Original Article

Science Mapping of "Trauma Surgery" by Co-Word Analysis and Thematic Clustering in MEDLINE

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Abstract

Background: Trauma surgery has an interdisciplinary nature among the surgical specialties, and trauma surgeons are required to identify its related scientific fields to acquire the needed skills in controlling the injuries. This study was conducted to investigate the science mapping of trauma surgery based on the bibliographic data of MEDLINE. **Methodology:** Based on the bibliographic data from the MEDLINE database, the visualizing techniques of bibliometric networks and all the scientific products of the trauma surgery realm indexed at MEDLINE from 2008 to 2017 were investigated. Data analysis was performed using co-word analysis and cluster analysis using the VOSviewer. **Results:** The growth trend of scientific productions in the field of trauma surgery has been on the rise in the past 10 years. The keyword "trauma," followed by "osteoporosis," "fracture outcome," "trauma surgery," and "mortality" had respectively the highest frequency. The results of cluster analysis identified the most important basic research subjects of trauma surgery published in MEDLINE in the past 10 years and categorized them into five clusters. Trauma surgery field had a close relationship with the field of orthopedics, basic studies, and laboratory research in comparison with its clinical domains. **Conclusion:** We attempted to identify the vastness of the knowledge subjects of trauma surgery and to conduct educational research, and technological planning so that the managers and stakeholders can trace the path of future scientific activities in the field of trauma surgery. The identification of this important realm and provision of the required information on the core issues for the users can be facilitated by drawing up a science map and visualizing the main traumatic sciences.

Keywords: Co-word analysis, MEDLINE, science mapping, thematic clustering, trauma surgery

Introduction

Trauma surgery has become a branch of surgical specialty since the 1980s, and it deals with invasive treatment of physical injuries, especially in emergency situations.[1-3] This specialty has a broad scope in surgical acute care training and enables the trauma surgeon to address most injuries of the neck, chest, abdomen, and body organs. In large parts of Europe, trauma surgeons mostly treat the musculoskeletal damages, but in the US and Britain, the surgeons deal with the skeletal and orthopedic injuries.[4] Trauma surgeons must be familiar with a large variety of general, chest, and vascular surgical procedures. They also should be able to make complex decisions often in little time and with incomplete information. Proficiency is needed in all sensitive medical care/critical care aspects. In recent years, the experience paradigm of trauma surgeons has shifted gradually into acute surgical care. A combination of trauma surgery and general emergency surgery is often known as acute care surgery.[4,5] Surgical trauma is often referred to as the "neglected step-child" in the global health coverage in terms of patients' number, mortality, and costs. Annually, 234 million surgeries are performed and depending upon the country and organization, up to 4% of patients die before leaving the hospital, up to 15% have serious

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post-operative complications, and 5%-15% are re-admitted within 30 days. These percentages are equal to around 1000 deaths and 4000 major complications per hour; however, it has been estimated that50% of these rates may be preventable.[5] Trauma surgery has permanently evolved during the centuries and has been updated to cope with the modern injuries. Over the last few decades, a large number of advances have been made in Trauma field and its related critical care, leading to an increasing improvement in the frequency of non-operative care for injuries of the neck, chest, and abdomen. Most injuries that require operative treatment are musculoskeletal.[6,7] Trauma Surgery/Trauma Specialization Committee of the American Association for the Surgery of Trauma indicates that the development of new future trauma training depends on the general surgery. The goal of this program is to train the surgeons with extensive expertise in trauma for critical care and emergency general surgery under the name of acute care surgery.[3,4,6] Studies and innovations in the treatment and care of traumatic diseases, considering its interdisciplinary nature, especially in surgical specialties and injury control, have a set of special features and challenges different from other medical areas and include all surgical emergency cases.[8-10] A bibliometric analysis method with quantitative basic features has been used by many researchers in their studies.

At present, the co-word analysis is the most popular bibliometric analysis method that was proposed in the late 1970s by the French bibliometric scientists. The principle of this analysis can be summarized as follows: when two or more specialized keywords appear under the same research topic in the same document, they have significant relationships, higher correlation between the two keywords shows their closer relationship, and these methods are helpful for the researchers to have an overview of a field and play an important role in identifying the value of academic disciplines.[11-14] Co-word analysis is one of the scientometric indices through which we can identify and investigate the conceptual relationships among texts and documents of the scientific fields. Visualization has turned out to be a powerful approach to analyze a large variety of bibliometric networks, a range of citation relationship networks between publications and journals, as well as the network of co-authorship relations between researchers or networks of co-word relations among the keywords.[15]

Co-word analysis is a content analysis technique that investigates the co-occurrence pattern of the pairs of phrase terms in a collection of texts to achieve the relationship of ideas within the subject areas. The co-occurrence analysis of words is based on the assumption that the research areas can be described according to the patterns of vocabulary usage in publications. This technique is a tool in discovering the knowledge and drawing a bibliographic map.[16]

Although many scientific studies and products have been carried out in the field of trauma surgery, no research has ever been conducted on analyzing and drawing the traumatic surgery science map. Through co-word analysis, we can recognize the lexical links in the realm of trauma surgery. Due to the significant increase in the production of interdisciplinary works and the shift toward more interdisciplinary citation patterns, an interdisciplinary study of different domains is needed.[17] Hence, drawing a scientific map and identifying the combination of its domains, recognizing the most widely used and influential fields, examining the interactions of this field with other domains, and determining trauma surgery structure of thought and citation interactions are required to understand the current situation and to predict the future situation. The purpose of this study was to draw and analyze a science plan of trauma surgery based on the papers published in MEDLINE Science and Citation Center during 2008–2017.

Methodology

The current research was a kind of scientometric study carried out using bibliometric networks visualization techniques. The mapping of interdisciplinary communications in the form of scientific maps and visualization techniques has been one of the most important aspects of scientific studies in recent decades.[18] Scientific maps are drawn by a variety of methods, including the co-occurrence of words and visualization. The three most popular visualization approaches are distance-based visualization, graph-based visualization, and time-based visualization.[18,19] The statistical population of this study included all the indexed articles related to the trauma surgery area, which were published from 2008 to 2017 in the MEDLINE: Medical Literature Analysis and Retrieval System Online, or MEDLARS Online.

These papers were extracted from PubMed in May 2018. The keyword "trauma surgery" was entered into the advanced search section under the thematic MeSH terms. The PubMed database was then selected, and the titles, the authors, the journals' index, and the other bibliographic data required by the articles were saved by applying the intended filters as comma-separated value (CSV) file and in MEDLINE format.

The bibliographic data on trauma surgery were uploaded in MEDLINE and analyzed using the visualization of similarities (VOS) technique by text-mining and visualization techniques of VOSviewer version 1.6.8 (Centre for Science and Technology Studies, Leiden University, The Netherlands).[20,21] The VOSviewer provides distance-based visualizations of bibliometric networks. VOSviewer also has some special text mining features. In addition to drawing a map, this software specifies clustering of concepts with specific colors. The number of clusters is determined by a resolution parameter, and higher resolution parameter is representative of the larger number of clusters. In a bibliometric network, often many differences exist among nodes in their number of relationships with other nodes. In the analysis of bibliometric networks, a user should usually perform normalization for these differences among nodes. VOSviewer applies the association strength normalization by default.[20,21]

Results

Scientific productions in the realm of trauma surgery

In this study, 98,226 documents related to the trauma surgery were retrieved through the advanced search tool of PubMed from the MEDLINE database during 2008–2017. Diagram 1 shows the frequency of articles considering the year of publication. As shown in Diagram 1, most articles ($n = 11481$) were published in 2015, and the least number of papers (4677) was related to 2008.

The trend of scientific productions in the field of trauma surgery

The results of data analysis showed that the growth rate of scientific productions related to the trauma area in the MEDLINE had a steady upward trend in the publication of articles from 2008 to 2009. Diagram 2 shows the publication trend of trauma surgery articles in MEDLINE during 2008–2017 based on the growth rate indicator.

The products' growth trend accelerated during 2009–2015 and the highest percentage of the products' growth with a rate of 13.24% happened in 2015, which has been declining since 2015. The average annual growth rate was calculated as 11.05 based on the study years.

Active countries and organizations in the publication of articles in the area of trauma surgery

The identification of organizations active in every field of science is important. Table 1 shows the list of top countries and organizations that have published more than eight articles in the field of trauma surgery during 2008–2017 in MEDLINE.

The global publication of articles in the field of trauma surgery by academic organizations and research institutes indexed in the MEDLINE database was wide and diverse. Based on the findings, Italy with two research centers had the largest publication of articles indexed in MEDLINE during 2008–2017. The countries of Australia, Qatar, Germany, Switzerland, the United Arab Emirates, Finland, the Netherlands, the United States, Iran, Taiwan, and Finland were among the next top countries in the field of producing articles on trauma surgery in MEDLINE.

Co-occurrence map of the keywords and the most important thematic areas of trauma surgery

To find out the most important subjects on trauma surgery, the co-occurrence of words was mapped, and they were visualized using the VOSviewer. The words extracted from the title, keywords, and abstracts of the articles published during 2008–2017 were downloaded from the MEDLINE database with the CSVs. Later, we uploaded the words separately in the software. The threshold for the co-occurrence of words was considered 20 times, and they were sorted according to their occurrence. The co-word network and the density map of the keywords in these domains are depicted in Figures 1-3. In these Figures, the size of each circle implies the knowledge that existed in each concept and small circles represent poverty of information. The

Table 1: Publication of trauma surgery articles during 2008-2017 in MEDLINE based on the source of publication

Rank	Country	Organization/Institution
1	Italy	Department of Surgery, Macerate Hospital
		Department of Orthopedic and Trauma Surgery, Campus Bio-Medico University, Rome
2	Austria	Department of Trauma Surgery, Medical University of Vienna
		Department of Trauma Surgery, Medical University of Innsbruck
3	Qatar	Department of Clinical Medicine, Weill Cornell Medical College, Doha
		Clinical Research, Trauma Surgery Section, Hamad General Hospital, Doha
4	Germany	Institute of Medical Biometry and Informatics, University of Heidelberg
		Cologne Center for Musculoskeletal Biomechanics, Medical Faculty, University of Cologne
		Center for Orthopedic and Trauma Surgery, University Medical Center, Cologne
		Clinic for Orthopedics and Trauma Surgery, Heidelberg University Hospital, Heidelberg, Germany
		Department of Trauma Surgery, Regensburg University Medical Center, Regensburg
5	Switzerland	AO Research Institute Davos
		Department of Trauma Surgery, University Hospital Zurich, Zurich, Switzerland
6	United Arab emirates	Department of Surgery, College of Medicine and Health Sciences, UAE University, Al-Ain
7	Finland	Abdominal Center, University Hospital Meilahti, Helsinki
8	The Netherlands	Department of Trauma Surgery, VU University Medical Center, Amsterdam
		Department of Trauma Surgery, University Medical Center Utrecht, Utrecht, The Netherlands
9	The USA	Southern Oregon Orthopedics, Medford
		Department of Surgery, University of Arizona, Tucson, AZ
		Department of Orthopaedics and Rehabilitation, Oregon Health and Science University, Portland
10	Iran	Department of Molecular Biology, Baqiyatallah University of Medical Sciences, Tehran
		Department of Orthopedic and Trauma Surgery, Shariati Hospital, Tehran University of Medical Sciences, Tehran
		Department of Orthopaedic and Trauma Surgery, Birjand University of Medical Sciences, Birjand
11	Taiwan	Department of Neurosurgery, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Kaohsiung City
12	Finland	-Tampere Research Center of Sports Medicine, UKK Institute for Health Promotion Research, Tampere

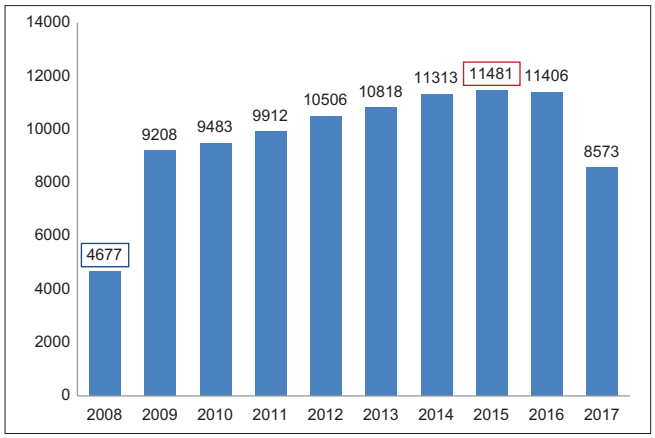

Diagram 1: Frequency of trauma surgery articles published in MEDLINE from 2008 to 2017

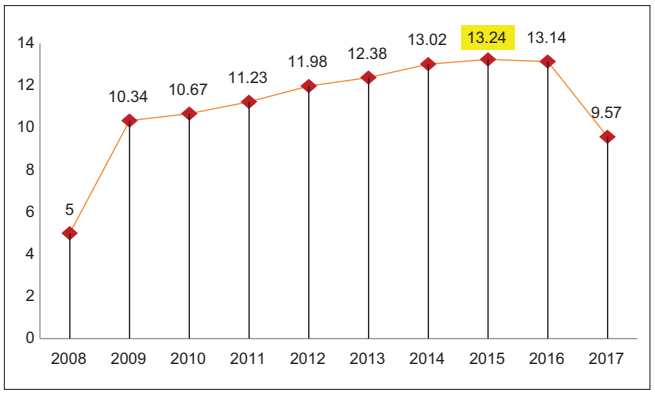

Diagram 2: Trends of the publication of trauma surgery articles in MEDLINE during 2008–2017

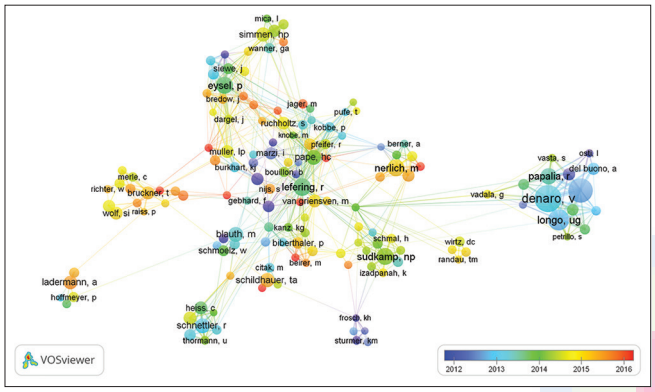

Figure 1: The co-occurrence of authors active in trauma surgery in MEDLINE during 2008–2017. "denaro, v" with 242 articles, "mafulli, n" with 190, "longo, ug" with 143 articles, "el-menyar, a" with 112 articles, and "al-thani, h" with 103 articles

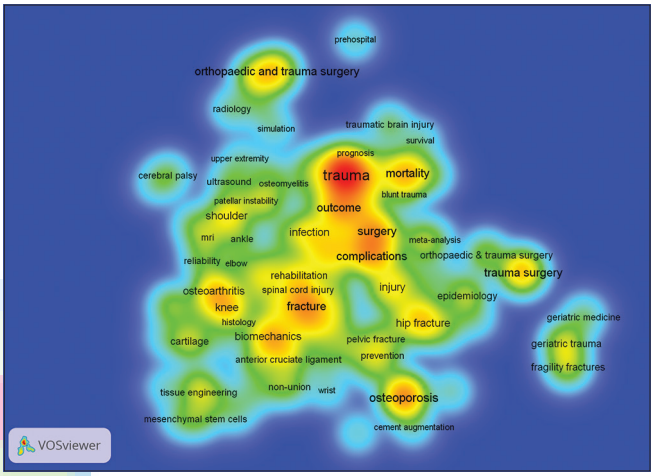

Figure 2: The density of words used by the authors based on the trauma surgery articles published in MEDLINE during 2008–2017 (threshold = 10)

distribution of concepts emphasizes on the scope of studies from different perspectives and interdisciplinary contexts. The lines represent the relationship of concepts with each other, and the relative distances between the concepts indicate their reciprocal influence. The use of these networks can clarify the probable similarities of the citation areas with the trauma area.

Frequent words in the co-occurrence analysis of the authors' keywords

The co-occurrence of keywords used by the authors of articles published in the field of trauma surgery indicated that 8972 keywords had frequency. Considering the frequency of >10 for MEDLINE indexed articles in 2008–2017 (threshold = 10), only 115 keywords were investigated to draw the map based on their density, which are represented in Figure 2.

Each colored point in the density view indicates the density of the items at that point. By default, the colors range from blue to green and from yellow to red. As the number of items around one point increases and the weights of the neighboring items become larger, the color of the points will be yellow to red. On the other hand, with less number of items at one point and lower weight of the neighboring items, the colors are closer to blue. Based on Figure 2, the keyword "trauma" is red and has the highest frequency (occurrence = 176) that is followed by "osteoporosis" (occurrence = 90), "outcome" (occurrence = 66), "fracture" (occurrence = 65), "trauma surgery" (occurrence = 64), and "mortality" (occurrence = 58). The frequency of various keywords in the field of trauma surgery indicates the extent of knowledge and subject areas of this specialty.

Results of co-concurrence analysis of the keywords

In the results of the co-word analysis of the published articles in the field of trauma surgery, 12737 keywords had a frequency. Considering the frequency of >20 in MEDLINE articles in the last 10 years (threshold = 20), only 469 keywords were used for mapping [Figure 3].

Results of trauma surgery thematic cluster analysis

In order to achieve the most important thematic axes of trauma surgery articles, we drew their co-occurrence and visualization map using the text mining and the VOS clustering technique. In this technique, the terms are grouped into clusters, and a cluster is a set of terms and expressions in a map. A cluster is sometimes referred to as a community, but this term is

not used by VOSviewer. The clusters do not overlap in the VOSviewer software. In other words, an item can only belong to one cluster. The analysis of terms and expressions extracted from the titles and abstracts of articles published in MEDLINE during 2008–2017 by the VOSviewer software resulted in 111,003 co-word terms, among which 1483 terms were studied by considering the occurrence threshold of 30 terms. We applied 60% default presupposition of the software for the terms (number = 890) and set the resolution to 1.5. Then, we performed the refinement process, sorted the words, and deleted the stop words (words independent of the context, which connotations do not depend on the intended domain). At the end, five domain clusters with 511 terms were identified. Figure 4 shows the density view of the cluster items.

Figures 5 and 6 show the density and labeled views of the cluster analysis of the MEDLINE studies, which dealed with the most important issues in trauma surgery over the past 10 years. The first and the largest cluster, marked in red, consisted of 162 terms. In this cluster, the two terms of "mortality" and "trauma surgery" were the most frequent words with occurrence rates of 1197 and 1096, respectively. In this cluster, terms such as "care," "death," and "trauma surgery" were more frequent than other terms. The second cluster, distinguished by green, consisted of 148 terms and its most frequent term was "degree" with the frequency of 2098 followed by "range" with a frequency of 1630. Other frequent terms of this cluster included "fixation," "dislocation," and "screw," respectively. The third cluster, shown in blue, had 146 terms, among which the words of "effect" and "cell" with frequencies of 1825 and 1343 were respectively the most frequent expressions.

The fourth cluster, distinguished by a yellowish color, included 48 terms. The most frequent words of this cluster were "knee," "magnetic resonance imaging (MRI)," "graft," and "sport" with respective frequencies of 864, 426, 356, and 321 in studies of the trauma surgery field. Finally, the fifth cluster, which was the smallest cluster and was hardly identifiable with violet color, consisted of seven items, among them the word "exercise" was the most frequent word with a frequency of 52.

Diagram 3 indicates the frequency of active scientific domains based on the scientific clusters and thematic axes of trauma surgery obtained from MEDLINE over the past 10 years.

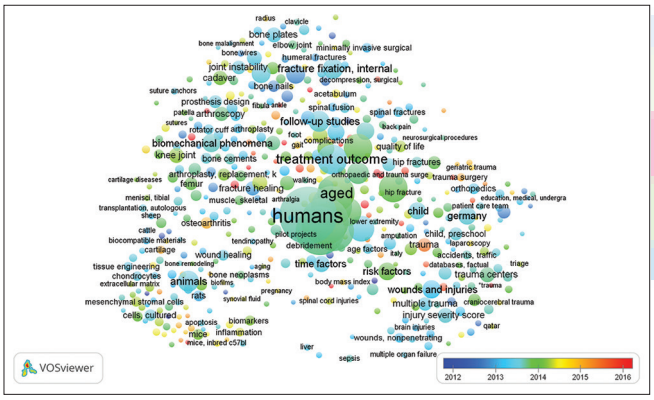

Figure 3: The map of frequent co-words in the field of trauma surgery in MEDLINE articles during 2008–2017 (threshold = 20)

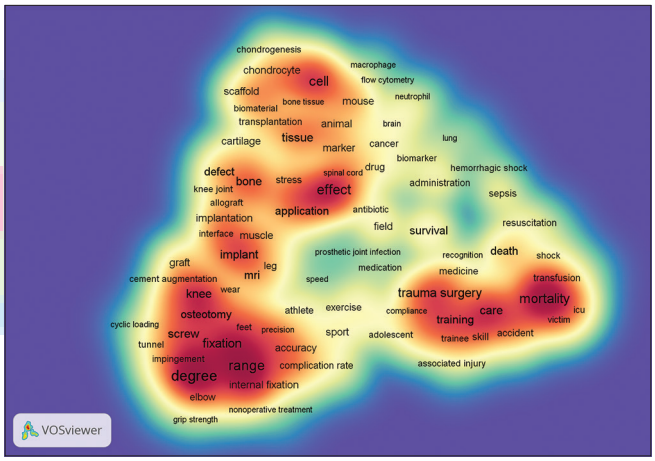

Figure 4: The density of terms in the thematic clusters of trauma surgery field in MEDLINE articles during 2008-2017

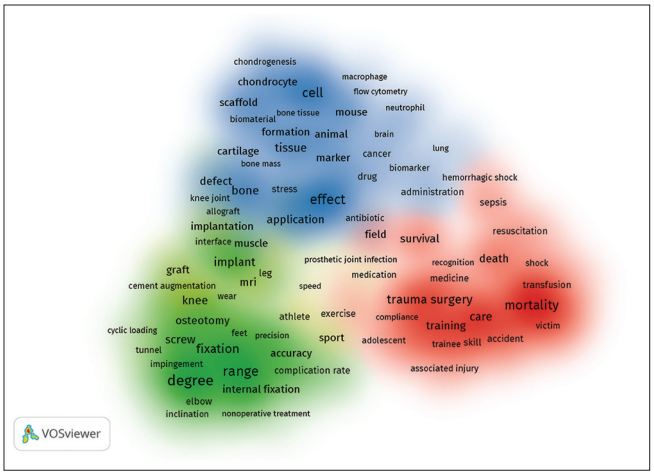

Figure 5: Thematic clusters of the trauma surgery field based on the MEDLINE studies published in 2008-2017 from the density view

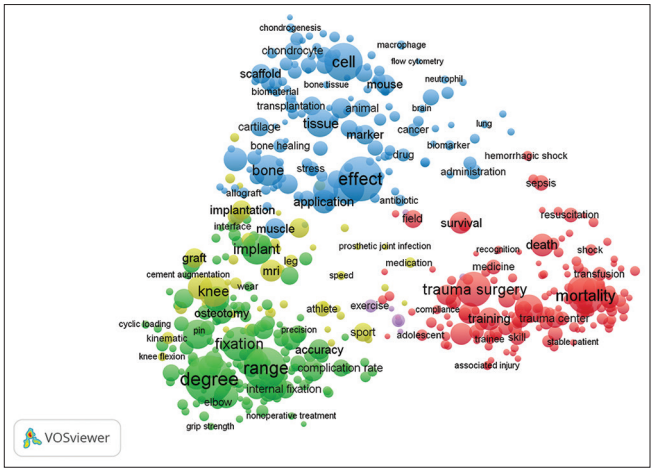

Figure 6: Thematic clusters of the trauma surgery field based on the MEDLINE studies published during 2008-2017 from the the labeled view

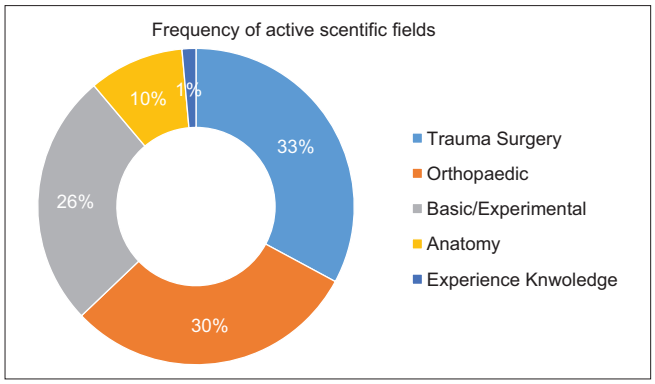

Diagram 3: Trauma surgery knowledge areas in MEDLINE during 2008–2017

Based on the results, the field of trauma surgery had a close relationship with the orthopedic area. Basic and laboratory studies have also grown in comparison with the clinical fields of trauma surgery, and their scientific publications accounted for 26% of the scientific productions of the past 10 years in MEDLINE. The use of imaging techniques and methods was significant in the development of surgical and orthopedic sciences of the trauma field and dedicated 10% of the scientific productions to it. The application of practical experiences and knowledge and reflection of them as scientific findings was 1%.

Discussion

The science map represents the scientific or conceptual structure of a scientific field and is used to illustrate the results derived from the analysis of publications in a field of science from different angles. It is also used to draw up a general view of the domain with the aim of discovering the hidden relationships.[22] This study was conducted for the first time to investigate the trends and draw a science plan of the trauma surgery based on the articles published in the MEDLINE Scientific and Citation Center. The results of the bibliographic data analysis of the studies on trauma surgery published in PubMed indicated that growth of the indexed scientific productions had an upward relatively stable rate. Due to the lack of similar studies in the area under study, results of the current study cannot be compared with other findings. The co-words analysis is a suitable method for drawing the knowledge structures and thematic maps with more advantages than other analytical approaches such as citation analysis in the scientometrics field.[22-24]

Various studies were carried out using text mining and analysis of co-word occurrence to investigate the publication of various scientific topics. In this regard, we can mention studies conducted by Makkizadeh (2016) on addiction[25] Sedighi (2016) with on The Field of Informetrics[14] Makkizadeh (2015) over depression[11] and Yao (2015) over Health Research System (HRS)[12] over health research system.[11,12,14,25] The findings of these studies showed that in the maps obtained at different times, the concepts of the scientific domain make some changes and sustainabilities. The results of our study also indicated that the thematic structure of scientific productions over trauma surgery changed over time and their approach was influenced dynamically by the type of trauma and its damages. The existence of terms such as accident, victim, injury pattern, and fracture type indicates the progression of the traumatic area and is a conformance to the patterns of injury and damage diversity, which is consistent with the results of the Jinescu, *et al* (2013).[7] As previously mentioned, trauma surgery knowledge has an interdisciplinary nature, which is referred to as scientific "crossroad" in the United States. In other words, the specialists of such field use various sciences to deal with it.[4]

The results of a study indicated the extensiveness of this field and its close interactions with other clinical and nonclinical areas. In this study, we investigated the co-occurrence of words and conducted a cluster analysis of the scientific articles in the field of trauma surgery published in the MEDLINE database. The focus of subjects over the past 10 years was on five main clusters and fields, the most important of which were related to trauma surgery and its postoperative care, surgeons' experiences, and life-saving interventions for the survival of trauma patients. The occurrence of the words "death," "mortality," and "survival" indicates the surgeons' concern to provide life-saving cares. Acute care surgery was born from the need to improve taking care of the nontraumatic emergency patients. However, over the past six decades, with the evolution of traumatic systems, the trauma surgery cares have also progressed to an unprecedented level. Trauma teams have been formed, and trauma centers have saved lives. Trauma surgeons have stopped the deterioration of technician surgeons and have shown interest in acute resuscitation and care.[10] Tang and Inaba described the trauma surgery as a scope wider than action, including all the surgical emergencies.[8]

Over the past years, basic medical science studies and laboratory research in interaction with the traumatic surgical knowledge have had a significant growth. Extensive studies conducted with animal models to investigate anatomy, physiology, hematology, pathology, biology, and infection control to develop the boundaries of human knowledge and to create new techniques and technologies.

The thematic cluster terms related to therapeutic technologies, transplantation surgery, imaging techniques, and diagnostic tools such as radiography, sonography, microfilm, and so on, revealing manifestation of words such as implantation, joint Knee, and MRI along with surgery over the past years. According to Galante *et al*., making complex decisions by trauma surgeons requires detailed information for all surgical emergencies.[5] The results this research were less frequent and emergence of terms such as "exercise" and "controlled trial" indicated that the traumatic surgery studies were more focused on the increase of the practical skills and experiences of the trauma surgeons. The occurrence of terms such as "accuracy," "administration," "admission," and "speed" represents the complexity and speed of the trauma surgeons in dealing with the emergencies.

Knowledge areas of general surgery, trauma, as well as emergency and orthopedic cares have the strongest and most influential effects on other areas. The relationship between the subtitles and their extensiveness indicates that the trauma surgery field is very dynamic and its structure has developed over time, which in turn, shows its further interaction with other sciences. The overall structure of this area with five dependent main clusters indicates the richness of the trauma surgical information network and refers to the widespread nature of its interdisciplinary relationships. This point can be useful in understanding the current state of knowledge and scientific policy in this field. It also can identify new research trends in this field of knowledge. Therefore, with regard to the common concepts between the field of trauma surgery and other disciplines, we suggest researchers of this field to carry out more scientific and specialized studies, have more interdisciplinary interactions with more citations, and produce valuable scientific content. We further propose investigation and analysis of the co-occurrence network of the five main domains identified at various time scales to monitor the dynamics of science in these influential areas and to identify the possible strengths and gaps in the path to the expansion of this domain.

Conclusion

The goals of this study were to identify the knowledge vastness of trauma surgery and conduct educational, research, and technological plans so that the managers and stakeholders can trace the path of future scientific activities in the field of trauma surgery. We can facilitate identification of this important area by drawing up a scientific map and visualizing the main traumatic sciences and so providing the users with information on core issues.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Ball CG. Damage control resuscitation: History, theory and technique. Can J Surg 2014;57:55-60.
2. Moore EE. Trauma surgery: Is it time for a facelift? Ann Surg 2004;240:563-4.
3. Peitzman AB. Status of trauma and acute care surgery in the United States. Ulus Travma Acil Cerrahi Derg 2008;14:1-4.
4. Spain DA, Miller FB. Education and training of the future trauma surgeon in acute care surgery: Trauma, critical care, and emergency surgery. Am J Surg 2005;190:212-7.
5. Galante JM, Phan HH, Wisner DH. Trauma surgery to acute care surgery: Defining the paradigm shift. J Trauma 2010;68:1024-31.
6. Ball CG, Das D, Roberts DJ, Vis C, Kirkpatrick AW, Kortbeek JB, *et al.* The evolution of trauma surgery at a high-volume Canadian centre: Implications for public health, prevention, clinical care, education and recruitment. Can J Surg 2015;58:19-23.
7. Jinescu G, Lica I, Beuran M. Traumatic colon injuries – Factors that influence surgical management. Chirurgia (Bucur) 2013;108:652-8.
8. Chico-Fernández M, Terceros-Almanza LL, Mudarra-Reche CC. Innovation and new trends in critical trauma disease. Med Intensiva 2015;39:179-88.
9. Pretz JL, Magnus D, Spain DA. Emergency innovation: Implications for the trauma surgeon. J Trauma 2009;67:1443-7.
10. Velmahos GC, Alam HB. Acute care surgery: The natural evolution of trauma surgery. Scand J Surg 2010;99:59-60.
11. Makkizadeh F, Hazeri A, Hosininasab SH, Soheili F. Thematic analysis and scientific mapping of papers related to depression therapy in PubMed. J Health Adm 2016;19:51-63.
12. Yao Q, Chen K, Yao L, Lyu PH, Yang TA, Luo F, *et al.* Scientometric trends and knowledge maps of global health systems research. Health Res Policy Syst 2014;12:26.
13. Börner K, Scharnhorst A. Visual conceptualizations and models of science. J Informetr 2009;3:161-72.
14. Sedighi M. Using co-word analysis method in mapping of the structure of scientific fields (Case Study: The Field of Informetrics). Iran Res Inst Sci Technol 2015;30:373-96.
15. Xiuwen Chena B, Chena J, Wua D, Xiea Y, Lic J. Mapping the research trends by co-word analysis based on keywords from funded project. Procedia Comput Sci 2016;91:547-55.
16. Neff MW, Corley EA. 35 Years and 160,000 Articles: A bibliometric exploration of the evolution of ecology. Scientometrics 2009;80:657-82.
17. Porter A, Rafols L. Is science becoming more interdisciplinary? Measuring and mapping six research fields over time. Scientometrics 2009;81:719-45.
18. VanEck NJ. Waltman L. Visualizing bibliometric networks. In: Ding Y, Rousseau R, Wolfram D, ediotrs. Measuring scholarly impact: Methods and practice. Q J Res Addict 2017;11:285-320.
19. Börner K, Klavans R, Patek M, Zoss AM, Biberstine JR, Light RP, *et al.* Design and update of a classification system: The UCSD map of science. PLoS One 2012;7:e39464.
20. VanEck NJ. Waltman L. Text mining and visualization using VOSviewer. ISSI Newsletter 2011;7:50-4.
21. VanEck NJ. Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 2010;4:523-38.
22. Lee S. A study on research trends in public library research in Korea using keyword networks. Libri 2016;66:263-74.
23. Hu J, Yin Z. Research patterns and trends of recommendation system in China using co-word analysis. Inform Process Manage 2015;51:329-39.
24. Hu C, Hu SL, Liu H. A co-word analysis of library and information science in China. Scientometrics 2013;97:369-82.
25. Makkizadeh F, Hazeri A. Thematic analysis and scientific mapping of papers related to addiction in medline. J Health Adm 2016;19:51-63.