

SCIENTIFIC PUBLICATION ANALYSIS ON LEAN MANAGEMENT IN HEALTHCARE SECTOR: THE PERIOD OF 2010-2019

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ABSTRACT

Lean management is an operation management approach to improve processes by concentrating the eliminating disruptions, waste management, and enabling smooth production principles. The interest has increased recently in scholarly publications in the healthcare sector. Authors aimed to explore the research outputs to identify and synthesize the results from studies on lean management following real-life sector practices. The bibliometric approaches employed to analyze the papers published in highly ranked and cited journals which indexed and ranked in Web of Science Core Collection from 2010 to 2019. Further, similar studies will be conducted on lean management fields and publication sources. The data of 74 highly ranked journal articles found in SCI-Exp and SSCI indexed sources.

Key Words: *Lean management, healthcare, bibliometric analysis, Web of Science*

SAĞLIK SEKTÖRÜNDE YALIN YÖNETİME İLİŞKİN BİLİMSEL YAYIN ANALİZİ: 2010-2019 YILLARI ARASI

ÖZET

Yalın yönetim, aksaklıkları ortadan kaldırmaya, israf yönetimine ve düzgünleştirilmiş üretim ilkelerini mümkün kılmaya odaklanarak süreçleri iyileştirmek için başvurulan bir üretim yönetimi yaklaşımıdır. Son zamanlarda sağlık sektöründeki bilimsel yayınlara ilgi artmıştır. Yazarlar, sağlık sektörü uygulamalarına uygun olarak yalın yönetim üzerine yapılan çalışmaların sonuçlarını tanımlamak ve sentezlemek için araştırma çıktılarını ortaya çıkarmayı amaçlamıştır. 2010-2019 yılları arasında Web of Science Core Collection'da dizine eklenen ve sıralanan yüksek sıralarda ve atıf alan dergilerde yayınlanan makaleleri analiz etmek için bibliyometrik yaklaşım kullanılmıştır. Ayrıca, yalın yönetim alanları ve yayın kaynakları üzerinde benzer çalışmalar yapılacaktır. SCI-Exp ve SSCI endeksli kaynaklarda yüksek dereceli 74 dergi makalesinin verileri bulunmuştur.

Anahtar Kelimeler: *Yalın yönetim, sağlık sektörü, bibliyometrik analiz, Web of Science*

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1. INTRODUCTION

Lean philosophy emerged as a result of Toyota's struggle for survival after the Second World War and had found widespread application as a requirement of improving the system, reducing costs, increasing efficiency, and customer satisfaction in developed and developing countries over time (Birgün et al., 2006). Although Lean management, known for its success in the manufacturing sector, it is also used recently in other sectors as well as healthcare to increase the performance of the organizations.

Lean philosophy determines the value through the eyes of the customer, and any activity that the customer will not want to endure is considered as waste, and lean management focuses on eliminating waste and coordinating all related activities. In health systems, waste could be seen in excess medical supplies and equipment, unnecessary or repetitive activities of healthcare professionals, transfers of the patients for examinations and tests, improper treatments, unnecessary waiting of patients and their relatives. The cost structure is an essential factor for health institutions. Furthermore, dissatisfaction with the patients causes loss of income as they damage the image of health institutions in a highly competitive environment. Keeping patients in the queue as a matter of capacity shortage as well as a result of improperly designed processes.

Lean management would positively affect the performance criteria in any health organization, such as ensuring the patient and employee satisfaction with the right processes, increasing the number of patients served per unit time, performing more jobs with less inventory, reducing losses and cost, and ensuring sustainability and other related issues.

Lean transformation is likely to encounter many obstacles in an organizational environment, mainly dominated by doctors. Those barriers would be as follow; lack of top management support, less employee engagement, and the existence of resistance, not adopted the daily practices with clear procedures of roles and responsibilities. As with any project, the most critical factor for lean transformation is human. In this study, in order to reveal many issues such as lean management, implementation steps, difficulties and obstacles encountered, models developed for the improvement of processes, implications from practices, and the outputs that will be important for both academics and practitioners.

Authors applied bibliometric analysis with data received WoS Core Collection to explore the scientific patterns in scholarly publications on lean management with healthcare research. Significant findings showed that: (a) the number of journals published from 2010 significantly increased between 2017 to 2019; (b) the leading countries for research in the field, including the USA, the United Kingdom, Italy, and Brazil; (c) there are two predominant peer-review journal sources as Journal of Health Organization and Management, and Production Planning Control (nearly 20%). The top popular research

areas are Management, Engineering Industrial, Health Policy Services, Healthcare Sciences Services, Public Environmental Occupational Health with (nearly 70%); (d) among citation counts; the leading countries are United Kingdom, Sweden, Italy, and Canada, respectively.

The paper is constructed with five research questions and formed bibliometric research analysis structure to explore the publication patterns and distribution by years of 2010 to 2019; publication sources; most productive authors/co-authors; most productive organizations and countries with citation results.

2. LITERATURE REVIEW

The articles studied can be divided into several categories. It has been observed that the studies carried out as a survey focused on employees' adoption and adaptation of lean practices and patient satisfaction. Holden et al. (2015) studied the survey on how hospital workers' perceptions of hospital-wide lean implementation, and discussed the findings concerning strategies for implementing lean in healthcare. Kaltenbrunner et al. (2017) designed a questionnaire that measures the lean adoption of the employees in healthcare and tested psychometrical properties. Mazur et al. (2019) surveyed to reveal whether or not healthcare professionals have lean consciousness while performing lean transformation practices. By creating lean awareness for lean consciousness, they concluded that both the person and the system should be taken into account during the transformation.

Ajmera and Jain (2019) conducted a survey study to evaluate the essential factors affecting the application of lean principles in the health sector and developed a model using the Fuzzy Interpretive Structural Modeling approach. They concluded that lean leadership, professional organizational culture and teamwork, and interdepartmental collaboration are essential factors, and the clarity of organizational vision, communicating goals and results, follow-up, and assessments are factors with full driving dependency power. Dinulescu et al. (2018) conducted a statistical analysis and indicated that the delay time of patients is affected by the delay in the information system. D'Andreamatteo et al (2019) investigated the external forces that direct the transfer of information about lean in the private and public health sectors.

Some of the research studies focused on the literature review. Mazzocato et al. (2010) studied and conducted a thematic analysis. The results reveal as to realise the potential benefits for healthcare organizations need direct involvement with top management, cross-functional teamwork, value creation to patients and other stakeholders, and establish a long-term vision for continuous improvements.

Filser et al. (2017) presented a bibliometric analysis of the papers subjected to the application of Lean Philosophy in a healthcare environment, 2002 through 2015. Costa and Godinho (2016) conducted a quantitative literature review with 107 articles by classifying the five categories, such as research method, country, healthcare area, implementation, lean tools and methods, and results. D'Andreamatteo et al. (2015) reviewed 243 articles and made thematic analyzes, including empirical and theoretical studies. According to the results of the comprehensive review study, lean application is understood as the best way to increase efficiency; hospitals and especially emergency and operating rooms are the ones that adapt the lean philosophy the most; The USA is the leader in this regard; and theoretical studies mainly focus on obstacles, challenges and success factors.

In the systematic literature (Moraros et al., 2016) research conducted by the authors, 22 studies were examined, and in lean applications, there was no statistically significant relationship between customer satisfaction and health outcomes; it is concluded that there is a negative relationship between financial costs and employee satisfaction, and potential benefits on process outcomes are inconsistent and that there is no support for quality improvement. Rees and Gauld (2017) conducted a literature review and discussed that there was no evidence that the lean affects jobs and employees and that the lean effects are uncertain in the healthcare sector.

Crema and Verbano (2017) conducted a systematic literature review to investigate the state of lean health management's support for Choosing Wisely goals, and found that lean had a positive effect. Borges et al. (2019) conducted a review study to investigate lean practices and implementation barriers in health supply chains and reported that most of the practices were carried out in a specific part of the healthcare institution, not across the entire healthcare provider, and therefore were removed from the target.

By conducting a qualitative study, Lindsay et al. (2020) found that the reason why the lean transformation project could not progress was that medical professionals were not able to lead clinical support to support lean. Leite et al. (2020) investigated the deeper causes that produce ostensible barriers to implement lean in emergency areas of healthcare and conducted a thematic analysis. Fournier and Jobin (2018) reported that the poor understanding of the organizational context prevented continuity of lean applications in healthcare organizations in Quebec.

Ramori et al. (2019) conducted a systematic literature review on lean business models used in the healthcare industry. They stated that this review is a guide for the healthcare industry for reducing waste, costs, and improving overall patient care and satisfaction. Al-Balushi et al. (2014) focused on a literature review to determine the readiness factors for

lean implementation in healthcare organizations. They found out leadership, organizational culture, communication, training, measurement, and reward systems were the readiness factors of lean implementation; however, a decentralized management and end-to-end process view were challenging to apply in healthcare systems.

Flynn et al. (2018) researched on the lean sustainability in pediatric healthcare using realist methods. Flynn et al. (2019) conducted a qualitative realist evaluation on the sustainability of lean in pediatric healthcare by using a heuristic approach. They stated that sense-making and staff engagement were the essential factors, and externally led to the implementation and lack of customization were the obstacles for sustainability.

Some authors focused on developing a methodology to improve lean healthcare systems. Dahlgard et al. (2011) developed a model named '4P Excellence Model', which contains both intangible systemic factors such as Leadership, People Management, Partnerships, and more relevant tangible factors such as Processes and Product/Service Results for healthcare organizations. Barnabe et al. (2018) presented a simulation game that enables healthcare professionals to play their roles in the implementation of lean principles and stated it is a useful tool for the training of employees on the lean subject. Robinson et al. (2012) developed the 'SimLean' approach and used the discrete event simulation and lean for increasing the improvement of healthcare processes.

Papadopoulos et al. (2011) conducted a qualitative study using ANP to explore the dynamics in the implementation of process improvement in the Pathology department of the UK NHS, and they have provided a framework to ensure that management takes appropriate and timely interventions during lean transformation. Hussain et al. (2016) listed the wastes by using AHP to conceptualize waste reduction strategies in healthcare organizations in Abu Dhabi and determined that the most critical waste was inventory waste.

Adebanjo et al. (2016) conducted a study to investigate practitioners' perceptions by using the Q-sort with fuzzy AHP for continuous improvement and operational performance. Narayanamurthy et al. (2018) developed a fuzzy-based framework that ranked the improvement needs to assess the readiness of lean health institutions. Efe and Efe (2016) investigated the patient-perceived value to improve the performance of an emergency department; they found that by using DEMATEL the availability of equipment value has a remarkable influence on the other values.

Schonberger (2018) presented a quick response system based on lean principles for the case study of widely scattered heart attack patients were transported to a central treatment hospital in a system-wide. Rosso and Saurin (2018) developed a framework that combines lean and resilient engineering principles to support the design of socio-technical systems

and tested it in a system that includes patient flow from the emergency room to the intensive care unit. Al Khamisi et al. (2019) developed a hybrid knowledge-based system to improve quality management performance by applying Lean Six Sigma in the healthcare environment. Fogliatto et al. (2020) proposed a methodology that contains lean healthcare principles, group technology, and Kaizen applications, in order to rationalize surgical trays and to reduce sterilization processing costs in a sterilization plant. Testing proposed methodology in high complexity, tertiary care hospital, they obtained positive results from the number of instruments, the time-to-assemble trays and, sterilization processing cost.

de Koeijer et al. (2014) proposed a theory-driven framework based on Lean Six Sigma enabling HRM and strategic management successful and improving organizational performance. They also suggested that the sustainability of continuous improvement was remarkable. Wilson et al. (2018) created a causal model for lean-guided quality improvement in healthcare clinical microsystems and examined the effects of contextual factors on the efficacy of healing in this setting. According to the findings obtained, variables defined for teamwork, respect for people, lean actions, and negative motivating factors showed significant effects, and the model well predicted and explained the perceived success.

Tay et al. (2017) proposed a conceptual framework conducting a case study of eight lean projects in two large hospitals in order to investigate how the efficiency paradox can be avoided. They identified service variety, interdependency, capital resource intensity, and service uniqueness were critical contextual factors that drive the orientation of a project to the resource or flow efficiency. Barnabe et al. (2019) developed a comprehensive measurement framework for Lean interventions in the healthcare sector and tested in a large multisite hospital.

van Rossum et al. (2016) conducted an empirical study in an operating room in a Dutch hospital, and using the Change Competence Model they determined that were the positive relations between the transformational leadership and team leadership styles and lean healthcare implementation, and stable relations between worker flexibility and lean healthcare services. There are also publications on real-life applications. In the study of Waring and Bishop (2010), lean transformation practice in an English NHS hospital operation department was analyzed in rhetorical, ritual, and resistance dimensions. The authors concluded that Lean is not an easy solution for efficiency and effectiveness improvements in healthcare due to tensions in the social environment.

Drotz and Poksinska (2014) investigated how the roles, responsibilities, and job characteristics of employees in lean healthcare businesses have changed. They highlighted positive effects on the work environment, staff development, and teamwork. Poksinska et

al. (2013) searched the managerial practices and leadership in lean organizations via five case studies. They found that the manager's role changed radically as from managing processes to developing and coaching people, and the need for transformational leadership behaviors was smaller due to a strong supporting management structure.

Radnor et al. (2012) conducted a case study in the NHS of the UK. They stated that there is a constraint on demand and resource use due to the dependence of health services on capacity, and it would affect lean practices negatively. In Hicks et al. study (2015), seven drug flows were examined in a UK NHS hospital to determine the placement of the new endoscopy unit, primarily as a pilot project, and Lean 3P was used for layout design (production, preparation, process); a framework then was developed for using 3P in the overall design process.

Mazur et al. (2017) and Johnson et al. (2017) conducted a case study to design a new building and its layout in a large academic hospital by using Lean Exploration Loops for the programming phase and schematic phase, respectively. Ker et al. (2014) conducted a case study to understand the effect of technology on the medication distribution system in a multi hospital-healthcare system. They compared no carbon required and digital scanning technologies. As a result, they determined that digital application provided a significant decrease in process times and total cost, and queue time, order entry time, outgoing delay time, and outgoing transit time were significantly reduced.

Boronat et al. (2018) made the lean transformation in the urology department in a tertiary hospital and achieved positive results (such as high practitioner satisfaction and improved quality indicators) with a value of with practices such as team training, process management, continuous improvement and delegation of responsibilities.

Poksinska et al. (2017) conducted case studies for investigating patient satisfaction in primary-care centers that applied and did not apply lean principles, and they found that lean application did not cause a significant increase in patient satisfaction and no improvements over time. The authors suggested that the value should also be handled from a patient perspective, and arrangements should be made accordingly. The results of the one year-5S pilot application in health systems in Senegal were investigated, and thematic analysis was done, and the increases in service quality and personnel motivation observed (Kanamori et al., 2015). Lindskog et al. (2017) explored the impact of lean tools on innovation and found that 5S and value stream mapping facilitated innovative thinking.

Dogan and Unutulmaz (2016) applied a simulation-based value stream mapping (VSM) method to the physical therapy and rehabilitation department of a public hospital in Turkey. They improved the patient flow and patient length of stay, eliminating non-value activities. In this study (Costa et al., 2017), the lean implementation process in the

operations of two hospitals in Brazil has been examined, and the reduction of patient lead times and costs, financial improvements have emerged as motivation factors for lean implementation. The human factor affecting the organizational structure and outsourcing have been identified as the most significant obstacles. Various methods and tools such as VSM, DMAIC were used in the study. Alkher et al. (2019) applied VSM and simulation to simplify the laboratory work in the department of clinical biochemistry. They obtained savings such as eliminating non-value-added times, increasing the number of laboratory analyses, eliminating unnecessary movement, and decreasing patient waiting times.

Yeh et al. (2011) conducted a study by applying Lean Six Sigma to improve the medical process of acute myocardial infarction. In this study, by following DMAIC steps to find critical-to-quality factors, applying VSM to determine non-value-added activities, and using cause and effect diagram to analyze the root causes of waste, they obtained shorter cycle time, higher process efficiency, shorter average days of staying in the hospital and NT\$ 4.422 million savings in the medical resource. Chiarini and Bracci (2013) investigated the ways of using Lean Six Sigma in healthcare institutions and discussed the effects of their research on managers and doctors. Montella et al. (2017) reported that Lean Six Sigma was applied in the general surgery department to reduce the number of patients affected by sentinel bacterial infections. As a result of the improvement of the process, the percentage of patients with infection and the duration of hospitalization decreased. Improta et al. (2018) used Lean Six Sigma for identifying variables affecting the risk of healthcare-associated infections and improving the performance of the care process; as a result, in 1-year, significant reduction is provided in the number of infected patients. Ahmed (2019) used DMAIC and TOC together to improve healthcare performance.

Flynn et al. (2018) investigated lean sustainability in child health services using practical methods. Regis et al. (2018) conducted a case study that analyzed the process of applying lean healthcare in three Brazilian hospitals and stated that the lean healthcare application processes in hospitals are similar in terms of patient, material, or information flow.

Sari et al. (2017) have investigated the cost of lean transformation projects across Saskatchewan province in Canada, which is a state sanction for lean projects. They reported that although the estimated cost for lean projects between 2012 and 2014 was CAD 16 million to CAD 19.5 million, the total cost realized ranged from CAD 44 million to CAD 49.6 million.

3. METHODOLOGY

3.1. Purpose of the Study and Research Questions

The main objective of this study is to explore scientific publication patterns for “lean management to healthcare” domains for the period of 2010 to 2019. The authors decided to study on highly ranked and impacted sources for research. The research also aims to provide insights and information for further studies; therefore, future studies on lean management would be extended with different subject areas. Research questions formed based on the research objectives. The research questions are;

- Q1 What are the characteristics of publication results? How many papers on “lean and healthcare” have published in 2010 and 2019?*
- Q2 Which sources did publish the research domains most frequently?*
- Q3 Who are the most productive authors/co-authors published in those periods?*
- Q4 What are the most productive organizations and countries?*
- Q5 What are the citation results of authors?*

3.2. Bibliometric Study and Data Collection

The bibliometric study requires a structured database to collect and analyze the data. It has various analysis methods for literature review and bibliometric research (Kulakli and Osmanaj, 2020), (Kulakli and Shubina, 2020). The authors employed descriptive analysis, author/co-author productivity, organizations and country publication outcomes, sources (journals), and citation counts for the period. A single bibliometric database of Web of Science Core Collection (SCI-Exp and SSCI) selected. There are two reasons for conducting the data collection, the first structure of data for bibliometric design, and the second is for citation accuracy—the publication data retrieved from the WoS database with the below search strategy in July 2020.

Search criteria

Database ISI Web of Science Core Collection (Clarivate Analytics)

Indexes=SCI-EXPANDED, SSCI

Timespan=All years of (2010-2019)

TITLE: (“lean” AND “healthcare”)

74 publications found in DOCUMENT TYPES of “All”

Within the framed search criteria, the study conducted in bibliometric methods. The data retrieved from the WoS database and downloaded as plain .txt and .bib file formats. In the analysis and data visualization steps, Microsoft Excel and R Studio (Bibliometrix Package) used.

4. RESULTS

4.1 Descriptive Publication Results

Total of (n=74) articles found in Web of Science Core Collection database (SSCI and SCI indexes) for the period of 2010-2019. The majority of the papers are written in the English language (n=73, 98.64%). The only (n=1) article found in the Spanish language (1.35%). Table 1 shows the documents type of 74 publications.

Table 1. Documents Types by Publication Records (2010-2019)

Document Types	Records	% of n=74
Article	58	78.37
Book Review	1	1.35
Editorial Material	6	8.10
Review	8	10.81
Review, Early Access	1	1.35

There are 234 authors/co-authors from 30 countries leading the USA, England, and Italy, followed by Brazil, Sweden, Australia, Canada, and 23 other countries. The keyword distribution found as Keyword Plus (ID) (n=167) and Author's Keywords (DE) (n=193). Table 2 shows the top ten Web of Science subject categories in the data set.

Table 2. Top Ten WoS Subject Areas by Articles (2010-2019)

WoS Subject Categories	Records	% of n=74
Management	18	24.32
Engineering Industrial	13	17.57
Health Policy Services	13	17.57
Healthcare Sciences Services	11	14.87
Public Environmental Occupational Health	10	13.51
Operations Research Management Science	9	12.16
Engineering Manufacturing	7	9.46
Business	5	6.76
Medicine General Internal	3	4.05
Public Administration	3	4.05

In addition to the table, results with (n=2) *Computer Science Interdisciplinary Applications, Engineering Multidisciplinary, Ergonomics, Information Science Library Science, Medical Informatics, Psychology Applied, Social Sciences Biomedical, Urology, and Nephrology*.

4.2. Distribution of Articles by Years

Figure 1 presents the publication records by years starting from the year 2010 to the year 2019. Records started with (n=3) in 2010 then keeps the same amount through the year 2013, the only exception is 2011 with (n=4). From 2014 to 2016, rises to (n=6) and (n=7) steadily. From 2017 to 2019 period doubles the amount of publication as of (n=14). The sharp increase in this period shows the interest in the subject area. The linear trend similarly shows an upward movement in the records—the mean of the publication period as of (n=7.4) yearly overall. However, the last five year represents as (n=11) even for the last three years as (n=13.67).

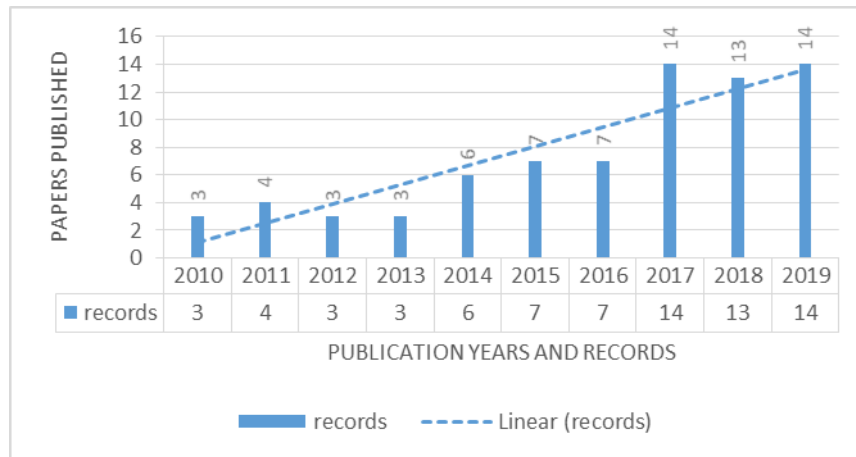


Figure 1. Publication Records by Years

4.3. Journal and Source Frequency and Productivity

According to published data, there are 46 various journals published lean management with healthcare related articles. Table 3 shows the publication frequency in the most relevant sources. The top contributed journals of 13 sources (n>=2 records) listed in Table 3. The most productive publication sources sorted from the highest on top of the list with (n=7; 9.46%) records are *Journal of Health Organization and Management*. Followed by (n=5; 6.76%) *Production Planning Control*; with (n=4; 5.41% each) *Herd Health Environments Research Design Journal*, and *Total Quality Management Business Excellence*. With (n=3; 4.05% each) *BMC Health Services Research*, *International Journal of Lean Six Sigma*, and *Public Money Management*; with (n=2; 2.70% each) *Applied Ergonomics*, *Business Process Management Journal*, *International Journal for*

Quality in Healthcare, International Journal of Production Economics, Journal of Evaluation in Clinical Practice, Social Science Medicine.

Table 3. Most Relevant and Top WoS Publication Sources

Most Relevant-Top Publication Sources	Record	Percent
Journal of Health Organization and Management	7	9.459
Production Planning Control	5	6.757
Herd Health Environments Research Design Journal	4	5.405
Total Quality Management Business Excellence	4	5.405
BMC Health Services Research	3	4.054
International Journal of Lean Six Sigma	3	4.054
Public Money Management	3	4.054
Applied Ergonomics	2	2.703
Business Process Management Journal	2	2.703
International Journal for Quality in Healthcare	2	2.703
International Journal of Production Economics	2	2.703
Journal of Evaluation in Clinical Practice	2	2.703
Social Science Medicine	2	2.703

Besides, data shows that there are thirty-three publications as single articles in the following sources. Those source are namely as *Arquivos de Neuro Psiquiatria, BJU International, BMI Quality Safety, Business Horizons, Creativity and Innovation Management, Economic Computation and Economic Cybernetics Studies and Research, Engineering Management Journal, European Journal of Operational Research, European Journal of Public Health, Fujitsu Scientific-Technical Journal, Global Health Action, Health Affairs, Health Policy, International Journal of Computational Intelligence Systems, International Journal of Health Planning and Management, International Journal of Human Resource Management, International Journal of Information Management, International Journal of Operations Production Management, International Journal of Technology Management, Investigative Ophthalmology Visual Science, Journal of Nuclear Medicine, Neurosurgery, Nursing Research, Operations Management Research, Quality Safety in Healthcare, Rae Revista de Administracao de Empresas, Reviews on Environmental Health, Scientometrics, Systematic Reviews, Tehnicki Vjesnik Technical Gazette.*

4.4. Author's Productivity

Table 4 presents the author/co-author's detailed results according to published data. Six articles published as single-authored documents, while multi-authored documents stand as (n=238) documents and (n=234) authors with (n=268) appearances. Documents per author ratio is (n=0.32), while authors per document are (n=3.16).

Table 4. Author/Co-author Descriptive Results

Descriptive results	Records counted
Authors	234
Author Appearances	264
Authors of single-authored documents	6
Authors of multi-authored documents	238
Documents per Author	0.32
Authors per Document	3.16
Co-Authors per Documents	3.57
Collaboration Index	3.35
Average citations per documents	24.74

The author's productivity results are not significantly different among authors. The most productive authors have three papers each (n=3; 4.05% each) namely McCreery J., Radnor Z., and Rotter T. followed by 25 authors with (n=2; 2.70% each) Al-Balushi S., Barnabe F., Chadwick J., Costa L.B.M., D'andreamatteo A., Drotz E., Eriksson A., Flynn R., Godinho M., Guercini J., Hartfield D., Ianni L., Improta G., Johnson K., Mazur L.M., Newton A.S., Papadopoulos T., Poksinska B., Pooya P., Radnor Z.J., Robinson S., Sargiacomo M. Scott S.D., Singh P.J., Triassi M. The remaining of the 205 authors appeared in articles with (n=1; 1.35% each).

4.5. Organizations and Countries Productivity

Contributed countries have counted as 30 (without corresponding author records) in Figure 2. Similar patterns can be seen as leading and top countries as the USA, England, and Italy among the top three in the list also.

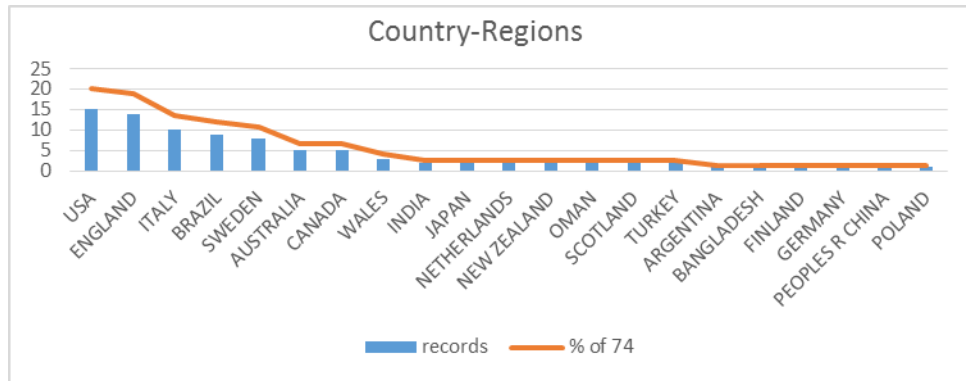


Figure 2. Country-Regions by publication

Table 5 presents the most productive (top 10, with $n \geq 2$ articles) countries based on the corresponding author country list ($n=21$) in the research domains. The leading countries are the USA, and the United Kingdom. The table shows two dimensions of collaboration patterns as Article Counts (n), Frequency, Single Country Publications (SCP) and Multiple Country Publications (MCP), and MCP Ratio (MCP/SCP).

Table 5. Country Productivity by the Corresponding Author

Country	Articles (n)	Frequency	SCP	MCP	MCP_Ratio
USA	12	0.1714	9	3	0.25
United Kingdom	10	0.1429	9	1	0.1
Brazil	8	0.1143	5	3	0.375
Italy	8	0.1143	8	0	0
Sweden	7	0.1	4	3	0.429
Canada	6	0.0857	4	2	0.333
Australia	2	0.0286	0	2	1
Netherlands	2	0.0286	2	0	0
New Zealand	2	0.0286	2	0	0
Turkey	2	0.0286	2	0	0

Besides, countries with ($n=1$) publications are sorted as *Bangladesh, India, Japan, Romania, Serbia, Singapore, Spain, Switzerland, Taiwan, Thailand, and the United Arab Emirates*.

Figure 3 represents organization affiliated and contributed to the lean management with healthcare research with ($n \geq 2$) list. There are 135 organizations in total, 28 are more than ($n \geq 2$) articles (shown in Figure 2), remaining 107 of them have ($n=1$) articles each.

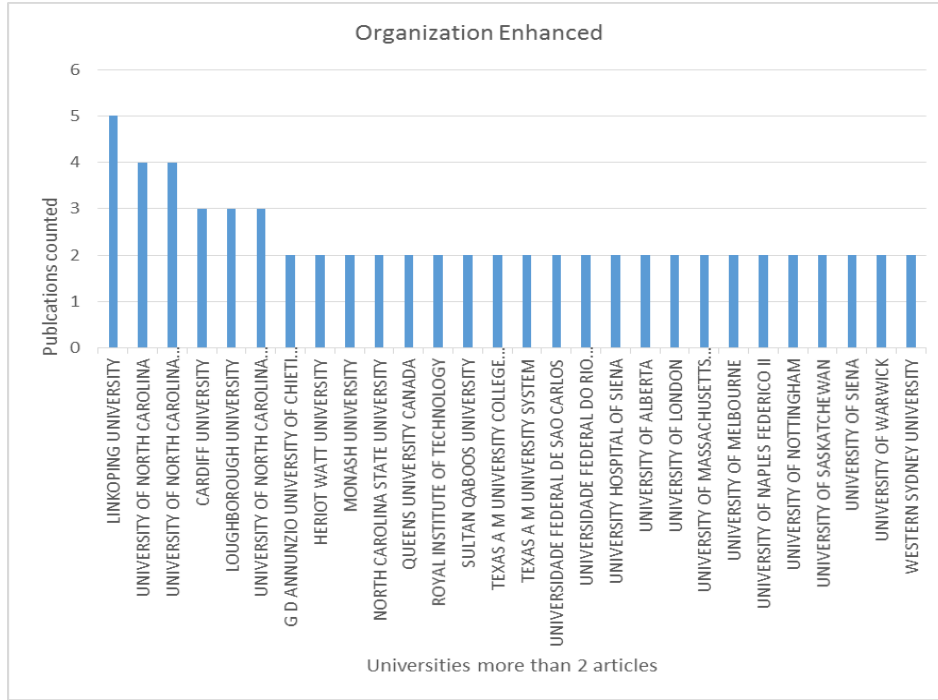


Figure 3. Affiliated Organizations

4.6. Citation Results

The citation report of 74 publications resulted from the Web of Science Core Collection between 2010 and 2019. Findings show that h-index 19; average citations per item 24.74; the sum of times cited 1831; without self-citations 1664; citing articles 1073; without self-citations 1028 counted. Figure 4 represents the total citation distribution throughout the research period. Although the citation figures started in 2010, it starts rising in 2015 with (n=99) then sharply increased in 2016 (n=235). Between the years 2016 and 2017 were stable. It again started sharply increase even doubled the citation counts and reached (n=496) in the year 2019. The last three years in the period have enormous rise, and it also reflects the importance and interest to the research areas of lean management to healthcare domains.

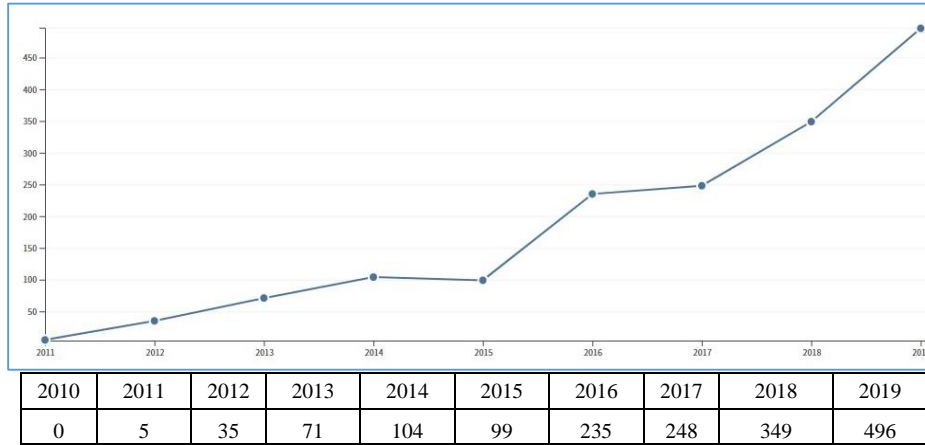


Figure 4. Total Citation Counts Per Year (2010-2019)

Table 6 demonstrates the total citations count by the top ten countries during the period. Similar findings can be seen in country productivity figures in comparison to citation count by countries also.

Table 6. Top Ten Citation Results by Countries

Country	Total Citations	Average Article Citations
United Kingdom	646	64.60
Sweden	523	74.71
Italy	195	24.38
Canada	104	17.33
Brazil	81	10.12
Australia	66	33.00
USA	44	3.67
Netherlands	43	21.50
Thailand	29	29.00
Turkey	21	10.50

5. DISCUSSIONS AND CONCLUSION

The study aimed to conduct a scientific publication analysis by using bibliometric techniques on lean management with the healthcare sector. The analysis was conducted on published sources, which indexed and ranked in the Web of Science Core Collection from 2010 to 2019. The research questions formed to understand and find out the outputs in scholarly publications to discover patterns in the data set.

The data set showed the publication distribution and highlighted the results. So, publications started in 2010 with a minimal number of (n=3) and continued until 2016 and reached the (n=7) double size. The years between 2016 to 2017 publication volume doubled with the same pattern as previously (n=7) to (n=14). Years 2017, 2018, and 2019 the same number of publications found (mean=13.67) while for the decade (mean was 7.4).

The leading countries for publication count are the USA, the United Kingdom, Brazil, Italy, Sweden, Canada, Australia, Netherlands, New Zealand, and Turkey. Moreover, similar patterns found in citation results for a country appear on the top of the list as United Kingdom, Sweden, Italy, Canada, however, the USA interestingly in lower rank compare to leading in publication count. Moreover, the leading journals are Journal of Health Organization and Management, Production Planning Control, Herd Health Environments Research Design Journal, Total Quality Management Business Excellence in thirty among the journals.

The leading productive and contributed organizations with (n \geq 2) publication counts are Eindhoven University, Hassel University, Kyung Hee University, National Taiwan University, and Tsinghua University among (n=135) in total.

Another interesting pattern can be seen in country productivity by corresponding author distribution (Table 5). While the USA and the United Kingdom have the highest article count in Single Country Publications (SCP, n=9), interestingly, both have fewer numbers in Multiple Country Publications (MCP, USA n=3, and UK n=1). Italy also shows impressive figures in SCP (n=8) compare to MCP (n=0), meaning that only domestic collaboration was common. The Netherlands, New Zealand, and Turkey (SCP n=2; MCP n=0) seem to concentrate on their country collaboration, whereas Australia shows the opposite (SCP n=0; MCP n=2). Therefore, Australian researcher concentrates international collaborations. On the other hand, countries like Brazil, Sweden, and Canada show domestic and international collaborations in balance within the data set. Consequently, country-level studies more common than the global level in terms of collaborative studies.

This study has some limitations, like any academic paper. First, the analysis conducted in the bibliometric database within the methodology, and it covers the last decade only. Second, the publications concentrated only on the English language. Furthermore, the study could not be generalized for the entire lean management context. Although having minor limitations, the study reveals crucial points for researchers to understand the structure of lean management with healthcare sectoral insights and perspectives. The highest quality sources used for the analysis, moreover, the level of scientific and domain-specific knowledge provided with comparison in the findings. The study also helps researchers for their further studies to concentrate the publication sources, which may provide suitable journal search and subject category queries. Therefore, in order to recognize and take account of the primary data collection needs, researchers and practitioners should be able to understand the patterns and trends of existing publications in the subject domains.

Lean management, which is an operational management discipline to improve processes and provide smooth production of goods and services to companies, still developing fields in academy and industry.

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