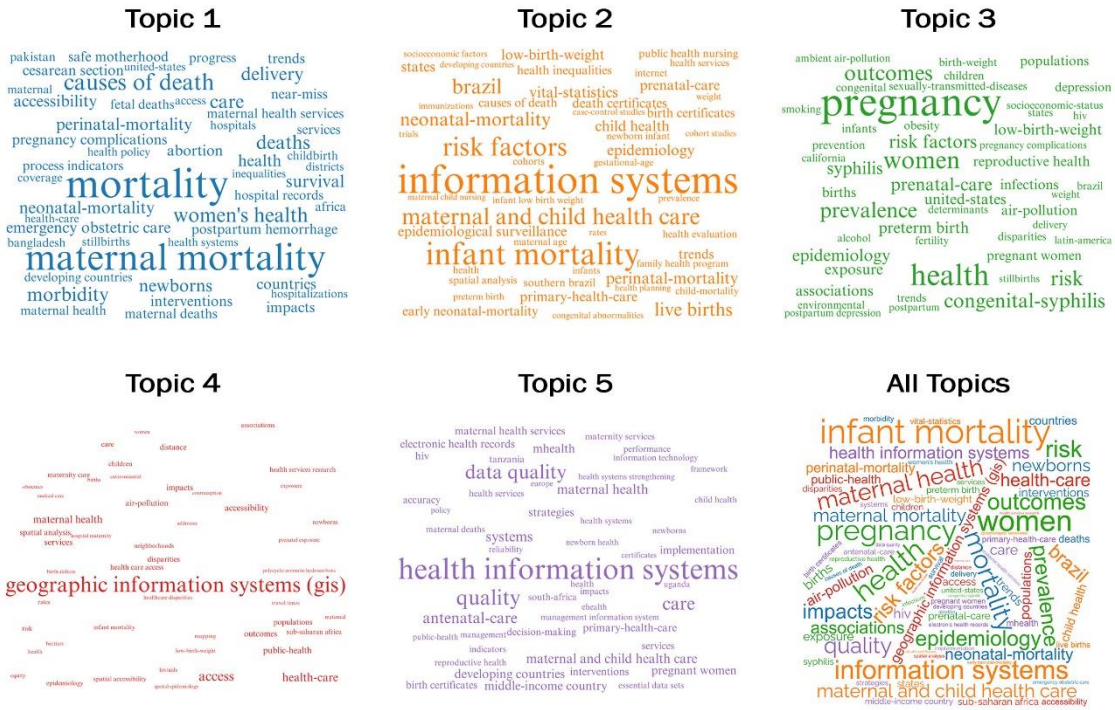

Figure 3: Top 50 words in each topic cluster in information systems in maternal health

Figure 4 illustrates the status of topics over five-year intervals. Each topic is identified with a unique color (Topic 1: blue; Topic 2: yellow; Topic 3: green; Topic 4: red; and Topic 5: purple). In 1991-2000 (10-year period), the number of documents in each topic were few, and Topic 4 (Geographic Information systems) had no articles in this period. However, the number of documents started to increase from 2001, such that from 2016 to 2021, Topic 3 (Pregnancy and maternal health) had the highest number of articles (n=173).

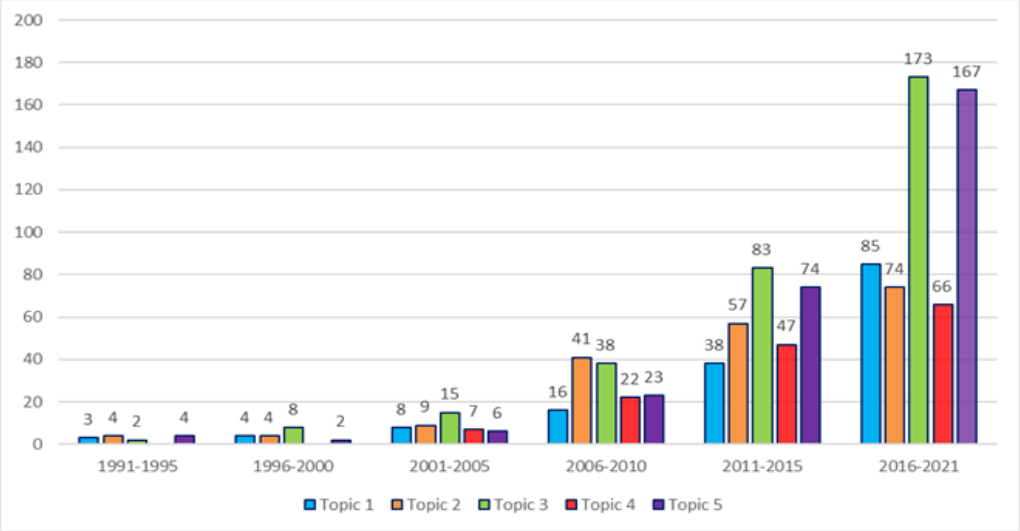

Figure 4: The status of each topic in the five-year interval in the field of information systems in maternal health

Discussion

The present research results showed that scientific outputs in maternal health information systems increased from 1991 to 2021. The trend in the number of articles can be due to the importance of maternal health for the development of society and the growing use of IT in all areas. This result is consistent with the findings of Yuan et al. (2022), who reviewed the articles on thyroid diseases during pregnancy using a bibliometric approach. They found a significant annual growth of articles in the studied area since 1991. Also, Wang et al. (2021) reported the rapid growth of articles in perinatal palliative care in recent years. In Xie et al. (2021) study on maternal health in the new media environment, the number of published articles showed an increased trend. In the bibliometric analysis of Hernández-Vásquez et al. (2020) on maternal near-miss over ten years, article production has also been rising. Similarly, Dai et al. (2020) pointed to the upward trend in article production on fear of childbirth.

In the present study, articles in the field of information systems in maternal health received an average of more than 15 citations; however, 55 articles received at least 55 citations, indicating their findings' use in other studies. The highest number of citations belonged to the year 2017. "Lawn JE", "Blank A", "Mathias TAD", and "Saraceni V" published the most articles, and Murray CJL", "Degenhardt L", "Patton GC", and "Lopez AD" received the most citations. In the study of Abdullah et al. (2022), who examined the structure and trend of articles in the field of single mothers, the highest number of articles (n= 60 documents) was in 2013, and Jones D. J., Forehand R., and Franz M. published the most articles (Abdullah et al., 2022). The highest number of articles in the field of perinatal palliative care (n=26 articles) was in 2020, and Wool, Charlotte; Cote-Arsenault, Denise; and Tosello, Barthelemy published the

most articles (Yuan et al., 2022). Cecatti JG, Souza JP and Parpinelli MA published the most articles in Maternal Near-Miss, and the highest number of published articles (n=45) was related to 2017 (Hernández-Vásquez et al., 2020). In fear of childbirth area, the most significant number of articles belonged to 2019, with Hildingsson, I.; Ryding, E.L.; And Fenwick, J. having the most articles in the studied area (Dai et al., 2020).

According to the results, the "University of London", the "London School of Hygiene Tropical Medicine", and "WHO" contributed the most to the field of information systems in maternal health, meaning that these information systems have been of great importance to them. Harvard University, the University of California System and the University Libre de Bruxelles were most involved in producing articles on thyroid disease during pregnancy (Yuan et al., 2022). Organizational affiliation of the University of California, the University of Georgia and the University of Michigan contributed the most to producing articles on single mothers (Abdullah et al., 2022). The University of Toronto, the University of California and the University of North Carolina played the most crucial role in researching the New Media Environment (Xie et al., 2021). KarolinskaInst/Hosp, Uppsala Univ/Hosp, and Linkoping Univ/Hosp spent the most researching fear of childbirth (Dai et al., 2020).

Researchers from the USA, Brazil, and England had the most scientific collaboration on publishing in the field of information systems in maternal health. The USA-England, the USA-Switzerland, and the USA-Canada had the most scientific collaboration. According to the research findings, the countries were divided into five clusters based on the collaboration network. The first cluster includes 15 countries, the second cluster 11 countries, the third cluster 10 countries, the fourth cluster 9 countries, and the fifth cluster seven countries. In the following, the three most productive countries in some related fields are represented, the results of which are partially consistent with the results of this study: they include thyroid disease during pregnancy (USA, China, England) (Yuan et al., 2022); single mothers (USA, Canada, UK) (Abdullah et al., 2022); perinatal palliative care (USA, France, Canada) (Yuan et al., 2022); the Maternal Near-Miss (Brazil, USA, India)(Hernández-Vásquez et al., 2020); fear of childbirth (Sweden, Iran, USA) (Dai et al., 2020), and the New Media Environment (USA, Australia, UK) (Xie et al., 2021).

"Cadernos de SaúdePública", "PLOS ONE", and "Revista de SaúdePública" were the most prolific journals. Portuguese was the most widely used language after English, and authors from Brazil had the highest number of articles after the USA. Two of the top three journals that published articles in the field of information systems in maternal health ("Cadernos de SaudePublica" and "Revista de SaudePublica") belonged to Brazil. These results indicate the attention of Brazil to the role of information systems in maternal health and can be considered one of the concerns of health research in Brazil. It is worth noting that reducing maternal mortality is considered a priority for Latin American countries (De La Torre, Nikoloski, &Mossialos, 2018). Thyroid, The Journal of Clinical Endocrinology Metabolism, and Clinical Endocrinology were the most prolific journals on thyroid disease during pregnancy (Yuan et al., 2022). Journal of Palliative Medicine, Frontiers in Pediatrics, and JOGNN: Journal of Obstetric Gynecologic and Neonatal Nursing were the most productive journals in perinatal palliative care (Yuan et al., 2022). Midwifery, BMC Pregnancy and Childbirth, and ActaObstetricia Et Gynecologica Scandinavica have published many articles on the fear of childbirth (Dai et al., 2020). BMC Pregnancy and Childbirth, International Journal of

Gynecology and Obstetrics, and BJOG: An International Journal of Obstetrics and Gynecology were the most prolific journals in the maternal near-miss (Hernández-Vásquez et al., 2020).

The results of the topic modelling analysis showed that the articles in Topic 1 mainly discuss maternal mortality and its contributing factors. The articles in Topic 2 focus on infant mortality, the related factors, and the use of information systems in this field. The most significant number of articles are under Topic 3, which focuses on epidemiological studies and identifying diseases and risk factors, as well as economic and social conditions affecting pregnancy and maternal and child health. In these studies, data from information systems have been used for testing, screening, surveillance, monitoring, etc. The articles in Topic 4 refer to GISs, and spatial data in the care of mothers and children and discuss inequality and access to health services in this area. Topic 5 articles focus on data quality validation and assessment of HISs in maternal and child health in developing or low- and middle-income countries. The topical analysis results based on time revealed that articles on GISs in maternal health (Topic 4) were presented from 2001 to 2005; then, the number of articles in this field grew. Articles related to Topics 3 and 5 have grown more than other topics in recent years, indicating the importance of these two topics in the view of researchers. In a topic modelling study on the news related to women's health in the years 1993-2015, 7710 articles were clustered in different periods using the LDA algorithm; the most important topic in each period was as follows: 1993-2000 (Healthcare); 2001-2005 (Medical services); 2006-2010 (Skin health); and 2011-2015 (Dietary supplement) (Cho et al., 2019). The most common keywords were pregnancy, Geographic Information System (GIS), health, information systems, mortality, risk factors, maternal mortality, health information systems/HISs, infant mortality, and women. Xie et al. (2021) study on maternal health in the new media environment, pregnancy, health, risk, Internet, care, intervention, mother, children, prevalence, and pregnant women were the most frequent keywords. Cesarean section, experience, factor, care, pain, anxiety, level, hospital, vaginal delivery, and support were ten frequent keywords in Dai et al. (2020) study on fear of childbirth.

Conclusion

This study was conducted with the aim of bibliometric and topic analysis in information systems in maternal health. Overall, 1140 articles were reviewed. According to the research results, it can be concluded that special attention is being paid worldwide due to the rising trend in the number of articles published in this field. It was revealed that the published articles had been cited and used in various studies. The United States, Brazil, and England have played a prominent role in scientific production. Brazilian journals also contribute the most to publishing articles on the information systems in maternal health, maybe due to the care network program implemented by the Brazilian Ministry of Health (called Stork Network) to improve maternal and child health indicators in Brazil in 2011. The program aimed gradually integrate maternal and child health throughout the country (Souza, de Morais, da Silva Costa & de Andrade, 2021). The USA and England had the most collaboration in the co-authorship network of countries. Similar studies in this area have pinpointed the role of the United States at the forefront of scientific production. Based on the topical analysis results, the topics related to the epidemiology of diseases and significant risk factors in pregnancy and maternal and child health had the major number of articles. The point made in the topical analysis is the need to pay due

attention to the quality of data recorded in information systems by low-income and developing countries to discuss proper data recording and storage.

Given that this study gives a snapshot of the current status of information systems in maternal health and visualizes the collaboration between countries, these results can guide future collaboration and encourage scientific institutes to develop their interactions. Also, according to the topic modelling analysis, the topics that have recently concerned more consideration and need more research can help future research. This study had some limitations, including using one source of information (WoS database); future studies should consider several sources of information for a more comprehensive search of sources. Another limitation was that the topic modelling of the articles was based on the "Author Keywords" and "Keyword Plus" fields to obtain more accurate algorithm results. In future studies, a deeper topic analysis can be performed on the "Title" and "Abstract" fields along with the "Keywords" fields.

Acknowledgements

This study was part of a Ph. D. dissertation supported by the Tehran University of Medical Sciences (NO: IR.TUMS.SPH.REC.1379.116).

References

Abdullah, S. S., Rahmat, M. I. Y., Ariffin, A., Rahim, S. A., Jamalludin, N. M. & Wahab, N. A. (2022). Exploring the structure and trends of research on single mother: a bibliometrics analysis. *Journal of Global Business and Social Entrepreneurship (GBSE)*, 7(23). Retrived from http://myscholar.umk.edu.my/bitstream/123456789/4268/1/Paper-285-.pdf

Ahmadian, L., Salehi, F. & Bahaadinbeigy, K. (2020). Application of geographic information systems in maternal health: A scoping review. *Eastern Mediterranean Health Journal*, 26(11), 1403-1414. https://doi.org/10.26719/emhj.20.095

Aria, M. & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959-975. . https://doi.org/https://doi.org/10.1016/j.joi.2017.08.007

Babamohamadi, H., Jangjo, M., Nejat, M. & Kahouei, M. (2016). Exploring the effectiveness of obstetrics and gynecology information systems in hospitals of a developing country: A qualitative content analysis. *International Journal of Medical Research Health Sciences*, 5(7), 554-563. Retieved from https://www.ijmrhs.com/medical-research/exploring-the-effectiveness-of-obstetrics-and-gynecology-information-systems-in-hospitals-of-a-developing-country-a-qual.pdf

Bazm, S., Kalantar, S. M. & Mirzaei, M. (2016). Bibliometric mapping and clustering analysis of Iranian papers on reproductive medicine in Scopus database (2010-2014). *International Journal of Reproductive BioMedicine*, 14(6), 371-382. PMID: 27525320; PMCID: PMC4971550

Chen, X. & Xie, H. (2020). A Structural topic modeling-based bibliometric study of sentiment analysis literature. *Cognitive Computation*, 12(6), 1097-1129. . https://doi.org/10.1007/s12559-020-09745-1

Chen, Y., Zhang, H., Liu, R., Ye, Z. & Lin, J. (2019). Experimental explorations on short text topic mining between LDA and NMF based Schemes. *Knowledge-Based Systems*, 163, 1-13. . https://doi.org/10.1016/j.knosys.2018.08.011

Cho, K. W., Kim, S. Y. & Woo, Y. W. (2019). Analysis of women's health online news articles using topic modeling. *Osong Public Health Research Perspectives*, 10(3), 158-169. https://doi.org/10.24171/j.phrp.2019.10.3.07

Dai, L., Zhang, N., Rong, L. & Ouyang, Y. Q. (2020). Worldwide research on fear of childbirth: A bibliometric analysis. *PLOS ONE*, 15(7), e0236567. . https://doi.org/10.1371/journal.pone.0236567

Frøen, J.F., Myhre, S.L., Frost, M.J., Chou, D., Mehl, G., Say, L., Cheng, S., Fjeldheim, I., Friberg, I.K., French, S. & Jani, J.V. (2016). eRegistries: Electronic registries for maternal and child health. *BMC Pregnancy and Childbirth*, 16(1), 1-15. . https://doi.org/10.1186/s12884-016-0801-7

Hernández-Vásquez, A., Bendezu-Quispe, G., Comandé, D. & Gonzales-Carillo, O. (2020). Worldwide original research production on maternal near-miss: A 10-year bibliometric study. *Revista Brasileira de Ginecologia e Obstetrícia*, 42(10), 614-620. . https://doi.org/10.1055/s-0040-1715136

Kihuba, E., Gathara, D., Mwinga, S., Mulaku, M., Kosgei, R., Mogoa, W., Nyamai, R. & English, M. (2014). Assessing the ability of health information systems in hospitals to support evidence-informed decisions in Kenya. *Global Health Action*, 7(1), 24859. . https://doi.org/10.3402/gha.v7.24859

Koblinsky, M., Moyer, C.A., Calvert, C., Campbell, J., Campbell, O.M., Feigl, A.B., Graham, W.J., Hatt, L., Hodgins, S., Matthews, Z. & McDougall, L (2016). Quality maternity care for every woman, everywhere: A call to action. *The Lancet*, 388(10057), 2307-2320. https://doi.org/10.1016/S0140-6736(16)31333-2

Le Meur, N., Gao, F. & Bayat, S. (2015). Mining care trajectories using health administrative information systems: the use of state sequence analysis to assess disparities in prenatal care consumption. *BMC Health Services Research*, 15(1), 200. . https://doi.org/10.1186/s12913-015-0857-5

Lebrun-Harris, L.A., Parasuraman, S.R., Norton, C., Livinski, A.A., Ghandour, R., Blumberg, S.J. & Kogan, M.D. (2021). Bibliometric analysis of research studies based on federally funded children's health surveys. *Academic pediatrics*, 21(3), 462-470. https://doi.org/10.1016/j.acap.2020.08.004

Li, K., Rollins, J. & Yan, E. (2018). Web of Science use in published research and review papers 1997–2017: A selective, dynamic, cross-domain, content-based analysis. *Scientometrics*, 115(1), 1-20 . https://doi.org/10.1007/s11192-017-2622-5

Lopes, N. & Ribeiro, B. (2015). Non-Negative Matrix Factorization (NMF). In *Machine Learning for Adaptive Many-Core Machines - A Practical Approach* (pp. 127-154). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-06938-8_7

Lund, S., Hemed, M., Nielsen, B.B., Said, A., Said, K., Makungu, M.H. & Rasch, V., (2012). Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: a cluster-randomised controlled trial. *BJOG: An International Journal of Obstetrics & Gynaecology*, 119(10), 1256-1264. . https://doi.org/10.1111/j.1471-0528.2012.03413.x

Manning, C. D., Raghavan, P. & Schütze, H. (2008). *Introduction to Information Retrieval*: Cambridge University Press Cambridge.

Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., Blondel, M., Prettenhofer, P., Weiss, R., Dubourg, V. & Vanderplas, J., (2011). Scikit-learn: Machine learning in Python. *the Journal of Machine Learning Research*, 12, 2825-2830.

Shi, T., Kang, K., Choo, J. & Reddy, C. K. (2018). Short-text topic modeling via Non-negative matrix factorization enriched with local word-context correlations. In *Proceedings of the 2018 World Wide Web Conference*, Lyon, France. https://doi.org/10.1145/3178876.3186009

Song, H., May, A., Vaidhyanathan, V., Cramer, E. M., Owais, R. W. & McRoy, S. (2013). A two-way text-messaging system answering health questions for low-income pregnant women. *Patient Education and Counseling*, 92(2), 182-187. https://doi.org/10.1016/j.pec.2013.04.016

Souza, D. R. S., de Morais, T. N. B., da Silva Costa, K. T., & de Andrade, F. B. (2021). Maternal health indicators in Brazil: A time series study. *Medicine*, 100(44). e27118. https://doi.org/10.1097/MD.0000000000027118

van Eck, N. J. & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

Visser, M., van Eck, N. J. & Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative Science Studies*, 2(1), 20-41. https://doi.org/10.1162/qss_a_00112 %J Quantitative Science Studies

Wager, K. A., Lee, F. W. & Glaser, J. P. (2017). *Health care information systems: A practical approach for health care management*. United States of America: San Francisco: John Wiley & Sons.

Wang, Y., Shan, C., Tian, Y., Pu, C. & Zhu, Z. (2021). Bibliometric analysis of global research on perinatal palliative care. *Front Pediatr*, 9, 827507. https://doi.org/10.3389/fped.2021.827507

Whitten, J. L. & Bentley, L. D. (2007). *Systems analysis and design methods*. New York, The United States: McGraw-Hill

Xie, Y., Lang, D., Lin, S., Chen, F., Sang, X., Gu, P., Wu, R., Li, Z., Zhu, X. & Ji, L., (2021). Mapping maternal health in the new media environment: A scientometric analysis. *International Journal of Environmental Research and Public Health*, 18(24), 13095.. https://doi.org/10.3390/ijerph182413095

Yuan, N., Wang, L., Li, Z. & Zhang, X. (2022). Thyroid diseases during pregnancy: bibliometric analysis of scientific publications. *Endocrine, Metabolic & Immune Disorders - Drug Targets*, 22(2), 247-258. . https://doi.org/10.2174/1871530321666210203214142