

Analysis Of Articles on Evidence-Based Medicine

Kanıtı Dayalı Tıp Konusundaki Makalelerin Analizi

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ABSTRACT

The aim of this study is to conduct a bibliometric analysis of articles on evidence-based medicine. Using Bibliometrix and VOSviewer software, the most efficient author, country, organization, and journals were identified. Web of Science articles between the years of 1975-2019 were downloaded with a search strategy and analyzed with Bibliometrix and VOSviewer software. It has been observed that evidence-based medicine articles were grouped under three main clusters (Management and Decision Support, Drug and Experiment and Measurement). The first three countries that have the highest international collaboration rate are Switzerland, New Zealand, and Sweden. The first five countries regarding publication numbers are the USA, United Kingdom, Canada, Australia, and Germany. While Khan and Green have the highest grade in h and g index; Bağlı, Castagnetti and Fossum have the highest grade in m index. Guyatt is the author who has the highest number of citations whereas Phillips is the one who has the most publications. While, on one hand, evidence-based medicine extends its function in illness and drug treatments, on the other hand, it is used as policy input to improve the education, curriculum, and the health system. Policy-makers, decision-makers, educators, and researchers can develop strategies according to the findings identified above.

Keywords: Evidence Based Medicine, EBM, Bibliometric Analysis

ÖZET

Bu çalışmanın amacı, kanıtı dayalı tıp ile ilgili makalelerin bibliyometrik analizini yapmaktır. Bibliyografya ve VOSviewerometrix kullanılarak en etkili yazar, ülke, organizasyon ve dergiler belirlenmiştir. 1975-2019 yılları arasındaki Web of Science makaleleri Bibliyografya ve VOSviewer yazılımları ile indirilerek analiz edilmiştir. Kanıtı dayalı tıp makalelerinin üç ana küme (Yönetim ve Karar Destek, İlaç ve Deney, Ölçme) olarak toplandığı görülmüştür. Uluslararası işbirliğinin en yüksek olduğu ilk üç ülke; İsviçre, Yeni Zelanda ve İsveç'tir. Yayın sayılarına göre ilk beş ülke; ABD, Birleşik Krallık, Kanada, Avustralya ve Almanya'dır. Khan ve Green h ve g indeksinde en yüksek puana sahipken; Bağlı, Castagnetti ve Fossum "m" indeksinde en yüksek değere sahiptir. Guyatt en fazla atıf alan yazarken, Phillips en fazla yayını olan yazardır. Kanıtı dayalı tıp, bir yandan hastalık ve ilaç tedavilerindeki işlevini genişletirken, diğer yandan eğitim, müfredat ve sağlık sistemini iyileştirmek için politika girdisi olarak kullanılmaktadır. Politikacılar, karar vericiler, eğitimciler ve araştırmacılar bu çalışma sonuçlarına göre gelecekle ilgili tahmin edilebilir stratejiler geliştirebilirler.

Anahtar Kelimeler: Kanıtı Dayalı Tıp, EBM, Bibliyometrik Analiz

Introduction

When the research articles studying Evidence-Based Medicine (EBM) are examined, it'll be noticed that the concept has been examined with many different approaches and techniques. The pioneering study of Guyatt and others (1992) starting with a different approach in terms of the application of medical training and quite a few publications regarding the decision-making process of physicians and physician candidates (Bates et al. 2003; Rosenberg and Donald, 1995; Sim et al. 2001) began to appear. Classification through EBM and studies based on the categorization related to evidence levels (Sackett, 1997;

Harbour and Miller, 2001; Burns et al. 2011) set up the substructure of clinical decision-making. EBM has both been the subject of software like ADDIS (Van Valkenhoef et al. 2013) in the clinical decision-making process in time and was evolved up to the cooperation through Bayesian networks (Ashby & Smith, 2000)

When examined in terms of illness types, many illnesses such as hypertension (Hyman & Pavlik, 2000), brain trauma (Fakhry et al. 2004), hepatocellular carcinoma (Raza and Sood, 2014), lumbar scoliosis (Bridwell et al. 2009), atrial fibrillation (Howitt & Armstrong, 1999), premature ejaculation (Waldinger, 2004), acute myocardial infarction

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(Meterko et al. 2010), cholesterol (Vale et al. 2002) and irritable bowel syndrome (Saha, 2014) were examined in illness process regarding EBM approach. There is not any study examining only in terms of illness types. Besides, there are EBM studies peculiar to drug treatments as it is in optimal vitamin D treatment. There are numerous studies examining health professions (McColl et al. 1998), health settings (Oliveri et al. 2004), health policy (Lohr et al. 1998), health ethics (Hope, 1995; Kelly et al. 2015), how EBM must be measured through Fresno (Ramos et al. 2003) and Berlin survey (Fritsche et al. 2002) and theoretical and application-based problems of EBM (Feinstein and Horwitz, 1997; Kravitz et al. 2004, Green and Britten, 1998; Straus and McAlister, 2000).

The number of EBM articles has increased significantly over the past decade. While studies focusing on drawing a conceptual framework at first (Guyatt et al. 1992; Sackett et al. 1996) were dominant, in the later process the concept of EBM succeeded in making a place for itself in almost every field of the health industry and showed a tendency to deepen. New paradigms have emerged in the EBM field, and various development pathways associated with different fundamental principles have become visible. In order to construct, evaluate and secure EBM, new methods and approaches have been developed by focusing on different application areas. One of the techniques used to evaluate many areas of interest and approaches from a general framework is bibliometric analysis studies.

Literature reviews on specific topics represent a useful approach to systematize and critically evaluate the current situation on EBM. One emerging approach to gain insight into the quantitative properties and properties of Science and scientific research is scientometrics and bibliometric analysis. Scientometric approach emphasizes research for the development of science using statistical mathematical methods (Goerlandt et al. 2021). Combined with analysis and visualization techniques, scientometrics can be used to map EBM's subspaces or work in specific applications. Thus, scientometric analyses can create a broad overview of EBM research areas, identify trends, boundaries, and important research areas and provide insights into other features of EBM research. Bibliometrix and VOSviewer software used in this analysis are some of the software used in both bibliometric analysis and scientometric analysis.

Bibliometrics is an important branch of Information Science and bibliometric methods are effective tools developed to evaluate a particular aspect of research or the values of a particular journal (Andonie et al. 2010; Shang et al. 2015). The evolution of a research direction can be revealed by bibliometric methods. Because bibliometry consists of the intersection and combination of linguistics, information and Statistical Sciences in a particular field (He et al. 2017). In order to use the bibliometric analysis process in studies, 5 stages are required. These include study design, data collection, data analysis, data visualization and data interpretation (Zupic and Cater, 2015). In the design of the study, research questions are defined and appropriate bibliometric methods are selected to answer the questions.

The aim of the research questions is to get information about the following topics (Aria and Cuccurullo, 2017);

- Determine the knowledge base and intellectual structure of a subject or research area;
- Ability to study the conceptual structure of a subject or research area based on research;
- Create a social network structure of a particular scientific community.

In the study design, one of the most important choices for scientists is the time interval. Bibliometric analysis can keep the time interval wide to capture the development of the topic related to the research area over time (Aria and Cuccurullo, 2017). In data collection, the database containing the bibliometric data is selected, the data set is filtered and the data is exported from the selected database (Waltman, 2016). In data analysis, one or more bibliometric or statistical software tools are used. The fourth stage is the visualization of the data. Visualization is a technique used for bibliometric analysis. Researchers can visualize the field of study, structure, or tendency of a subject with bibliometric analysis (Cobo et al., 2012). Bibliometrix analysis technique can be used for this purpose (Rodríguez-Sole, 2020; Jalal, 2019; Aria and Cuccurullo, 2017). The bibliometrix analysis technique, which is a quantitative approach used to analyze academic literature, is used to determine publications, citations and sources of information related to the field (Rodríguez-Sole, 2020). Bibliometrix analysis can be evaluated by some generally accepted bibliometric indicators, such as the total number of publications performed on the subject, the number of citations, the average number of citations, indexes (h, g, m), researchers/experts, countries published and words used in studies (Jalal, 2019). The final stage is the interpretation of the data. This is the part where researchers interpret and explain their findings from the data (Aria and Cuccurullo, 2017).

Bibliometry has been applied to many areas of research, including science mapping and visual mapping tools, as well as engineering (Huarachi et al. 2020), road safety (Zou and Vu, 2019), assessment of the social life cycle (Huarachi et al. 2020), financial performance (Xue et al. 2020), and re-planning of Higher Education (Ren et al. 2018). Thanks to bibliometry, the development process of a journal can be illustrated. For example, The development process of a journal, productivity, impact, total number of publications (TP), total citations (TC), average number of citations per publication (AC) can be evaluated by some generally accepted bibliometric indicators, such as the h-index, g-index, and m-index (Hsieh and Chang, 2009; Wang et al. 2020).

Visualization is one of the most important techniques for bibliometric analysis. Academics can visually analyze a research area or journal Structure and trend with bibliometric tools (Cobo et al. 2011). Free software such as Bibliometrix (Aria and Cuccurullo, 2017), VOSviewer (van Eck and Waltman, 2010), CiteSpace (Chen, 2006) and SciMAT

(Cobo et al. 2012) have become popular tools in bibliometric analysis, as they have a powerful user graphical interface and map visualization capability. There are many studies that use the above four software separately: Bibliometrix has been used in subjects such as political marketing (Perannagari & Chakrabarti, 2020), social responsibility of universities (Duque & Cervantes-Cervantes, 2019) and cyber behavior (Serafin et al. 2019). VOSviewer, CiteSpace and SciMAT have been widely used in many areas such as food chemistry (Kamdem et al. 2019), emergency medicine (Chan et al. 2019), information literacy assessment (Pinto 2015) and Covid-19 (Herrera-Viedma et al. 2020).

Due to the profound changes called forth by EBM approach in medical training, illness and drug treatment, publications regarding the EBM concept that are examined in such a different way should be systematically analyzed. One of the analysis techniques that thoroughly examines the EBM concept which expands every year is bibliometric analysis. To Tranfield et al. (2003) one of the techniques developed to synthesize the current knowledge repetitively is bibliographic analyses. The fact that the literature in any research subject is very wide does not allow the analysis and definition of the main tendencies of improvements and relationships. When the literature knowledge is very wide, bibliometric methods are used to make the analyses and definitions of the main tendencies of improvements and relationships. (Hajduk, 2017). The term bibliometry can be described as the methods that are used in the quantitative analysis of the author, field, subject, citation, institution, country, etc information of the scientific publications such as printed journals, books, and articles and that give some clues about the relevant discipline, field, subject, institutions, countries, authors, and cooperation between authors (Kurutkan & Orhan, 2018).

The questions of the research are as follows:

- Can the results of the performance analysis of publications on EBM (number of publications, authors' performance, performance of universities, authors with the highest number of publications on EBM) be visualized?
- Can the 27-year thematic development process of articles on EBM be determined in terms of main themes?
- Can co-authorship analysis be done by the authors who publish the most on EBM?
- How many clusters are EBM articles divided into in terms of text data analysis?

A bibliometric review of published scientific literature on EBM not only identifies current trends but also has the potential to identify gaps and guide researchers in their future work. Bibliometric analysis has the power to explain the research structure of the subject at a reasonable scale and quickly.

Methodology

The concept of Evidence-Based Medicine (EBM) was searched in the Web of Science database as article title, the time range between 1975-2019 was selected, and only articles were selected. Only SCI-EXPANDED and SSCI indexes were selected from the data core collection index and finally, 1161 articles were obtained. The Search Strategy is as follows:

“TITLE: ("Evidence Based Medicine") REFINED BY:
LANGUAGES: (ENGLISH) AND DOCUMENT

TYPES: (ARTICLE) TIMESPAN: 1975-2019. INDEXES:
SCI-EXPANDED, SSCI.”

Articles published in the original article type with the title “Evidence Based Medicine ” constitute the raw data of this study. “Articles” type publications were selected in the search strategy. The following are the types of publications that are not selected: Review, News Item, Book, Editorial Material, Proceedings Paper, Correction, Reprint, Letter, Book Chapter, Early Access, Data Paper, Meeting Abstract, Book Review, Biographical Item and Database Review. Articles are limited to English in terms of the language of publication. The time period covers the years 1975-2019. From the Web of Science Core Collection: Citation Indexes, Science Citation Index Expanded (SCI-EXPANDED) -- 1980-present and Social Sciences Citation Index (SSCI) -- 1980-present were selected. The excluded indices are as follows; Arts & Humanities Citation Index (A&HCI) --1975-present, Conference Proceedings Citation Index- Science (CPCI-S) --1990-present, Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) --1990-present, Book Citation Index- Science (BKCI-S) --2005-present, Book Citation Index- Social Sciences & Humanities (BKCI-SSH) --2005-present and Emerging Sources Citation Index (ESCI) --2015-present.

The research framework of the “EBM” study subject is presented in Figure 1. Web of Science (WOS) database was preferred for the bibliometric analysis of the EBM topic. WOS was chosen because of the large number of abstracts and references from high quality and effective scientific articles. WOS is a widely accepted database (Li & Hale, 2016). It was determined that the first publications started in 1992. Thus, the time range of the study has become to cover the years 1992-2019. The Free Bibliometrix program and VOSviewer program were used in this study. Bibliometrix is one of the newest, open-source software developed in the R environment for systematic scientific literature mapping (Aria, Cuccurullo, 2017). VOSviewer, on the other hand, is another software tool developed by Van Eck and Waltman that can be used free of charge to create and visualize bibliometric maps of scientific publications, authors, journals, countries, institutions, and keywords (van Eck, Waltman, 2010).

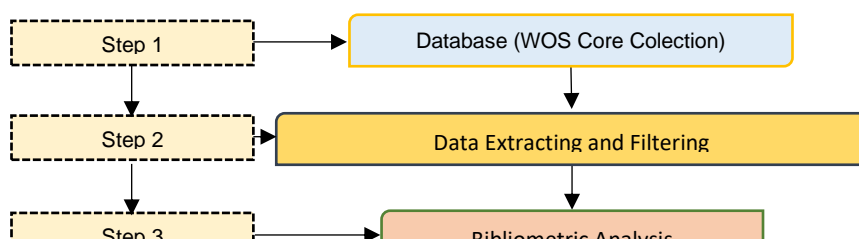




Figure 1. Research Framework of This Study

The methodological approach followed in the analysis with the data obtained is the 2017 study showing the use and stages of the bibliometrix program developed by Aria & Cuccurullo. There are also method approaches in the articles in which Van Eck & Waltman describe the bibliometric mapping technique of the VOSviewer program, they developed in 2010. Data obtained from the Bibliometrix program can be reported in three main headings. General information about the data set (Main data, Annual Scientific Production Thu Average Citations per year), performance

analysis (Sources, Authors and Document) and information structures (Conceptual, Intellectual and Social) constitute the three main headings. In this study, only general information about the data set and performance analysis results are available. Analysis with VOSviewer program is Citation, co-authorship and text data (data mining) analysis. The analyses used in the study were tabulated as follows.

Analyses performed within the scope of the study are as shown in Table 1:

Table 1. Software and Analytics

Data Source	Analysis Categories
Bibliometrix Biblioshiny	Main Statistics
	Total number of publications, number of citations and average number of citations
	Productivity and Collaboration Networks of Countries and Institutions <ul style="list-style-type: none">Country productivity mapCountry cooperation mapMost cited countriesUniversity citation numbersCorresponding author's CountryMCP rate per article
	Highly Contribute Authors Papers, Citations <ul style="list-style-type: none">Top authors production over time10 most cited authorsLotka's lawNumber of authors who have written the most articles
VOSviewer	Co- authorship
	Citation
	Text Data (data mining) analysis

Findings

Between 1992 and 2019, 1161 articles were published in 521 different journals. 1161 articles were written by 3251 authors

and the number of articles with a single author is 305. The average number of citations per article is 26.05. There are 3.32 authors per article in the field of EBM. Other statistical information was presented in Table 2.

Table 2. Main Statistics Obtained As A Result of Data Analysis

Description	Results	Description	Results
MAIN INFORMATION ABOUT DATA		AUTHORS	
Timespan	1992:2019	Authors	3251
Sources (Journals, Books, etc)	521	Author Appearances	3859
Documents	1161	Authors of single-authored documents	305
Average years from publication	11,9	Authors of multi-authored documents	2946
Average citations per documents	26,05	AUTHORS COLLABORATION	
Average citations per year per doc	1,965	Single-authored documents	342
References	29075	Documents per Author	0,357
DOCUMENT TYPES		Authors per Document	2,8
article	1058	Co-Authors per Documents	3,32
article; book chapter	2	Collaboration Index	3,6
article; proceedings paper	101		
DOCUMENT CONTENTS			
Keywords Plus (ID)	2609		
Author's Keywords (DE)	1862		

Annual Scientific Production and Average Quotations

As it is seen in the Figure 2 that the number of annual articles in the field of EBM increased from 1992 to 2004, fluctuated

between 2005 and 2013, reached the highest number of annual articles in 2004 and 2013, and the number of annual articles has decreased since 2014.

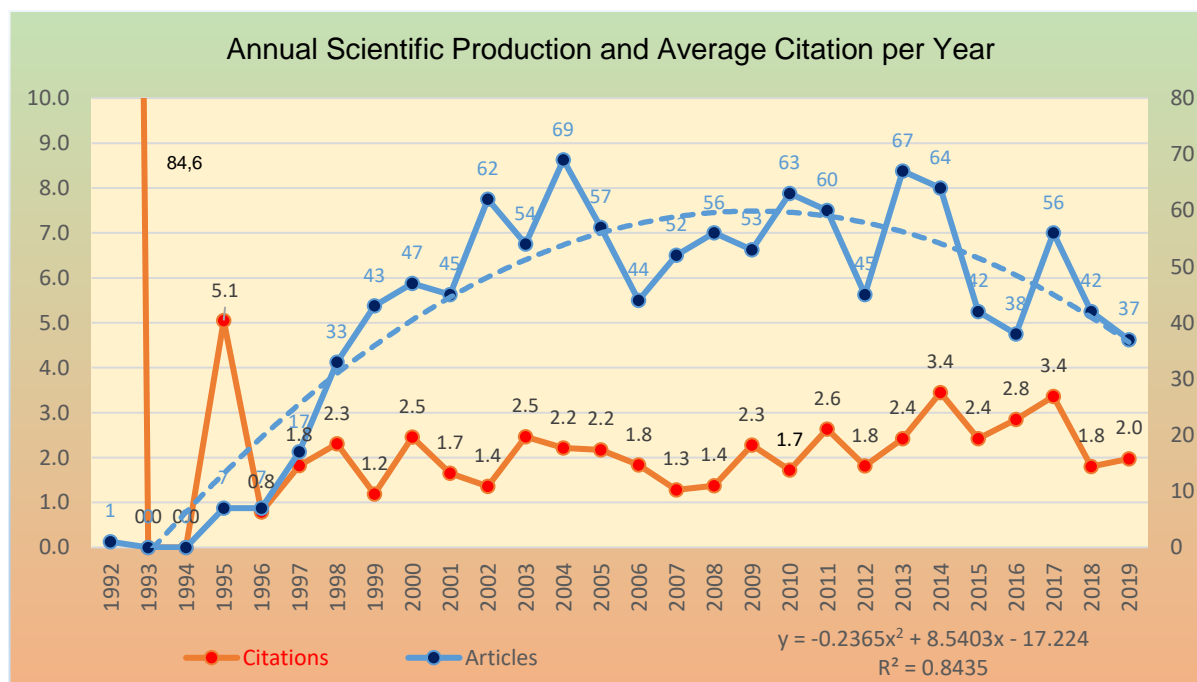


Figure 2. Annual Scientific Production and Annual Average Citations



When the Annual Scientific Production Trend Line is added to the graph, the R^2 value, which is the Reliability Coefficient, appears. The closer this value is to 1, the better the Trend Line represents the production values. Since the R^2 value is close to 1 with 0.84, it represented the values very well. The equation representing the trend line is presented on the graph. Regarding the annual average citations of each document, the publications in 1993 received the most average 84.6 citations. This was followed by an average of 5.1 publications in 1995, recently the years 2014 and 2017 follow the annual increase trend in the number of articles in those years, with an average of 3.4. The average number of citations per year for 2018-2019 seems low,

especially since newer publications require time to cite (Figure 2).

Country Statistics

The top five countries in terms of publication numbers are the USA, United Kingdom, Canada, Australia, and Germany. The countries that publish the most together with other countries are the same, respectively. Although the number of publications is small, the top three countries with the highest rate of international cooperation are Ireland, Switzerland, New Zealand, and Sweden (Table 3).

Table 3. Corresponding Author's Country

Country	Articles	Freq	SCP	MCP	MCP_Ratio
USA	485	0,43	442	43	0,09
UNITED KINGDOM	156	0,14	135	21	0,13
CANADA	77	0,07	57	20	0,26
AUSTRALIA	61	0,05	52	9	0,15
GERMANY	45	0,04	36	9	0,20
ITALY	38	0,03	33	5	0,13
NETHERLANDS	37	0,03	31	6	0,16
CHINA	24	0,02	20	4	0,17
BELGIUM	16	0,01	13	3	0,19
FRANCE	13	0,01	11	2	0,15
FINLAND	12	0,01	10	2	0,17
SAUDI ARABIA	11	0,01	9	2	0,18
SWEDEN	11	0,01	7	4	0,36
ISRAEL	9	0,01	7	2	0,22
SWITZERLAND	9	0,01	5	4	0,44
IRAN	8	0,01	6	2	0,25
IRELAND	8	0,01	4	4	0,50
NEW ZEALAND	8	0,01	5	3	0,38
NORWAY	8	0,01	6	2	0,25
SPAIN	8	0,01	6	2	0,25

Author Statistics

The h-index, g-index, m-index, total citations (TC), the total number of publications (NP) of the 20 most influential

authors, and the first publication year (PY-start) in the field of EBM are shown in Table 4.

Table 4. Statistics of the 20 Most Author Local Impact in the Field of EBM Research

Author	h_index	g_index	m_index	TC	NP	PY_start
KHAN KS	9	10	0,409	237	10	2000
GREEN ML	8	10	0,32	627	10	1997
ILIC D	8	9	0,667	253	9	2010
KUNZ R	7	8	0,28	380	8	1997
SHIN JJ	6	8	0,5	78	10	2010
BHANDARI M	6	8	0,316	191	8	2003
CHUNG KC	6	8	0,462	642	8	2009
GLASZIOU P	6	8	0,3	285	8	2002
RANDOLPH GW	6	8	0,5	70	8	2010
WYER PC	6	7	0,353	125	7	2005
KULIER R	6	6	0,429	168	6	2008
ARVANITIS TN	5	5	0,357	152	5	2008
BURLS A	5	5	0,357	139	5	2008
GUYATT GH	5	5	0,227	664	5	2000
HORVATH AR	5	5	0,357	152	5	2008
MOL BWJ	5	5	0,357	152	5	2008
REIS S	5	5	0,333	126	5	2007
WEINBRENNER S	5	5	0,357	152	5	2008
DECSI T	4	5	0,286	130	5	2008

The "hirsch index" or "h-index" was designed by Jorge Hirsch. It is a unique and simple performance index that includes both the amount and visibility of publications for micro-level application. It is an author-level scale that tries to measure the productivity and citation impact of publications made by scientists. Since H-indexes are influenced by the citation traditions and methods of scientific disciplines, it is quite difficult to compare between disciplines through this index (Bornmann & Daniel, 2007). The G-index was developed by Leo Egghe in 2006. It is an alternative that can be used to measure the global citation performance of a series of articles instead of the h-index that does not average the number of citations. Egghe found it a disadvantage that the h-index did not take into account the citation scores of the top articles. The index is calculated based on the distribution of citations received by a particular researcher's publications. While the G-index gives more weight to the highly quoted articles, the h-index does not. The G-index helps to make the difference between the author's relevant effects more apparent by calculating the performance of the author's most-read articles (Egghe, 2006).

The H-index is a less suitable measure of academic achievement for young scientists because their papers do not yet have enough time to cite. Especially in social sciences, it may take more than five years for an article to receive a significant number of citations. For young scientists, the impact factor of the journal they publish may be a more realistic measure of final impact. One way to make it easier to compare among scientists with varying lengths of academic careers is to divide the h-index by the number of years of academic activity (measured as the number of years since the first published article). This index, created by Hirsch, was defined as the m-index (Harzing, 2012). As a result, when the index scores of the authors are evaluated in terms of all these three indicators (h-g-m index), Khan and Green have the highest score in h and g index, while Ilıc D, and Randolph have the highest index values in m index. The most cited author is Guyatt (n:2455), and the author with the most publications is Phillips (n:16).

Figure 3 shows the publications of the authors who made publications on EBM over time. It is seen that most publications belong to Anonymous (includes the publications without authors of institutions such as the World Health Organization).

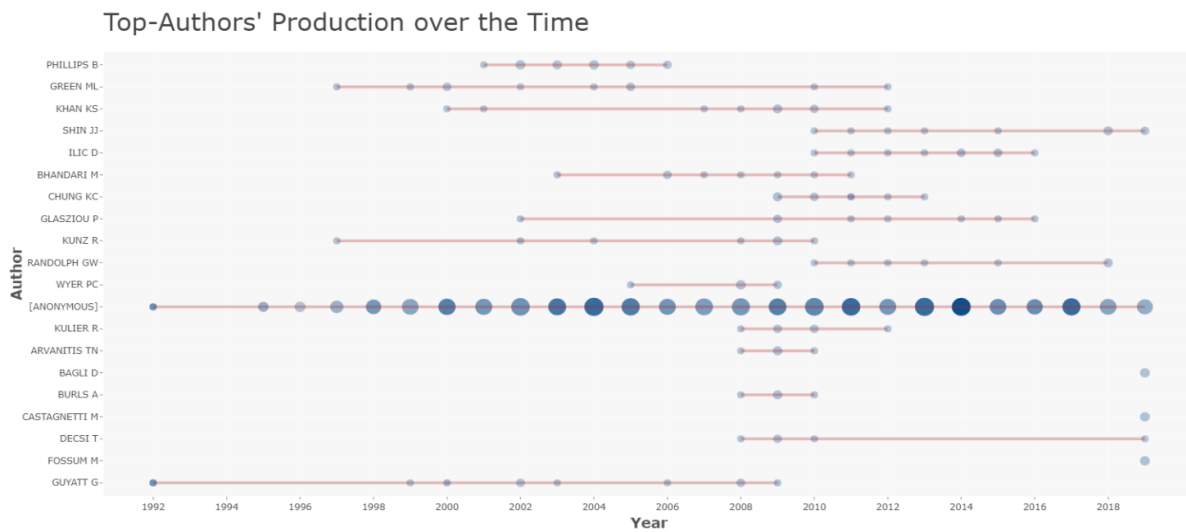


Figure 3. Top Authors' Production Over the Time

It is understood from the size of the balls in Figure 3 that Philips, Green, and Khan are the most influential authors in proportion to the number of publications. It is observed that Shin, whose publication effect continued in recent years, started publication in 2010 and similarly, Decsi started publication in 2008. Although Castagnetti and Fossum started publication in 2019, they draw attention with 4 publications.

The publications of the authors who work in the field of EBM according to Lotka law are presented in Figure 4. Lotka Law predicts that 60% of the authors contribute to that field with one article, 15% with 2 articles, and 7% with 3 articles (Birinci, 2008).

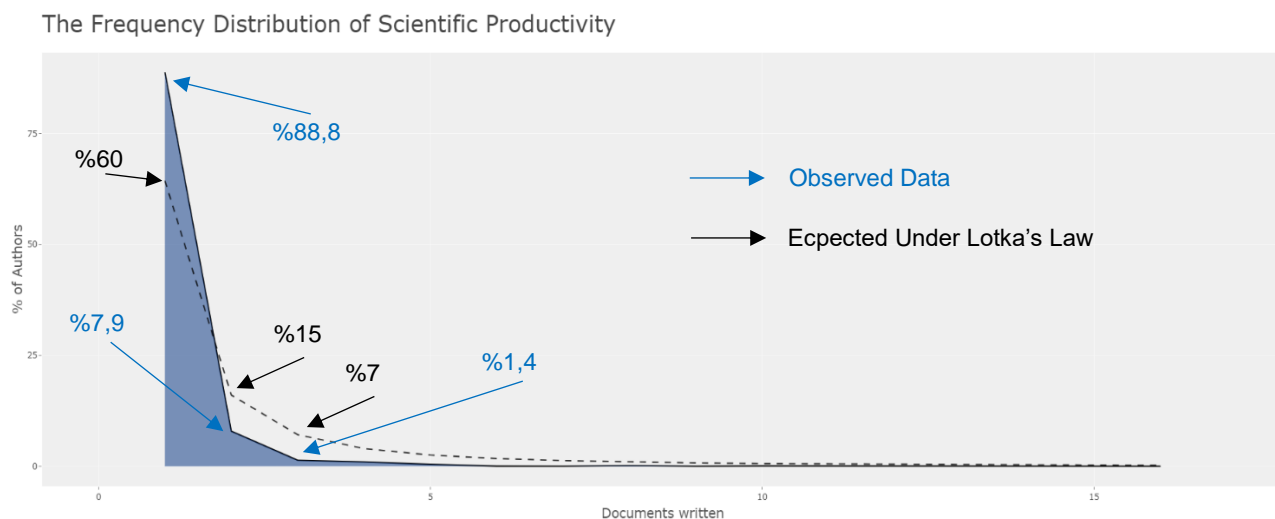


Figure 4. Lotka Law Chart

When the articles and authors are examined within the framework of Lotka law, it is seen that those who contributed with one article constitute 88.8% of the authors, followed by 7.9% of the contributors with two articles, 1.4% of the contributors with three articles, 1% of the contributors with four articles, and 0.5% of the contributors with five articles. It is understood that the author distribution of articles in the

field of EBM field does not comply with Lotka law (Figure 4). However, it should be accepted that the authors with more than 5 publications have deepened in the field of EBM and should be considered as core authors.

Journal Statistics

Articles on EBM are published in various journals. The 1161 articles we obtained were published in 521 different journals. The number of articles on EBM and the h-index of each

journal was used as measures to identify the most relevant and influential journals in the field of EBM research. Figure 5 shows the top 20 journals that published the most articles on EBM. These 20 journals can be regarded as the most relevant resources in their field related to EBM.

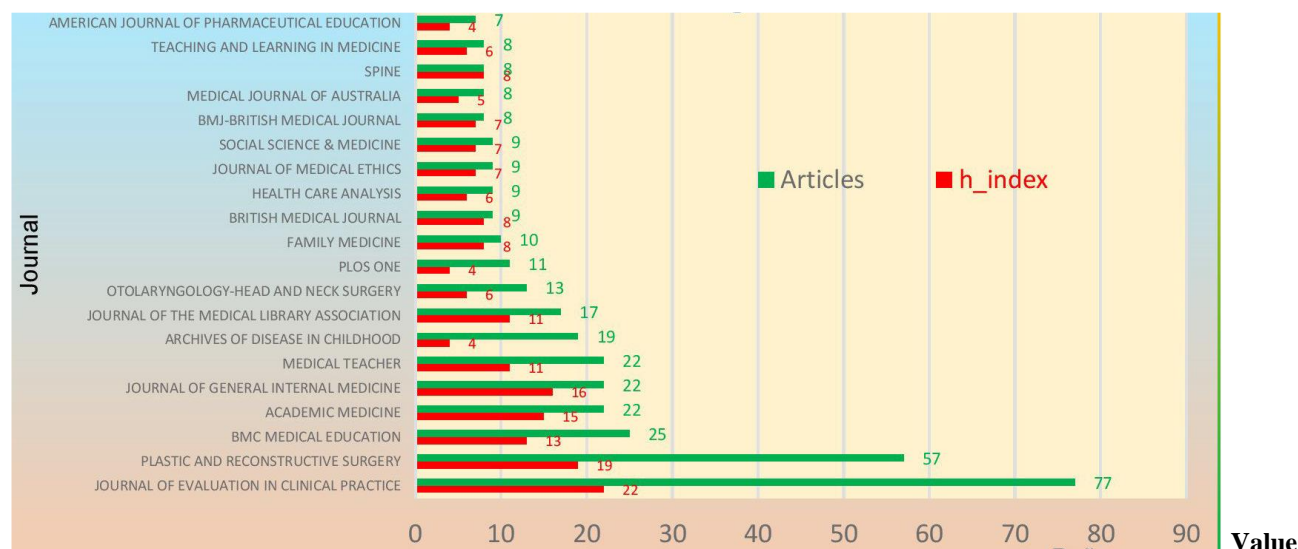


Figure 5. Top 20 Most Influential Journals on EBM

As shown in Figure 5, Journal Of Evaluation Clinical Practice and Plastic And Reconstructive Surgery are the first two journals to publish the largest number of articles on EBM and they also have the highest h index. It is possible to say that these two journals are the most influential journals in the field of EBM.

In Table 5, the top 20 of the journals with the most publications are tabulated below. In these first 20 journals, 32% (370/1161) of the total articles are published. Journal

Of Evaluation In Clinical Practice is the journal making the highest number of publications, representing 6.6% (77/1161) of the total articles. This is closely followed by Plastic And Reconstructive Surgery. The two journals that collect the most citations on EBM are concurrently the journals with the highest h-index and the highest number of publications. Besides, the number of citations per article was analyzed, which indicates the ratio between the number of citations for each journal and the number of documents. BMJ-British Medical Journal has an average of 176 citations per article.

Table 5. Statistics of 20 Most Influential Journals in the Field of EBM Research

Source	NP	TC	TC/NP	h index	PY start
JOURNAL OF EVALUATION IN CLINICAL PRACTICE	77	1437	19	22	1999
PLASTIC AND RECONSTRUCTIVE SURGERY	57	1482	26	19	2009
BMC MEDICAL EDUCATION	25	429	17	13	2008
ACADEMIC MEDICINE	22	971	44	15	1998
JOURNAL OF GENERAL INTERNAL MEDICINE	22	887	40	16	1997
MEDICAL TEACHER	22	344	16	11	1998
ARCHIVES OF DISEASE IN CHILDHOOD	19	198	10	4	1999
JOURNAL OF THE MEDICAL LIBRARY ASSOCIATION	17	356	21	11	2002
OTOLARYNGOLOGY-HEAD AND NECK SURGERY	13	111	9	6	2002
PLOS ONE	11	90	8	4	2009
FAMILY MEDICINE	10	177	18	8	2002
BRITISH MEDICAL JOURNAL	9	1149	128	8	1995
HEALTH CARE ANALYSIS	9	159	18	6	2002
JOURNAL OF MEDICAL ETHICS	9	265	29	7	2004
SOCIAL SCIENCE & MEDICINE	9	513	57	7	2004
BMJ-BRITISH MEDICAL JOURNAL	8	1410	176	7	1995
MEDICAL JOURNAL OF AUSTRALIA	8	129	16	5	2000
SPINE	8	405	51	8	1998
TEACHING AND LEARNING IN MEDICINE	8	185	23	6	2003
AMERICAN JOURNAL OF PHARMACEUTICAL EDUCATION	7	58	8	4	2011

NP = Number of publications, TC = Total citations, TC/NP = Citations per paper, PY start = Publication year starting.



Performance of Institutions / Universities

Figure 6 shows the cooperation network of the main institutions contributing to EBM research. The top 11 institutions that publish the most articles on EBM are also marked in Figure 4. The most productive institution is Univ Toronto and McMaster Univ with 42 articles. The country

with the two most productive institutions is Canada. These institutions are followed by Monash Univ with 38 articles and Univ Oxford with 37 articles.

The number of articles and the countries where the institutions are located is obtained from the "Bibliometrix, Authors, Most Relevant Affiliations" tab.

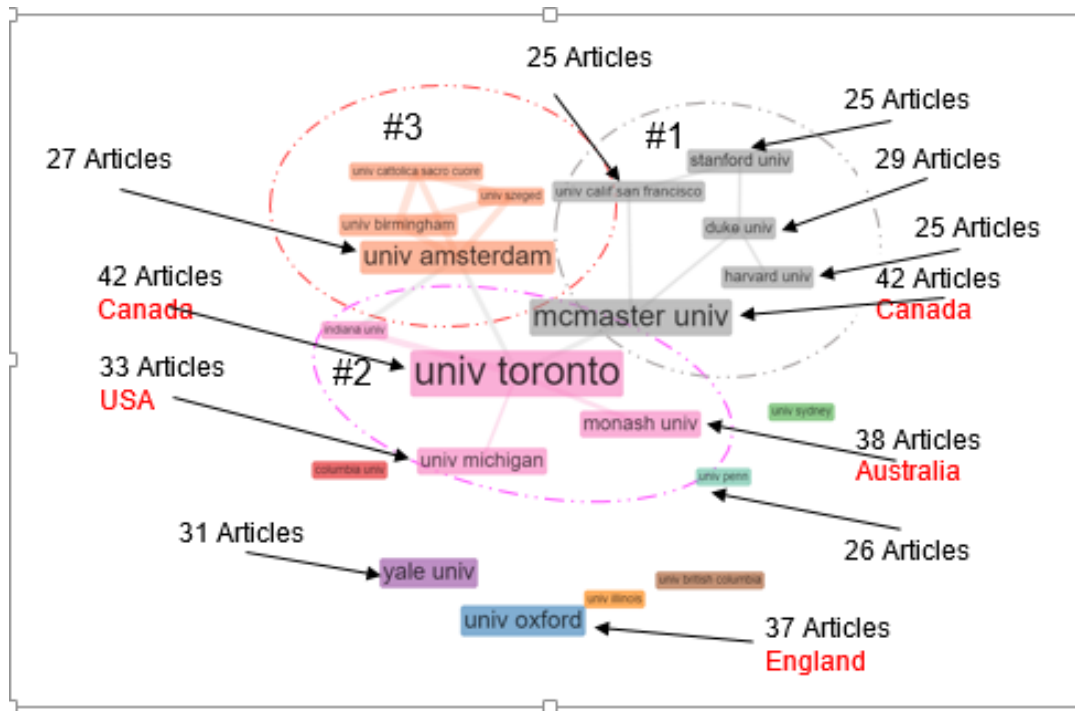


Figure 6. Institutional Cooperation Network for EBM Research

In Figure 6, three network clusters containing at least two interconnected institutions are defined. The largest cluster is marked # 1 and contains 5 institutions. Cluster # 2 and cluster # 3 contain 4 institutions each. Univ Toronto in Cluster # 2 can be considered as the core institution as it has the most cooperation network with 5 institutions. From the thickness of the lines between them, it is possible to say that the strongest cooperation network is between Univ Cattolica, Univ Szeged, and Univ Birmingham in cluster # 3. Although Univ Oxford produced 37 articles and Yale Univ 31 articles, they were not able to establish a network of cooperation with other institutions, however, they took their place among the strongest institutions. Organizations in cluster # 1 and cluster # 3 provide cooperation over cluster # 2.

Content Analysis Of The EBM Research Area

In this section, keyword analysis and citation analysis are evaluated together in order to define the basic elements of the knowledge base for EBM.

Keyword Analysis

Keywords in the articles are used by the authors as a clear, representative, and concise explanation of the research content. It is expected that the keywords represent the research article in the best way. Therefore, it is logical to determine the current issues and themes of a research subject based on keyword analysis (Zheng, Le et al., 2016).

Frequency Analysis for Keywords

The word cloud of keywords created using Bibliometrix can be seen in Figure 7. The word cloud is a clear and complete graphical display of current topics in the EBM research area. In Figure 9, the top 50 keywords that appear more than 6 times are highlighted. The size of the keywords has been correlated directly with the frequency of the display in the data set. The prominent words in the word cloud are evidence-based medicine and evidence-based medicine, evidence, medicine, meta-analysis, and medical education, with both spelling types.

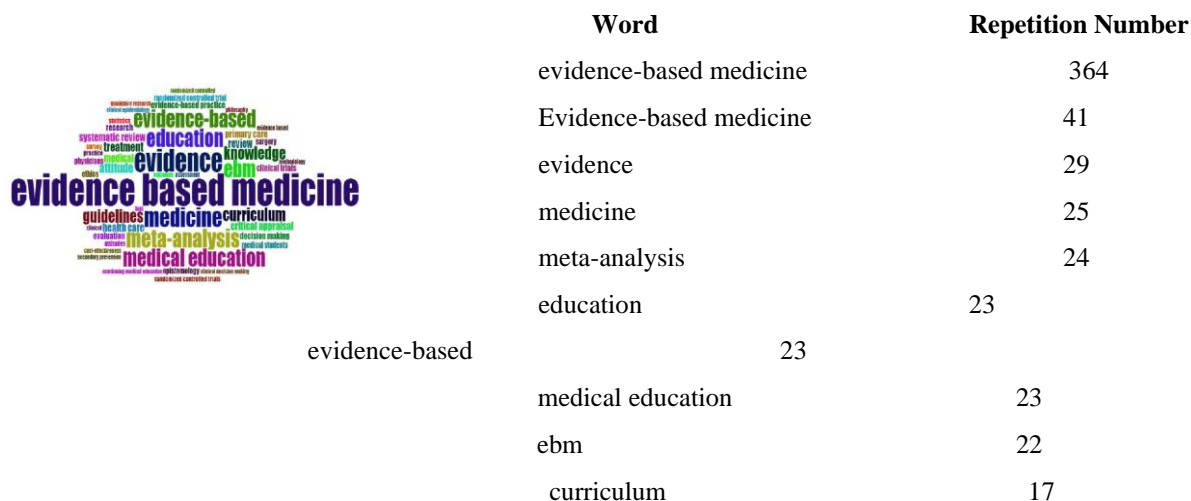


Figure 7. Keyword Cloud and Repetition Number of Keywords in EBM Research Area

Keywords Change Trend Analysis

In order to better understand the change of the study subject in different time frames, the 24-year time range from 1996 to 2019 was divided into seven 4-year time frames. As can be seen in the word cloud, two different keyword spelling types (1.evidence-based medicine, 2.evidence based medicine) of two different study fields from the author's keywords have stepped forward. As stated in the Keyword

Frequency Analysis, the first 4 keywords are composed of the words "Evidence", Based "and" Medicine", and the upward trend of the first two continues over the years. Other keywords have increased with little change from 1996 to 2019. The keywords in the publications in the field of EBM were analyzed without any combination process. These keywords that reflect the same topics but are in different formats are also presented in our study.

The most frequently used 10 keywords of the EBM domain obtained from Bibliometrix with this method are visualized in Figure 8.

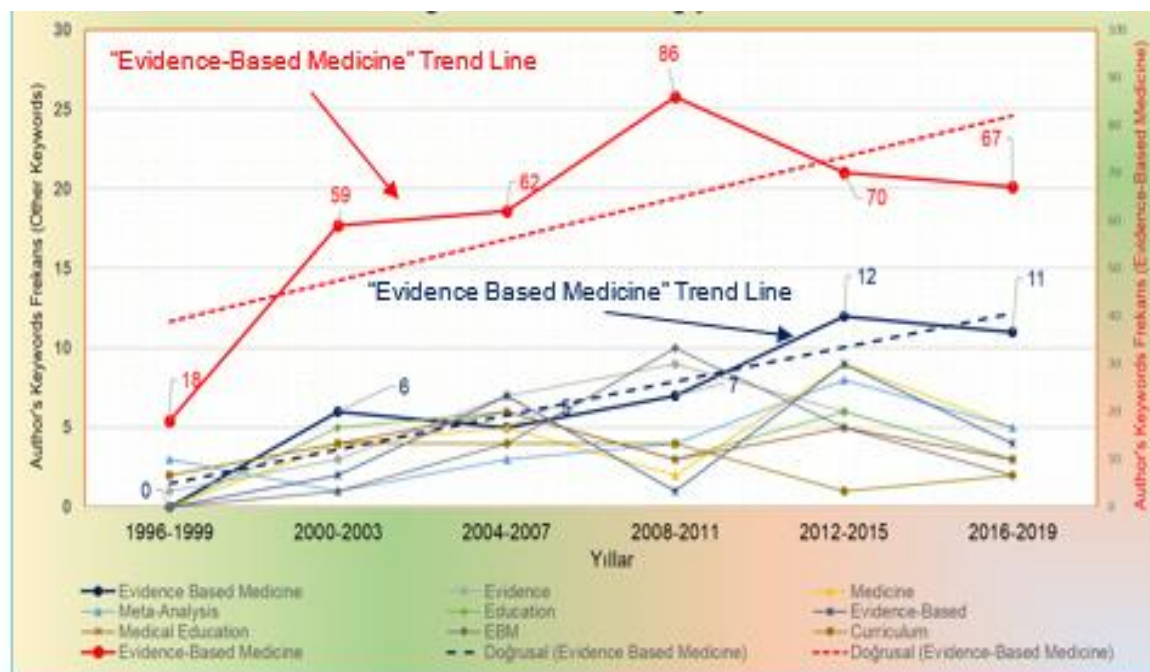


Figure 8. The Change in the Keyword Frequency of the Top 10 Keywords in the Field of Evidence Based Medicine Over the Years



Thematic Development Analysis

It was tried to analyze the thematic development of the EBM studies between 1992 and 2019 from a dynamic perspective. The research period (1992-2019) is divided into three consecutive sub-periods considering the number of documents and the definite time window. Although it seems common to identify sub-periods covering the same period, the first sub-period is fixed at 13 years due to limited publications made in the early years. The last two sub-periods are identified to cover 6 years each. As a result, the entire research period (1992-2019) is divided into three consecutive sub-periods (1992-2005, 2006-2012, 2013-2019). Each subform of Figure 9 is divided into four quarters representing different genre themes. Two measures of centrality and density are used to scale each quarter theme cluster. Density represents the thematic map as the y-axis and centrality as the x-axis. Centrality scales the importance of the chosen theme, and intensity scales the development of the chosen theme (Nasir et al., 2020).

Each period is divided into four quadrants;

- **Motor Themes-1st Quarter:** It is at the top right. It represents high density and high centrality. These themes, called the first quarter, are engine themes that are developed and required. They are important for configuring a workspace. Keywords in the engine theme have strong internal links. They appear more commonly together, making them relatively more "advanced" (Cobo, Lopez-Herrera et al., 2011). It contains important and well-developed themes to shape the EBM field.
- **Highly Developed and Isolated Themes-2nd Quarter:** This theme, located in the upper left part of the thematic map, is also called the second quarter and

expresses high density but lower centrality. This theme is well developed but isolated (Cobo, Lopez-Herrera et al., 2011). Developed and isolated themes represent a high specialty.

- **Emerging or Declining Themes-3rd Quarter:** These themes seen in the lower left part are the themes of the third quarter and are emerging or fading themes. These themes include themes with low centrality and low density. These are new themes that can emerge for the better or go beyond the research area (Cobo, Lopez-Herrera et al., 2011). These themes are not only poorly developed but also have a low significance for the EBM field.
- **Basic and Transversal Themes-4th Quarter:** The fourth quarter themes with low density and high centrality are located in the lower right part of the thematic map. Much research has been done on these basic themes and they have well-developed interconnections (Cobo, López-Herrera et al., 2011). It is vital for the EBM area.

The strategic diagrams of the EBM studies in each sub-period are presented in Figure 9. It was created by Bibliometrix using a common word analysis based on the authors' keywords. To identify the most emphasized and detailed themes in this field, the keywords that appeared at least five times were used for analysis. After this step, the most repetitive keywords are grouped into theme clusters as highly appropriate keywords. The first 200 keywords were used while analyzing. The first three words with the highest number of repetitions representing each cluster are shown in the diagram. The first words in the sets are the keywords with the highest frequency in that cluster. The size of the spheres is proportional to the keyword frequency of the name of each theme marked in each field.

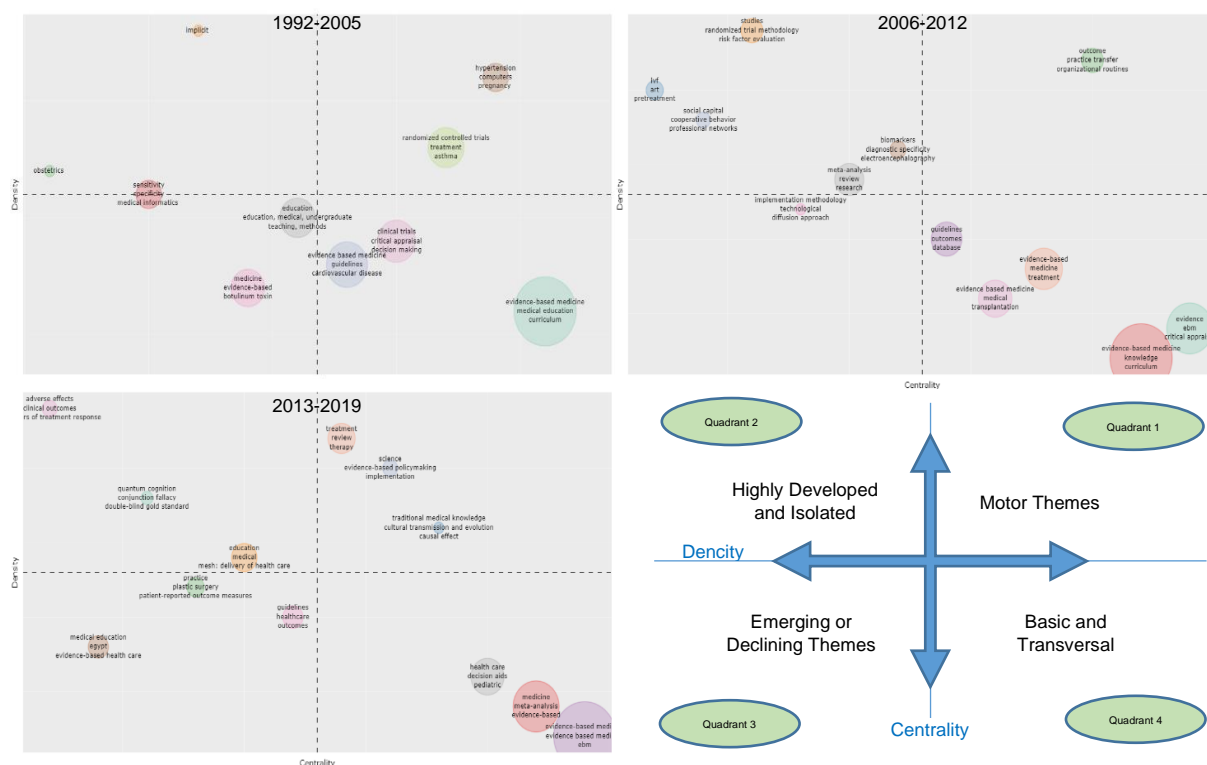


Figure 9. Strategic Diagram of the EBM Research (1992-2019)

It is seen that the most repeated and most related words are included in the Basic Themes theme. This indicates that these words have well developed internal links and have marginal importance for the EBM domain. Themes with a large number of publications are mainly located in the fourth quarter, which is quite logical. Because fundamental and varying themes are the main focus in the field of EBM. Within the theme, these words were clustered in 3 clusters in 1992-2005, in 5 clusters in 2006-2012, and in 3 clusters in 2013-2019. In 2013-2019, the first cluster is represented by "evidence-based medicine", the second cluster by "medicine" and the third cluster by "health care".

The words in the Emerging or Declining Themes theme do not have much significance in terms of EBM research. Within the theme, these words were clustered in 3 clusters in 1992-2005, in 1 cluster in 2006-2012, and in 3 clusters in 2013-2019. In 2013-2019, the first cluster is represented by "guidelines", the second cluster by "practice" and the third cluster by "medical education".

The words in the Highly Developed and Isolated Themes theme are important for the development of EBM research but have not been developed enough. Within the theme, these words were clustered in 2 clusters in 1992-2005, in 5 clusters in 2006-2012, and in 3 clusters in 2013-2019. In 2013-2019, the first cluster is represented by "education", the second by "quantum cognition" and the third cluster by "adverse effect."

The words in the Motor Themes theme are important and well-developed words to shape the EBM field. Within the theme, these words were clustered in 2 clusters in 1992-2005, in 1 cluster in 2006-2012, and in 3 clusters in 2013-2019. In 2013-2019, the first cluster is represented by "treatment", the second cluster by "science" and the third cluster by "traditional medical knowledge".

In addition to the three-period Thematic Map, a three-period Thematic Evolution map presented in Figure 10 has been made to evaluate how the EBM themes have developed historically.

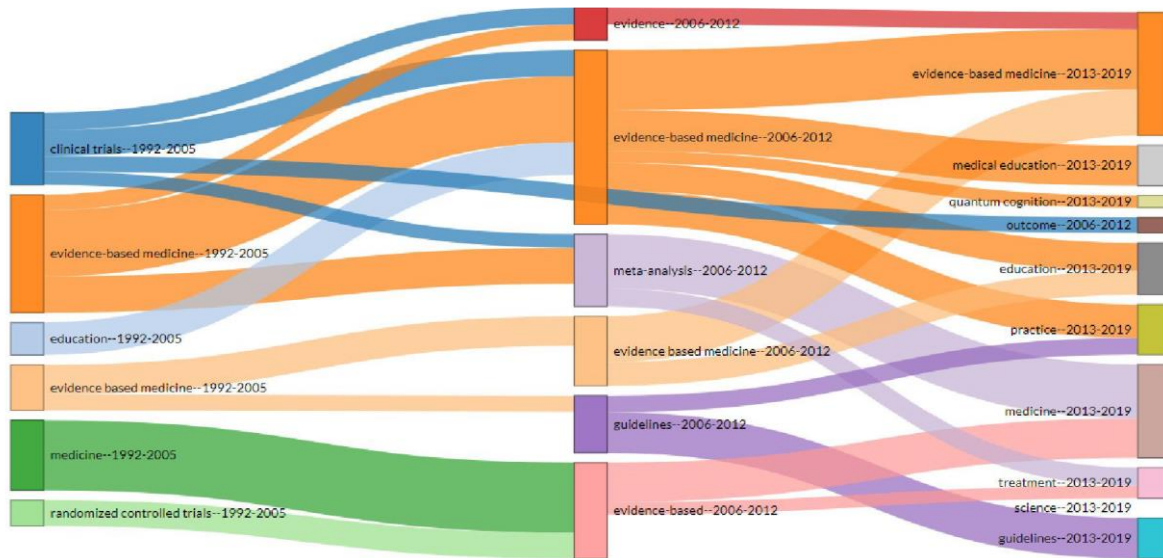


Figure 10. Thematic Development of EBM Research (1992-2019)

Sankey Diagram was used to make Thematic Evolution Mapping. Each anchor point in the Sankey diagram corresponds to a set of themes tagged with the keyword with the highest number of repetitions and corresponding subperiod. The size of the nodes is proportional to the number of keywords for the corresponding theme. Flow lines between nodes show the direction in which theme clusters evolve. The edge width of the node is the sum of the connected elements. A theme that develops during the sub-periods can be considered as a thematic area (Shi, Duan et al., 2020).

While creating the Thematic Evolution Map in Bibliometrix, the principles in Figure 13 were used. When the diagram is examined, it is seen that the number of themes increases over time. While there are 6 themes in the first two periods, there are 9 themes in the last period. Evidence-Based Medicine theme, which is our main theme, has been present from the first period to the last period. Recently, Medical Education, Quantum Cognition, Outcome, Practice, Treatment, and Science themes have been observed to derive from other sub-themes. The Evidence-Based Medicine

theme in the first period fed the Meta-Analysis theme in the second period and the Treatment theme in the third period.

Citation Analysis

Citation analysis is widely used to examine the intellectual structure and developmental dynamics underlying a research topic. Here, Citation Analysis was conducted to determine and research the most frequently quoted publications on EBM and their relationships. In Table 6, the 20 most frequently cited articles on EBM are shown in descending order according to local citation (LC) and global citation (GC) numbers. Local citation represents authors' citations to their work. It refers to the number of citations of a document cited by the articles in the collected data set (1161 articles). The global citation refers to the citation of authors other than the article author to the study. Guyatt (1992) received more citations for GC (2368) than other publications. This is also very natural. Because the first publication belongs to Guyatt. The other most cited work belongs to McColl (Table 6).

Table 6.Top 20 Most Cited Local Articles in the Field of EBM

Document	YP	LC	LC/YYP	GC	GC/YYP	Local Citations % (LC/GC)
GUYATT G, 1992	1992	172	6	2368	85	7,26
MCCOLL A, 1998	1998	82	4	484	22	16,94
FRITSCH L, 2002	2002	50	3	194	11	25,77
NORMAN GR, 1998	1998	49	2	180	8	27,22
RAMOS KD, 2003	2003	48	3	207	12	23,19
ROSENBERG W, 1995	1995	46	2	611	24	7,53
GREEN ML, 1999	1999	39	2	122	6	31,97
MCALISTER FA, 1999	1999	36	2	164	8	21,95
GREEN ML, 1997	1997	34	1	127	6	26,77
FEINSTEIN AR, 1997	1997	30	1	410	18	7,32
STRAUS SE, 2000	2000	30	2	227	11	13,22
GHALI WA, 2000	2000	28	1	68	3	41,18
TONELLI MR, 1998	1998	27	1	200	9	13,50
SMITH CA, 2000	2000	26	1	76	4	34,21
STRAUS SE, 2004	2004	25	2	75	5	33,33
GREEN ML, 2005	2005	23	2	124	8	18,55
YOUNG JM, 2001	2001	20	1	113	6	17,70
YOUNG JM, 2002	2002	20	1	97	5	20,62
GUYATT GH, 2000	2000	19	1	459	23	4,14
GREEN ML, 2000	2000	19	1	71	4	26,76

Year of Publication (YP), Local Citations (LC), YYP= Year 2020-Year of Publication, Global Citations (GC)

Normally, publications published in the early years of the publication period have more time to cite. Annual Local Citations (LC / YYP) and Annual Global Citations (GC / YYP) parameters were used to eliminate the negative effect of the years of publication of the articles published recently and to show the effect of the years of the publications. The first two publications in terms of LC / YYP and GC / YYP are Guyatt (1992) and Mccoll (1998). With the contents of these two articles, it will be able to be said that they can be the most effective articles on EBM research. Another concept developed for the most-cited authors is Local Citation Percentage. The author with the highest local Citation percentage is Ghali. We can examine Common Citation Analysis and Historical Citation Analysis to make more content analysis of the subject of EBM.

Historical Citation Analysis

Historical citation analysis provides a living perspective to EBM research. The historical citation network of the EBM topic was created using the functions of the R based Bibliometrix as shown in Figure 11. This figure visualizes the citation relationships among the top 20 articles that are cited locally. This reveals the evolution of research focuses of key literature on EBM over time. In this network, each node represents an article, and links between nodes represent citation relationships. If an article is cited by a subsequent article, these two articles form a citation relationship.

Historical Direct Citation Network

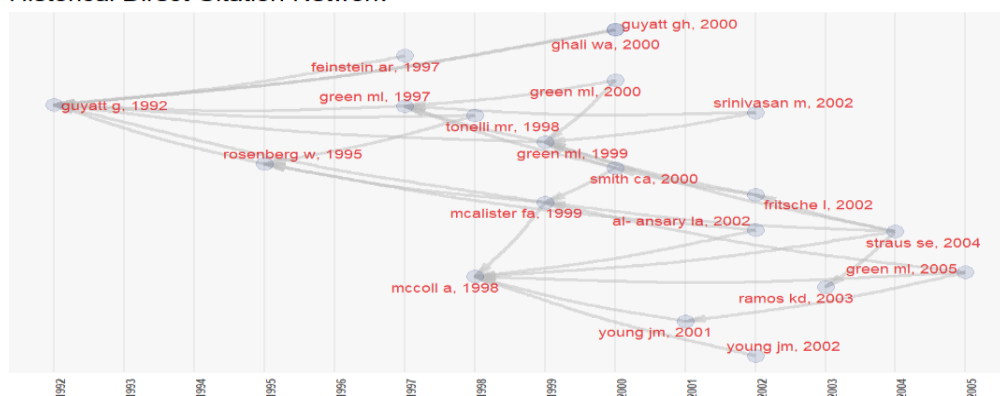


Figure 11. Historical Citation Network of EBM Area



The historical citation network has been formed as a single cluster with 20 nodes. Studying the full texts of these 20 key publications in depth could help to understand the evolution of research focuses on EBM. In general, 13% of the first 20 articles were published between 1998-2002. The Guyatt (1992) publication was cited by 7 articles over the years between 1992-2002. Mccoll (1998) was also cited by six articles after him between 1998-2005. Green (2005) has reached a sufficient number of citations, although it has been published in recent years. The publications published after 2005 could not be included in the Historical Citation Analysis chart. In the steepness of the link line between Mccoll (1998) -Mcalister (1999), Ramos (2003) -Straus (2004), Mcalister (1999) -Smith (2000), and Green (1999) - Green (2000) publications, it will be possible to say that these publications were cited very quickly. When Figure 16 is examined together with Table 5, Guyatt's (1992) publication can be regarded as the dominant publication on EBM with the highest number of citations. Mccoll's (1998) publication comes in second place with 82 local citation points.

VOSviewer analyses

Common Citation Analysis; A total of 29032 references cited by 1161 articles obtained regarding EBM research constitute the citation basis of the EBM field. It can be assumed that the more common citations are made to the two articles, the more similarity can be assumed between them (Van Nunen et al.2018). Common citation analysis helps to identify the strongest articles on the designated study and can express common citation relationships. As shown in Figure 12, VOSviewer software has been used to obtain the common citation network of the sources cited on EBM. In Figure 12, each node represents a publication. The size of the nodes is proportional to the number of citations of each article, and the lines between the nodes indicate common citation relations. The thicker the line, the more the two publications were in other publications.

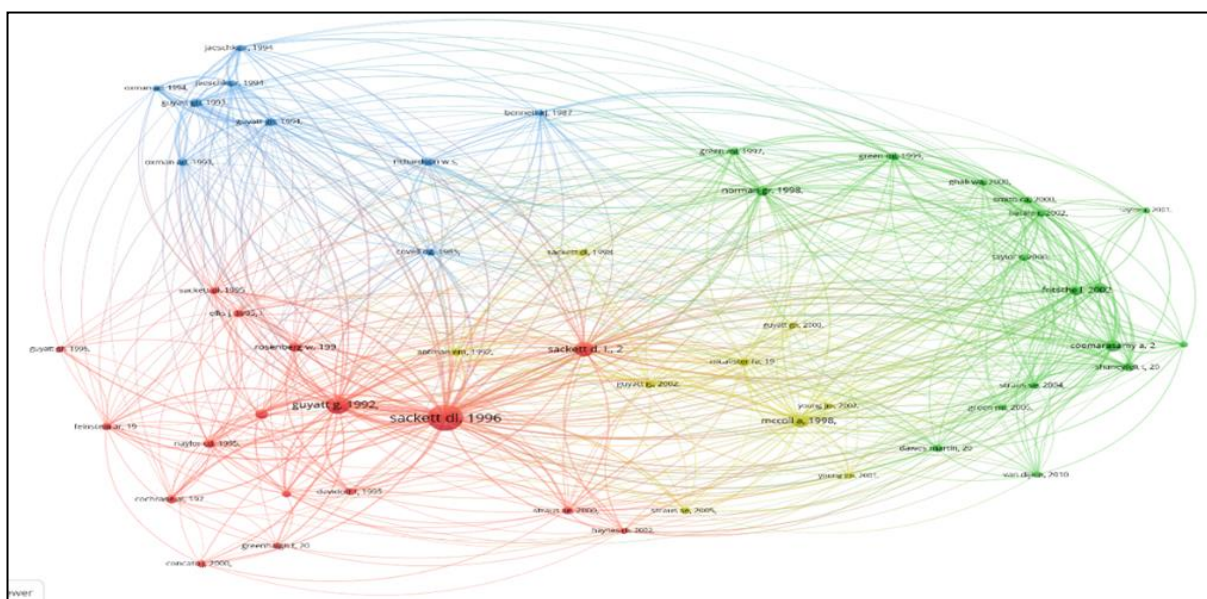


Figure 12. Common Citation Network of References Cited on the Subject of EBM

Sackett (1996) and Guyatt (1992) are located close to each other, the knot it represents is large, and the link line between them appears thick. In light of this information, these two publications have been frequently observed together in other publications. It can be judged by the size of the node that they are frequently used in other publications, and also because of the thickness of the line between them, these two publications are frequently mentioned in other publications. Red and Yellow clusters stand closer to each other, while Green and Blue clusters stay further away. The red cluster is the largest in the common citation network. This cluster was formed around the publication of Sackett (1996) and Guyatt (1992). The Green Cluster has formed a cluster around the Coomarasamy (2004) publication, although it was formed

away from the Red cluster. The blue cluster also formed away from the Red and Green cluster and formed a cluster in the center of Guyatt (1993) and Guyatt (1994) publications. The yellow cluster formed a cluster in the middle of the Red and Green cluster and around Mccoll (1998) publication, providing the connection of these two clusters. While the Red cluster has links with all clusters, there is no link between the Blue and the Green cluster.

Co-authorship analysis

In VOSviewer, when the minimum number of publications was set as five, 19 co-authors out of 3325 authors met the

threshold value. The collaboration network of 19 authors is presented in Figure 13. Different color clusters, which can help define academic collaboration represent the main authors' groups. Prominent authors are represented by larger nodes due to the high number of publications. Small nodes

are authors with a low number of publications. While Phillips, Green, Shin, Ilic, Chung, Wyer, Bhanda, and Reis could not create their networks, Arvanitis, Decsi, Mol, Kunz, Khan, Horvat, Weinbr, Kulier, and Burls were observed to have formed a common network.

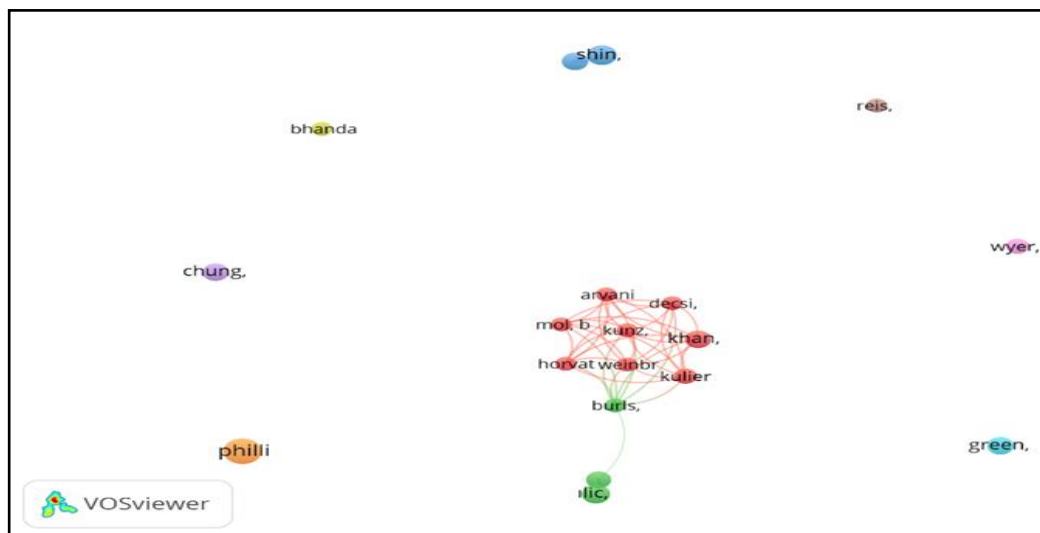


Figure 13. Co-Authorship Network Between Authors

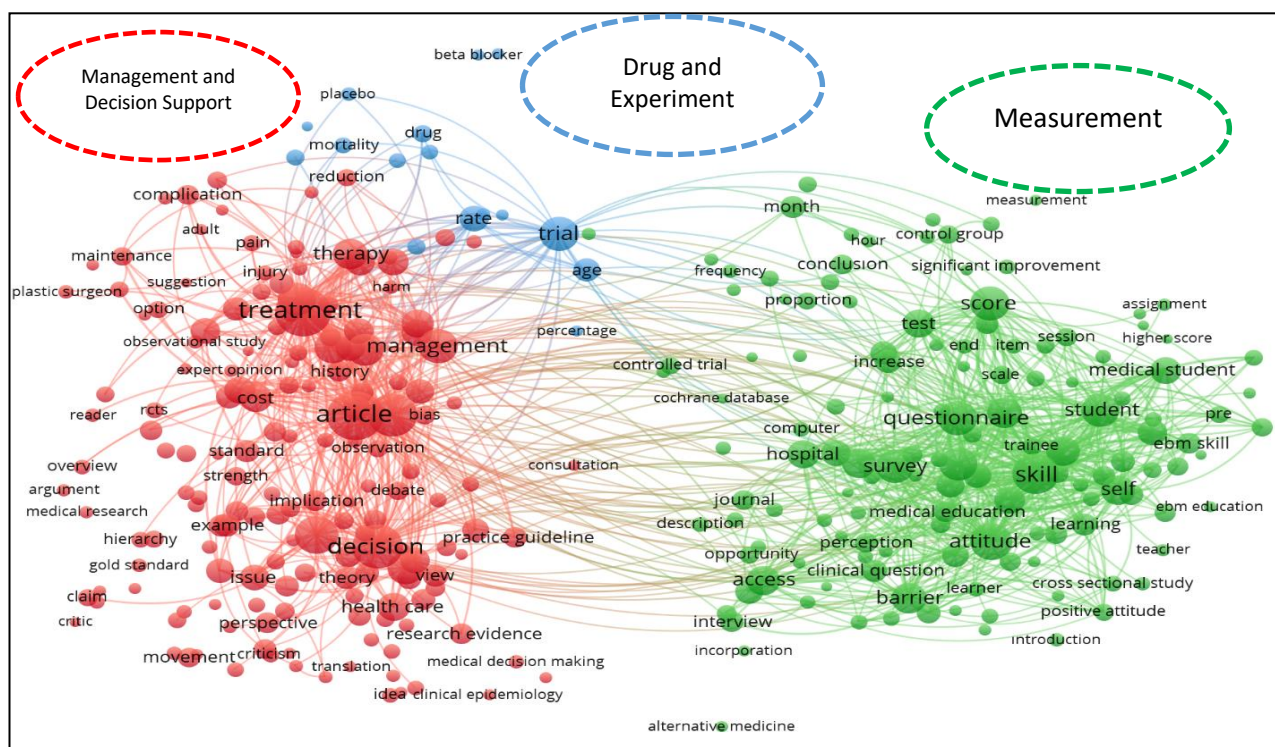


Figure 14. Word Mining Analysis

When the figure above is examined, it is seen that three main clusters are represented in three different colors. The red cluster is the largest and is named as "Management and decision support system". The green cluster is the second

largest cluster. It was named "measurement" because it represents the measurement side of words related to EBM. The smallest cluster, the blue cluster, represents the EBM side in the drug and experimental research processes.



Discussion

The main purpose of this study is to examine the concept of EBM with bibliometric techniques. Using Bibliometrix and VOSviewer software, the most influential authors, countries, institutions, and journals have been identified.

As understood from word mining, the EBM field can be divided into three main clusters. These are; "management and decision support system", "measurement" and "drug and experimental research processes". The EBM concept is widely used to make judgments, the best and most meaningful decision for the patient. Publications of Sacket et al. (1996) and Kerridge et al. (1998) which are some of the first pioneering studies, can be evaluated in this context. The continuation of this trend can be understood from the recent increase in related publications (Barzilai et al. 2017; Schlegel et al. 2017; Bonner et al. 2019).

When the publications in the "Measurement" cluster, which is expressed as a feedback mechanism and measurement practice, are examined, EBM can be used as a measurement tool in the general evaluation of the disease (Hagell & Nygren, 2007) as well as as a general measurement function (Boren & Balas, 1999). There are studies that focus on the meaning of measurement and try to analyze it (Upshur et al. 2001). Studies focusing on non-Hospital Behavioral Health Services (more specific health services outside hospitals and educational institutions) (Lewis et al. 2019) and how to adjust measurement to new areas of expertise (Al Zoubi et al. 2018) are seen when examining the publications of the relevant cluster over the past five years.

When EBM studies in the field of medicine and experimental research are analyzed; in the first period of studies, studies measuring the quality of drug research (Bero & Rennie, 1996), studies examining drug selection in hypertension treatment from the point of view of EBM and studies examining whether drugs used in antirombotic treatment are given according to the level of evidence came to the fore. In the publications after 2017, it was seen that they were designed as a guide for pediatric drugs (Sun et al. 2018), personalized medicine in cardiovascular diseases (Ennezat et al. 2017), and some drugs for clinic pharmacologists (Woodcock & Harder, 2017).

The most cited countries in the bibliometric analysis, the research-intensive countries, are England, the USA, China, Japan, Germany, Italy, Canada, and France (Kisjes, 2013). However, the top eight productive countries in the study were the USA, the United Kingdom, Canada, Australia, Germany, Italy, the Netherlands, and China. Only five countries, UK, USA, Italy, China and Germany, Canada are on the above list and their rankings differ. The productivity of these countries may be related to specific funding opportunities, the number of laboratories, and the number of production programs in these countries.

No comparison was made based on similarities or differences between findings since there was no bibliometric

study on EBM in the literature beforehand. There are many systematic compilation studies on the subject. These systematic reviews were not evaluated because they both examined the data with a separate technique and are related to very specific topics.

Limitations

In this study, there are limitations peculiar to bibliometric analysis tools per se. As it is inherently impossible to construct a perfect and all-encompassing search query, there is always the possibility that false positive and false negative results will be found in any bibliometric research. Citation analysis represents an objective and quantitative measure of research but does not provide information about its quality or its impact on clinical practice, but it can be hypothesized that the more cited an article is, the greater the impact the article will have on scientific research (Fortuna et al. 2020).

Due to the search strategy and limitations of bibliometric analysis, many studies that were not downloaded and examined could not be included in this analysis. There are several reasons for this. If an article is not indexed in WOS even though it receives many citations, it may not find a place in the downloaded raw data. For example, Haynes et al. 1997; Grol & Grimshaw 1999; Richardson et al. 1995; Dunning et al. 2003; Murad et al. 2016 and Straus et al. 2018 publications, which were indexed in other indexes and received a large number of citations, were excluded from this analysis. We must be aware of these handicaps of all bibliometric analysis and use the analysis results accordingly.

In addition, bibliometric analyzes are generally carried out on original articles. Although the leading books of the EBM field have many citations, these books are generally not included in the research. For example, Howick's book "The philosophy of evidence-based medicine" (2011), Greenhalgh's book "How to read a paper: the basics of evidence-based medicine" (2014) and Timmermans & Berg's book "The gold standard: the challenge of evidence-based medicine" (2010) could not be examined.

Conclusion

The results obtained in this study revealed the relationship between EBM and elements such as curriculum, clinical decision support systems, integration of the concept into education and training policies, the function of guides, systematic review, and randomized controlled study. EBM is used as a policy input for the improvement of education, curriculum, and health system while expanding its function in disease and drug treatments. Policymakers, decision-makers, educators, and researchers can develop strategies based on the findings identified above.

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