Systematic review and meta-analysis of the use of lean methods and tools in healthcare services: an alternative to improve care during the pandemic

Laryssa Carvalho de Amaral (laryssaamaral@id.uff.br)
Universidade Federal Fluminense https://orcid.org/0000-0003-2320-4383

Robisom D. Calado (robisomcalado@id.uff.br)
Universidade Federal Fluminense https://orcid.org/0000-0003-3349-0344

Adriana Melo Teixeira
Ministério da Saúde

Maria Helena Teixeira da Silva
Universidade Federal Fluminense https://orcid.org/0000-0001-5330-3361

Saulo Cabral Bourguignon
Universidade Federal Fluminense https://orcid.org/0000-0003-2098-8880

Helder Gomes Costa
Universidade Federal Fluminense https://orcid.org/0000-0001-9945-0367

Systematic Review

Keywords: Lean Healthcare, Lean Hospital, Tools, Health Service.

Posted Date: August 5th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-53743/v1

Abstract

Background: Lean approach has become a trend due to its credibility achieved in several sectors, including Health services having target at the care and security of patients. This paper aims to map how Lean tools are being used in healthcare and what are their results, including those related to humanization.

Methods: A Systematic Literature Review was performed according to the following steps: search for articles approaching the Lean Healthcare theme published in English between 2014 and 2020, selected on the databases of Web of Science, Scopus and Compendex (no other articles were introduced on the literature review), followed by discarding duplicates. The records were screening focusing in the section of articles reporting cases of lean healthcare adopting. No articles were excluded after the screening, which resulted in 48 articles that were deeper analysed through both qualitative and quantitative analyses.

Results: Value Stream Mapping (VSM), 5S and Kaizen were the most used Lean tools in related study, with 24, 14 and 13 occurrences. The simulation and the “5 Whys” were Lean tools less used, with 3 and 2 occurrences. The main benefits found with the use of such tools were a reduction in the service time and an increase in patient satisfaction. The influence of teams and doctors behavior was identified as barrier to Lean implementation.

Conclusions: The word "human" was discovered to be the most used word to describe Lean works in healthcare, that was not related in earlier reviews. There was also an increase in the number of Brazilian publications on subject, compared to previous period, in which the United States led on the number of publications. Throughout the study, two related cases added an annual savings of US $ 444,911, with the implementation of Lean Healthcare. The Lean approach has been applied in some health services to reduce the time of attendance and increase patient satisfaction. These results are indicative for expanding its application in the context of pandemics such as COVID-19.

1. Background

The Lean management system, proposed by Womack, Jones and Roos (1990) has, among other consequences, the reduction of waste, including time wasting, being steps for the continuous improvement of the efficiency and effectiveness in a healthcare system. Reducing the number of people in the waiting room, triage and attending room, will reduce waste and facilitate its management.

On the other hand, the time spent by patients at care units is a variable that must be reduced to mitigate the exposure of patients to hospital risks, especially at the moment of a pandemic, as the COVID-19 reported in the most varied newspapers, broadcasters and social media, due to its rapid spread worldwide, and with many cases, deaths, incidence and mortality rates in all regions of Brazil, as shown in table 1. This fact forces the health sector to look for new ways to manage its processes, in order to offer higher quality and faster services, and to provide better and higher numbers of patients assisted.

Therefore, the search for new tools to improve seems to be an inevitable goal in the health sector. In this scenario, Brazilian Ministry of Health in partnership with the Universidade Federal Fluminense implements a project entitled “Lean nas UPAs” (i.e. Lean in the Emergency Care Units), as a successful Lean bet to humanize and improve the flow of patients cared in the UPAs.

Table 1- Shows the number of cases, deaths, incidence rate and mortality in all regions of Brazil. This table was extracted from the Ministry of Health website and its information is updated every day.

Thus, the application of Lean concepts within hospitals seeks to increase the patient care quality, support employees and doctors to eliminate waste and allows them to focus on providing care, according to Graban (2012).

There are reports of Lean practices applications in hospital emergencies and among other health sectors, characterizing the term “Lean Healthcare”. However, the records of these actions are dispersed in the literature, which, as described in Azevedo and Costa (2001) implies a loss of systemic vision about the applications of Lean Healthcare in hospital emergencies and in other health sectors.

In this context, Mazzocato et al., (2010), Souza (2009), Costa and Godinho Filho (2016) and Gomes et al., (2017) produced literature reviews that provide progress on the topic.

The following research question was used to guide data collection: What are the main benefits in the hospital system when taking the Lean Healthcare approach?

This paper aims to map how Lean tools are being used in healthcare and what are their results, including those that regards with humanization on the principle of respect for people. To this end, the results found in earlier research, cited in previous topic, are updated and complemented, and contribute to knowledge expansion on the topic of Lean Healthcare. In addition, the research methods used in the present study did not find studies of systematic reviews, following PRISMA protocol, related to the years 2014 to 2020 that applied a statistical method of quantitative studies of publications, indicating research trends. Which makes it difficult to establish comparison standards.

This study also aims to contribute filling this gap, for this purpose the tool 5W1H was adopted (acronyms that represent the main questions that must be answered: What, Where, When, Who, Why and How) as a way to define the questions used in this work: 1) What Lean methods and tools were implemented in the health service and what results were found? 2) Where were implemented Lean methods and tools in health services? 3) When were the articles published? 4) Who dealt with the subject in the literature? 5) Why is Lean used in health services? 6) How was lean thinking implemented in health services? Therefore, these questions are the basis that this research was developed on, to report the cutting-edge of the state of the art of the Lean Healthcare in the period from 2014 to April 20, 2020.

In relation to the traced objective, it is possible to relate humanization through the application of Lean methods and tools (value stream mapping, work standardized, rapid improvement events / Kaizen event and process mapping), which result in continuous improvement. They deal with patients as a priority and try to understand what creates value according to the patients. In Brazil, the Política Nacional de Humanização – PNH (i.e. National Humanization Policy - PNH) launched in 2013 that seeks to put into practice the principles of Sistema Único de Saúde - SUS (i.e. Single Health System) in the daily basis of health services, producing changes in the way of managing and caring. It can be associated with the Lean methods and tools use.

In recent years, the health sector has changed its efforts to quality initiatives, such as Lean systems, which were introduced by the manufacturing industries (SLOAN et al., 2014).

When we think about the hospital area, Lean, together with its tools, shows great efficiency, because it makes possible to reduce waiting time in patients admission process, the time spent by patients at care unit, seeking control mechanisms for rational use of resources, which can promote a better quality of life for patients and reduce costs.

Thus, as described by Costa and Godinho Filho (2016) the systematic elimination of waste is one of the main focuses of Lean philosophy, and according to Toussaint and Gerard (2010), the seven categories of waste from the Toyota Production System can be adapted from Ohno (1998) to healthcare: waiting (for an appointment), motion (searching for drugs), transport (transferring patients to new rooms), overproduction (unnecessary treatment), defect (work already done for errors), over-processing (unnecessary forms) and inventory (stock of medicines). Liker and Meier (2006) mentioned the eighth waste, not using people's creativity.

In their study, Mazzocato et al., (2010) presented four tools: Value Stream Mapping (VSM) for Lean intervention as methods to understand processes, to identify and analyse problems; Process mapping to organize more efficient and/or efficient processes; 5 whys to improve error detection, relay information to problem solvers and prevent errors from causing damage; 5S (so called due to the first letter of 5 Japanese words *Seiri* - Classification, *Seiton* - Order, *Seiso* - cleaning, *Seiketsu* - standardization, *Shitsuke* - Discipline) to manage change and solve problems with a scientific approach, these were the most used tools according to the studies found. This article classified the studies found between the years 1998 to 2008, 33 articles were reviewed in total. The main results of the Lean implementation found were the reduction of errors, patient satisfaction, reduction of mortality, reduction of costs and waiting time. It can be highlighted the preference for the applicability of Lean tools, according to the literature, in the following health sectors: emergencies, anesthesiology/intensive care, gynecology and obstetrics.

Souza (2009) in his study separated the articles selected by the research methodology (case studies and theoretical studies) and the countries cited in the literature between the years 2002 to 2008 analysing 90 articles. The case studies analysed by the author refer to the use of Lean methods and tools in some departments of a hospital, including, pharmacy, radiology, pathology and laundry. The study of the patient flow made it possible to reduce the waiting list and reduce costs, yet, it improved the quality of

patient care and patient satisfaction, they realized the use and effectiveness of the application of other tools of the Lean like A3, 5S and Just in Time. They identified the United States, United Kingdom and Australia as the main countries in the implementation of Lean, according to the literature.

The study conducted by Costa and Godinho Filho (2016), reviewed 107 articles in the Engineering Village, Web of Knowledge, Scopus and Google Scholar databases between 2009 and 2014. In this study, the United States, United Kingdom and the Netherlands appear as the leading publishers of scientific articles detailing the Lean implementation in health services. Authors classified health services into four categories: 1) auxiliary services, 2) therapeutic and clinical operations, 3) hospital and 4) general. In category 1, they identified hospital pharmacy, radiology, pathology, anesthesia, laboratory, hospital laundry and outpatient clinics. Standard work was the most accepted tool, but Value Stream Mapping (VSM) was the most used tool. At the outpatient clinic he found unsatisfactory results and the project was finished because of the team's discouragement. In category 2, the implementation of Lean approach in the emergency department and operating room was identified as relevant in numbers of cases. Some doctors report that the work standardization impairs the individualized treatment of the patient, but the standard work was the most cited tool in the literature, behind the VSM. The main results were the decrease in the patient's stay and an increase in the service capacity. In category 3, it reports on the application of the Lean approach throughout the hospital, highlighting the Value Stream Mapping and Ishikawa (or fishbone) diagram and the DMAIC method (composed of the steps: Define, Measure, Analyse, Improve and Control). Most frequent results were related to cost, time and increased service capacity. Finally, in category 4, the greatest use of the Lean tools mentioned in the literature was highlighted, the Value Stream Mapping and the Work Standardization. Other studies mentioned in this article highlighted the state of the art of Lean Healthcare.

In the study by Gomes et al., (2017), also used as the basis for this work, a systematic literature review was carried out including 175 articles from the years 2002 to 2015. The study highlighted three main Lean tools and techniques mentioned in the literature. for Value Stream Mapping, Kaizen and 5S. It was also noted the use of quantitative tools applied along with the Lean approach such as Six Sigma and Simulation. The health sector identified as the most used for Lean tools application are emergencies, followed by the surgery sector and the post-operative team. Decreased processing time (exams and visits) and reduced queues were the results found.

In order to understand the topic, this article is organized as follows: the methods are presented in section 2 applied to generate the core of references; in section 3, the results found are presented; section 4 the discussion; section 5 presents the conclusions and considerations about the work.

2. Methods

Search strategy and appraisal of studies

The review was performed in papers that approached the subject Lean tools and Healthcare which were published in journals indexed in Web of Science, Scopus and Compendex, limited to articles written in

English that were published from January 2014 to April 20, 2020. The choice of these databases intends to avoid grey literature from the able of papers. This study was conducted according to the Preferred Reporting Items of Systematic Reviews and Meta-Analysis Protocols (PRISMA) checklist guideline. In addition to that, the journals were also verified through a search in lists of predatory journals to ensure that all used articles of this study do not belong to grey literature neither were published in predatory journals. The key terms used for the database searches were connected by Boolean operators and combined as follows: “Lean Healthcare” OR “Lean Hospital” AND “Tools”.

Inclusion and exclusion criteria

Inclusion

Study area: Have not delimitation area, all countries were included.

Participants/population: Articles published in indexed periodicals, approaching the use of lean tools in hospital environment.

Intervention: The exposition about subjects found.

Comparison: Comparison with found results in previous review as Mazzocato et al., (2010), Souza (2009), Costa and Godinho Filho (2016) and Gomes et al., (2017).

Exclusion

Studies that had as research methodology literature review were not highlighted.

Studies that have not the full text in English or that were published until December 2013 or after April 2020 were not analysed.

Outcome measurement

Mapping of lean tools, opportunities, and barriers.

The database search results were exported

Duplicate articles from the merging of Web of Sciences and Scopus results were removed from the sample using Mendeley Desktop software (version 1.19.5 / 2019; Paul Foeckler, Victor Henning, Jan Reichelt, London, England). In this article was utilized also VOS Viewer (version 1.6.14; Leiden University, Netherlands) with the focus to map keywords and authors citation found on step 3.2 (Selection of articles) and shown on step 3.4 (Statistical analysis of the selected records). Therefore, VOSviewer is a computer program that can be used to create maps based on network data. Maps are created using the VOS mapping technique and the VOS clustering technique. Any disagreement between reviewers was resolved through discussion and reaching consensus.

Statistical analysis

Information on the studies characteristics such as years of publication, study region, Lean tools, authors, countries, journals and actuation health area were extracted from each study using a Microsoft Excel. Then, data were exported to BibTex (version 0.99d; Oren Patashnik, Leslie Lamport, California, United States) for further analysis to use in VOSViewer Software.

Study design

In this study, all articles were included giving a highlight for case studies. All selected works were full-text articles written in English-language and published from January 2014 to April 20, 2020. A Systematic Literature Review (SLR) is carried out, a mapping of the literature, which is structured in the following steps (Figure 1): 3.1) Choice of databases to be searched and define, test and apply the search phrase or Query to search on the selected databases; 3.2) Selection of articles to be analysed; 3.3) Reading and analysis of texts and framing of subjects of accord with the construct: health area, Lean methods and tools mentioned, country of application, main journals and authors, ways to implementation and their results, barriers and opportunities found; 3.4) Statistical analysis of the selected records and obtain from the analysis the graphic content for this article; 4) Discussion; 5) Conclusion of the work and proposition of suggestions for future research.

3. Results

In this section, the results obtained through the application of the steps defined in the methods of this work are presented.

3.1 Choice of database to be searched and definition of Query

For the selection of articles, the Web of Science and Scopus database was used because it has data processing and analysis of bibliographic mappings. To complement the study, the Compendex database (Engineering Village platform) was used. The research carried out on the Compendex database did not change the number of articles for the present study.

Definition and application of Query.

For *Web of Science*

Query: **TOPIC:** (“Lean Healthcare”) *OR* **TOPIC:** (“Lean Hospital”) *AND* **TOPIC:** (“Tools”).

Refined by: YEARS OF PUBLICATION: (2020 OR 2016 OR 2019 OR 2015 OR 2018 OR 2014 OR 2017) AND LANGUAGE: (ENGLISH) AND TYPES OF DOCUMENTS: (ARTICLE).

For *Scopus*

Query: (TITLE-ABS-KEY (*"Lean healthcare"*) OR TITLE-ABS-KEY (*"Lean hospital"*) AND TITLE-ABS-KEY (*"tools"*)) AND (LIMIT-TO (PUBYEAR , *2020*) OR LIMIT-TO (PUBYEAR , *2019*) OR LIMIT-TO (PUBYEAR , *2018*) OR LIMIT-TO (PUBYEAR , *2017*) OR LIMIT-TO (PUBYEAR , *2016*) OR LIMIT-

TO (PUBYEAR , *2015*) OR LIMIT-TO (PUBYEAR , *2014*)) AND (LIMIT-TO (DOCTYPE , *"ar"*)) AND (LIMIT-TO (LANGUAGE , *"English"*)).

3.2 Selection of articles

In the selection criteria, the search string “Lean healthcare” OR “Lean hospital” AND “Tools” was used. This keyword choice represents most of the terms described within this literature. With this search criterion, in the database Web of Science were found eighty-six publications, fifty-six publications were found in Scopus and twenty publications were found in Compendex, identifying a total of one hundred and sixty-two articles. The next step was the selection for the year of publication of the articles. Only publications made between 2014 to April 20, 2020 were considered. In this stage, the total of seventy-eight publications resulted in the Web of Science, in Scopus there were forty-one documents and in Compendex there were twelve documents.

In addition, three filters were defined as criteria for selecting documents. The first filter selects only documents of type “Article”. In this step, thirty-two records were excluded in the Web of Science database, in Scopus twenty-two records were excluded and in Compendex ten records were excluded from the selection process. With forty-six articles selected on the Web of Science, nineteen articles selected on Scopus and two articles selected on Compendex, the second selection filter was English language. In this step, two articles written in German and three articles written in Spanish on the Web of Science were excluded. Based on these criteria, forty-one articles were selected for the work by the Web of Science database. One article written in German and two articles written in Spanish were excluded from the Scopus database. Based on these criteria, seventeen articles were selected for the work of the Scopus database. In the Compendex database, articles were not excluded, because two articles selected in the previous step were written in English. Based on these criteria, two articles were selected for the work of the Compendex database. In the eligibility stage, she obtained a total of sixty records identified in English.

Replicated records were excluded from the selected studies in a total of twelve replicated articles. Therefore, forty-eight documents were included for the analysis, following the criteria: applied research methodology, the mentioned country, the health area covered by the document, in addition to the Lean methods and tools used and the results of each study, classifying them.

Thus, a meta-analysis was used, addressing the PRISMA method according to Moher et al., (2009) for the selection of the analysed articles. Also addressed by Lobo et al., (2018). Being illustrated in the flowchart represented in figure 2.

3.3 Reading and analysis of texts

3.3.1 Implementation areas

In this step, the analysis of the articles selected for the study was carried out, with the areas and departments of health that applied the methods and tools of Lean Healthcare, as shown in Figure 3. The applicability preference of the methods and tools can be highlighted in hospitals as a whole, found in fourteen documents, emergencies and the surgery department, found in six documents. Even so, it is possible to verify the success of the tools application in other health sectors such as oncology, mental health center, cardiology, radiography, pharmacy, public hospitals, health organizations, chemotherapy, urology, Intensive Care Unit - ICU and among other sectors, however, they were found in fewer documents in the literature.

Table 2 compiles the results found in this section, relating the areas of health with the respective article, the number of times that each area has been addressed in the literature and the percent of each health area actuation in analysed cases.

3.3.2 Lean methods and tools mentioned.

The other stage of the study was to identify, among the forty-eight documents selected, the methods and tools of Lean that are being applied in health departments identified in the previous stage and their purposes of use. Thus, it was found out which and how these methods and tools were being implemented and the results caused by their application. Figure 4 shows the percent of times that each Lean method and tool was addressed in the selected studies through of the methods described in item 3.2. The use of Value Stream Mapping to find problems such as bottlenecks and delays in production processes, helping to solve problems in different health sectors, is cited in twenty-four articles selected in this research, with seventeen percent of the total number of lean tools applications, appointing a preference of use.

Another tool addressed as preferential is the 5S, being used in ten percent of the studied applications and being presented in fourteen documents, and the Kaizen method with the application being cited in thirteen articles and used in nine percent of studied applications, the 5S acts, above all, in the improvement of quality, using 5 “senses”, sense of use and discard, sense of order and organization, sense of cleanliness, sense of standardization and sense of self-discipline. Its importance in health can be attributed to the need for a clean and sterile environment. According to Kanamori et al., (2015) there is a reduction in the time to search for items; greater capacity of the team to move around the office; centrality of the patient; reduction of waiting time for patients; better guidance for patients; improved sterilization processes and others. These were the results found by applying the 5S tools and Kaizen methods.

Following by the tools Visual Management, Standardization and Kanban, in this order with ten, seven and six articles mentioning their use. It was also observed in the literature the application of Lean tools along with other methods such as DMAIC, found five times, Analysis of variance (ANOVA), being mentioned twice, Simulation, found three times, Total Quality Management (TQM) and Total Quality Control (TQC),

found twice each, Theory of constraints (TOC) and Fast-Track, each being found once in the literature. These results are best seen in figure 4.

3.3.3 Country of application

Figure 5 shows the percentage of publications by countries. It can be seen that Brazil and the United States are two countries that stand out the most with the largest number of publications related to the theme Lean Healthcare. Brazil has thirteen publications found within the period studied and in the United States with six publications, which are the two main countries in relation to the number of publications, citing the use of tools and the acceptable results of the applications.

We also highlight Sweden with five, Italy and England with four publications each, Ireland and India with two publications each. Scotland, Canada, Spain, Thailand, Kuwait, Netherlands, New Zealand, Oman, Czech Republic, Senegal, Turkey, Hungary, Lebanon and United Arab Emirates published one article each. In two articles studied - more than one country was presented, such as the article by Leite et al., (2019), had its study done by the University of London, England, however, the analysed case study was done in Brazil in an emergency of the Unified Health System. Alnajem et al., (2019) Literature Review the from 2013 to 2018, conducted by the Gulf University for Science and Technology in Kuwait, University of Derby and Heriot-Watt University, England.

3.3.4 Main journals and authors

Among the articles studied, the following Journals with the largest number of publications found in this research were highlighted: JOURNAL OF HEALTH ORGA-NIZATION AND MANAGEMENT, PRODUCTION PLANNING AND CON-TROL, BMC HEALTH SERVICES RESEARCH, BENCHMARKING: AN INTER-NATIONAL JOURNAL, with five, four, three and two publications in this order with the theme Lean Healthcare. Such Journals have together fourteen publications used to build the present study. Table 2 shows the main Journals found in this study and the respective number of publications. All other unlisted Journals have one publication each, about theme Lean Healthcare.

Among the authors studied are: Tony Butterworth, from the University of Lincoln, England; John SG Wells, Waterford Institute of Technology, Ireland; in addition to Mark White, from HSE-South, Ireland; Moacir Godinho Filho, Federal University of São Carlos - UFSCAR, Brazil; Jacopo Guercini, University Hospital of Siena, Siena, Italy; Federico Barnabè, University of Siena, Siena, Italy; Maria Cleofe Giorgino, University of Milano-Bicocca, Milan, Italy. The seven authors are responsible for at least three publications each, of the documents analysed in this research. Table 3 shows the highlighted authors and the respective number of publications, with three or more publications.

3.3.5 Ways to implementation and their results

Analysing the selected scientific documents, we found the preference for the applicability of the Value Stream Mapping tool in several areas of health following the 5S tools and Kaizen method, which is one of the objectives of the article to identify what Lean tools are most used in Lean implementation through different areas of health.

Thus, it was observed the primordial ways of implementing of tools and the main results obtained. In general, as a form of implementation, there are team training workshops, project simulation, meetings with the team, information gathering, separation of activities that generate value and those that do not generate value, engagement between employees and questionnaire with patients to identify what is value to the patient and what the patient identify as waste. Thus, the fundamental results were shown: decrease in hospital waste such as out-of-date medicines, decrease in stock, patient satisfaction, decrease in lead time, stabilization of the process, increase in the number of visits, decrease in errors doctors and errors with blood collection, reduction in the average time for exams delivery, reduction in patient's stay time, cost reduction in the appointment and decrease in the number of appointment and exam cancellations. Therefore, some of the studies analysed were highlighted below, highlighting the ways to implement the Lean tools and the results obtained. The following are related thirteen cases that show the application of Lean tools in health services and its achievements.

The tools of Lean 5S and Kaizen were implemented in the sterilization of surgical materials in Brazil in the study by Fogliatto et al., (2019). For implementation, Lean principles were studied, and it was divided which surgical materials could be prioritized and which could be rationalized to reduce costs and the burden of sterilization processes, divided the teams into Kaizens groups to achieve the objective of continuous improvement. They reported the results proposing a strategy to address the rationalization of trays, prioritizing complex and frequent surgical specialties, and using group technology to agroup surgical trays, streamlining specialized analyses. Thus, they reduced the number of instruments by an average of 9.75% and the time to assemble trays by 9.68%, achieving an annual savings of US $ 285,756.00 in sterilization processing costs.

In the study by Barnabè et al., (2018) he applied the principles of Lean thinking and shared competences in collaborative processes in a hospital, devoted to educational tools for training health decision-making agents. He used the role-playing game (RPG) as a simulation measure and team training. It guaranteed the satisfaction of patient demand, patients reported improvement in the process, improvement in lead time and quality in the process according to health professionals and patients.

Barnabè et al., (2017) proposed a simulation game that not only provides a suitable physical environment for the purpose (an open space within the hospital), but also stimulates and encourages the use of a large number of medical instruments (for example, a portable chest X-ray machine), administrative documents (for example, medical records and laboratory tests) and Lean tools to make the simulation as

real and engaging as possible. The game challenges participants with work-related tasks, a variety of possible scenarios (for example, a growing patient demand) and a complete set of metrics to measure their performance. In particular, a dedicated business intelligence software program is used to monitor and evaluate performance. The graphs, key performance assessment, tables and panels inform the discussion and decision making during all phases of the game. As a result, participants obtained recognition of the simulated environment as realistic (58.8%) or absolutely realistic (17.6%). In total, 86.7% of the participants perceived an increase in knowledge and understanding about the specific simulated process. 93.4% of the participants emphasized that the basis of a simulation game was more useful and effective than traditional classroom training. Specifically, players stated that this simulation game encouraged them to reflect and use / implement various Lean tools and techniques (for example: 5S technique, visual management tools, various Lean metrics, value stream mapping) during the simulation. Overall, 94% of the participants were willing to participate more often in the simulation game.

Barnabè et al., (2019) Identified two streams: of knowledge and practical. In his study, Lean training was reported to identify value creation for decision makers have defined a measurement framework to identify what is of value to the patient and training of staff for Lean implementation. Results obtained were improvement in lead time, reduction in the displacement of people, reduction in the cost of processes, reduction of walking time to 154 km, quality of care and safety in health processes.

Boronat et al (2017) used three steps for the implementation 1) team training and improved feedback among professionals, 2) process management and super-specialization and 3) improvement of assessments (continuous improvement). The assessments were obtained from the hospital's information systems. The main source of information was the Balanced Scorecard for health systems management. The comparison with other autonomous and national urology departments was carried out through a platform, with the help of the Hospital's records department. A baseline was established with the assessment obtained in 2011 for the comparative analysis of the results after the Lean Healthcare implementation approach. The results were: high professional satisfaction, improving quality assessment, reaching a risk-adjusted complication rate of 0.59 and a risk-adjusted mortality rate of 0.24 in 4 years. A value of 0.61 was reached with the efficiency assessment, with savings of 2869 stays compared to the national benchmarking. The risk-adjusted readmissions index was the only assessment above the standard, with a value of 1.36, but with a progressive annual improvement.

In the article by Cheng et al., (2015), were held Lean training workshops, a collection of information to establish the current status in each location of the mental health center. The results mentioned in this study were the stabilization of the operational processes in current state within each of the teams of the mental health center, identification of problems and identification of operational issues.

In the study by Demosthenes et al., (2015) for implementing Lean identified items with high cost for which there were less expensive alternatives, but with effective characteristics. As an educational intervention, were carried out the main rounds revising the research results, as well as recommendations that would allow changes in health care. In total, 50 of the 70 suppliers (71%) answered to the survey.

Vaginal insertions of hydrochloride acetate / pramoxin hydrochloride and dinoprostone were the target of intervention. The use of vaginal dinoprostone insertion decreased by 50.5%, with savings of US $ 66,500 when comparing the pre-intervention period with the post-intervention period. The use of hydrocortisone acetate / pramoxin hydrochloride decreased by 90%, with savings of $ 92,655. Combined, the decrease in the use of these products led to savings of US $ 159,155 within a year after the intervention. Through the use of research and educational intervention, they demonstrated that simple interventions can lead to changes in Lean healthcare quality.

In the studies by DiGioia et al., (2015) and Efe and Efe (2016) they used similar means for the implementation of Lean and obtained similar results. As implementation mean, they used employee engagement and training, space renovation, analysis of patient flow and process redesign. As a result, the elimination of waste, patient satisfaction, decreased expenditure per patient and length of stay were reported.

Gupta et al., (2018) with their article showed the use of VSM, Pareto chart and Ishikawa diagram (or fishbone). The application of these tools helped to identify the use of other Lean tools such as 5S and Visual Management. For that, they had weekly meetings to discuss progress, training employees and identification waste. The results were reduction in the response time for clinical examinations, patient satisfaction and teamwork.

In the work of Haddad et al., (2016) to comply with the objective of improving flow, reducing time and changing culture, the types of waste in each process were identified, making it possible to build a table describing the phase, the process, the description of the waste and the type of waste. The construction of a simulation model with the support of the Arena software, which identified the move time in the hospitalization sector. As a result, the patient's total time in the admission system was improved by 43%, increase of 95% in the patients' confidence level and the processes became standardized.

With the research by Costa et al., (2015) they discovered problems and opportunities through the application of VSM and DMAIC in five health departments where they analysed patient flows, exams need and patients' schedule. They obtained reduction in lead time and financial costs, 78% reduction in costs with pharmacy, 42% reduction in waiting time reported by patients and 93% reduction in blood analysis time.

Romano et al., (2015) in the emergency department of a Hospital analysed the use of the Fast-Track tool. Through medical screening, patients are sent to Fast-Track using the Emergency Severity Index parameter. Fast-Track has access to those less serious patients for whom the system's crossing time is supposed to be shorter. In medical screening, the patient is separated by colors, red (patients with a critical condition), yellow (patients with a potentially critical condition), green (patients who need a medical service) and white (patients who do not have changes in vital functions). Patients are sent to a specific emergency area according to their classification, the shock room receives all patients identified with the color red, in this environment it has a multidisciplinary team and all the necessary equipment to save lives. In the Urgency area, patients identified with the yellow and green code are received, the

distinguishing characteristics of this area is the system's flexibility in accepting additional patient flows (agglomeration). The area of minor codes is dedicated to the evaluation and treatment of patients with minor problems. Assisted waiting area for patients who need to complete treatment but are unable from accessing the hospital due overcrowding. Brief observation, for patients that it is not possible to make a decision about the result in the first hours of arrival at the emergency room. Finally, a short intensive observation area, patients with trauma and toxicology, in which the diagnostic procedures are not exhaustible in a few hours. In this way, they improved the flow of patients, allowing them to assist almost everyone in the ward and reallocating resources in a timely manner.

In this way, the Lean approach such as VSM, 5S, Kaizen and other tools mentioned in this work, can be applied to different sectors in health. Such as clinics, hospitals, surgical center, oncology, geriatrics, gynecology and obstetrics, neurology, emergencies, cardiology, Intensive Care Unit, hospital pharmacy, SUS, mental health service, chemotherapy, radiotherapy, sterilization, maternity and primary care. The use of such methodologies is recommended for health departments that wish to achieve better results and efficiency during health procedures. It is worth mentioning two related cases, one by Flogliatto et al., (2019) and Demosthenes et al., (2015), which presented results of annual savings of US $ 285,756 in sterilization processing costs and US $ 159,155 using educational research, which together generated an annual savings of US $ 444,911, resulting from the implementation of Lean Healthcare.

3.3.6 Barriers and opportunities found

In this stage of the study, it focused on finding in the studied documents the barriers and opportunities to start the Lean journey in health services, mentioned in this work. Therefore, some of the studies analysed were highlighted below, highlighting the barriers and opportunities to implement Lean tools in health services and the results obtained.

The application mentioned by Leite et al., (2019) reports the use of Lean tools in an emergency sector agreed by the SUS in Brazil, aimed at identifying and understanding the barriers to implementation of Lean tools in the public health system. The identified barriers could be answered with Lean management consultancy, six types of barriers were discoveries: 1) Influence of doctors in the process, 2) Patient behavior, 3) Restrictions related to resource management affecting the clinical team, 4) Impact of the SUS model on medical work, 5) The model that SUS operates creates restrictions, 6) Influence of team behavior as a barrier to Lean implementation . The results showed that there are two types of barriers to Lean implementation in health area: ostensible and underlying. Ostensible barriers, in general, are common during the Lean journey, but with deeper causes that influence its creation. These barriers come from the literature and knowledge of professionals. On the contrary, underlying barriers are based on rich qualitative data that emerge as the root cause of the ostensible.

Drotz and Poksinska (2014) reported the introduction of Lean culture and leadership through daily meetings, teamwork, through Value Stream Mapping, it is possible to see opportunities for implementing other tools such as Kaizen, visual control, 5S, takt time, work standardization and Poka-Yoke. He mapped

risks and safety and analysed what creates value for the patient. Reported results were the reduction of waste, greater interaction and cooperation between employees and patients.

Eiro and Torres (2015) also identified that through the Value Stream Mapping there's opportunity to implement other Lean tools such as PDCA (Plan, Do, Check and Act), A3, FMEA (Failure Mode and Effect Analysis), Kaizen, 5S, work standardization, Total Quality Management and Visual Management. Therefore, its mapped risks and safety, and analysed what generates value for the patient. Results: reduction in lead time, reduction of errors with blood collection, movement of such materials and in the performance of the exam, interaction between nursing and pharmacy which allowed less waste with medicines and quick search for specific medicines, decreased movement of health professionals.

New studies can be developed regarding specific barriers for adopting the Lean approach in health services. In addition, it is possible to study how other sectors such as urology, chemotherapy, maternity and primary health care are seldom mentioned for the applicability of Lean methods and tools in health services.

3.4 Statistical and graphic analysis of the selected records

In the identification stage of the articles it resulted in 48 documents with the union of the Web of Science, Scopus and Compendex databases. Figure 6 shows the graph of distribution of articles over the period from 2014 to April 20, 2020, illustrating the number of these publications per year.

Analysing the number of publications per year, since 2014 there a growing trend, with a peak of publications in 2015 and 2017. This indicates that the academic society's interest in this topic has increased and is increasingly discussed by professionals and researchers until the year 2017. In addition, it is noted that the number of publications fluctuates over the years and between the years 2018 to 20 April 2020 the number of publications with the theme about Lean Healthcare decreases. In 2017 there was a greater interest in publications on Lean Healthcare.

The last step of this SLR was to generate, through the VOS Viewer software, the co-citation and co-occurrence networks of keywords, for that it was necessary to join the bibliographic data acquired in the Web of Science and Scopus databases.

Co-citation map.

The co-citation network, shown in figure 7, is composed of 8 nodes and 28 edges. The size of the nodes indicates how many times they were mentioned by other authors. Among them they are mentioned in the same way, because the nodes have the same size.

Keywords co-occurrence maps.

In figure 8, it is about the keyword co-occurrence map made in VOSViewer software, to address the keywords used in the articles. Note that the possible Hot Topics are: “Lean healthcare”, “quality improvement”, “human” and “total quality management”. The least used keywords are: “Hospital operations”, “person-centered care” “Management” and “lean thinking”. The keyword co-occurrence network, illustrated in figure 8, is composed of 238 nodes and 2406 edges. The size of the nodes indicates how many times they were used in the articles. The generated network obtained 16 clusters, that is, 16 sets of items included in the map. Therefore, it was visualized, highlighted in the keyword “human”, it has been mentioned in the literature more over the years, due to the preference of humanized treatment focused on the client / patient defined as one of the pillars of Lean (respect and transparency) which is linked to the National Humanization Policy (PNH) created in 2003 linked to the Ministry of Health in Brazil.

Publication bias

In the present study there was no publication bias because studies were equally studied within PRISMA as shown on figure 2.

4. Discussion

In this stage, there criteria were used for comparative analysis of the results found in previous bibliographic studies: 1) The methods and tools of Lean most applied in health services and their results; 2) Where the tools were applied; 3) The years studied by each author and the countries that gained prominence by the number of publications.

4.1 The Lean methods and tools most applied in health services and their results: results from previous works of literature.

Mazzocato et al., (2010) found in their study the main tools acting in health: Value Stream Mapping, Process Mapping, 5 why and 5S. In the study by Souza (2009) the Lean tools highlighted were A3, 5S and Just in Time. Costa and Godinho Filho (2016) in their article related the Lean tools to health areas. The tools highlighted were Value Stream Mapping, Ishikawa Diagram (or fishbone), DMAIC and the Work Standardization. In the study by Gomes et al., (2017), Kaizen and the 5S ranked the most cited Lean tools Value Stream Mapping. The results found in these articles by the application of these tools are reduction of errors, patient satisfaction, reduction of mortality, reduction of costs and waiting time, reduction of the waiting list, improvement in the quality of patient care and reduction of processing time (exams and consultations). In the article by Costa and Godinho Filho (2016), he also mentioned the discouragement of employees for the application of Lean methods and tools in health services.

Comparison under tools adoption perspective

The most used Lean tools analysing the articles found from 2014 to April 20, 2020 were Value Stream Mapping, Kaizen, 5S and Visual Management. In previous studies, it also showed notoriety of these tools;

however, the Visual Management tool was not equaly mentioned. The results found in previous studies obtained by implementing the Lean approach were repeated in the present study.

4.2 Where the tools were applied: results from previous literature review

Mazzocato et al., (2010) classified the main health sectors according to the literature, for applying Lean in emergencies, anesthesiology / intensive care, gynecology and obstetrics. Souza (2009) refer to the use of Lean methods and tools in some departments of a hospital, including, pharmacy, radiology, pathology and laundry. Costa and Godinho Filho (2016) cite hospital pharmacy, radiology, pathology, anesthesia, laboratory, hospital laundry, outpatient clinics, emergency rooms and the operating room as the main actors of Lean. In the study by Gomes et al., (2017) the health sector identified as the most used for Lean tools application are emergencies, followed by the surgery sector and the postoperative team.

Comparison of actuation health area

The health areas that most appeared to start the Lean journey in health services in this study are hospital, surgery, emergency and oncology. In previous bibliographic studies, the preference for use in hospitals and emergencies is mentioned in additional to other areas that showed the application of Lean tools as a priority.

4.3 The years studied by each author and the countries that gained prominence by the number of publications: results from previous literature review

Mozzocato et al., (2010) described studies from 1998 to 2008, Souza (2009) from 2002 to 2008, the highlighted countries were the United States, United Kingdom and Australia. Costa and Godinho Filho (2016) from 2009 to 2014, the highlighted countries were the United States, United Kingdom and Netherlands and Gomes et al., (2017) from 2002 to 2015. The present study reveals the progress of research carried out in Brazil, followed by the United States and Sweden.

Comparison of countries

In relation to the countries found with the largest number of publications in the article Souza (2009) were the United States, United Kingdom and Australia, in the study by Costa and Godinho Filho (2016) the highlighted countries were the United States, the United Kingdom and the Netherlands.

4.4 Additional aspects analysed in this work

Behind the previous comparison, this work incudes other variables to the research that were not adopted in the previous literature review, such as: authors, journals, co-citations and co-occurrence maps. It allowed to discovery that, in the period analysed, the articles were:

- Authored by: Barnabe, Federico; Butterworth, Tony; Giorgino, M C; Godinho Filho, Moacir; Guercini, Jacopo; Wells, John S G; White, Mark most frequents.

- Published by: Journal of Health Organization and Management; Production Planning and Control; BMC Health Services Research; Benchmarking: an International Journal.
- Hot Topics: “Lean healthcare”, “quality improvement”, “human” and “total quality management”.

Limitation

This study was limited for years of publication between January 2014 to April 20, 2020, document of type: articles and only English language written articles were synthesized. Moreover, the articles were studies following the criteria: applied research methodology, the mentioned country, the health area covered by the document, Lean methods and tools used and the results of each study, classifying them in opportunities and barriers.

5. Conclusions

This article discussed some issues, above all, how health organizations can benefit from the concepts and tools of Lean Thinking to start the Lean journey in health services. In addition, some examples were reported in the present study. Being discussed, the role of some basic tools such as Value Stream Mapping, 5S, Kaizen and Visual Management in the process of adopting the beginning of the Lean Journey in health services. Considering that the objectives of this current study are to update previous studies on the implementation of the Lean approach in health services, to analyse the applicability of the tools in the articles studied and to verify the areas of application. Therefore, the subjects addressed throughout this article answered the research questions defined at the beginning of the study, which were: 1) What Lean methods and tools were implemented in health services and what results were found? 2) Where Lean methods and tools were implemented in health services? 3) When the articles were published? 4) Who discussed the subject in the literature? 5) Why is Lean used in health services? 6) How was lean thinking implemented in health services?

With the methodology applied in this work, it appears that despite the oscillations in the number of publications, there has been an advance in the acceptance and application of these tools in health services. This can be confirmed by the growing number of studies using the Lean healthcare approach in several countries in the world, with the main users of these tools are: Brazil, United States, Sweden, England and Italy. It is necessary to emphasize that Brazil has stood out in this scenario with a greater production of articles.

There is still a high degree of heterogeneity in the health areas where Lean practices have been implemented, but most of these areas are categorized as clinical operations and applied in hospitals. In addition to applications in emergencies, surgeries and public hospitals.

After the introduction described above, the SLR projected by Moher et al. (2009) was the research method selected to achieve the objectives of this research. The first step carried out allowed the identification of 48 records by consulting the Web of Science, Scopus and compendex database (from 2014 to April 20, 2020) through a structured search. Number of publications, provided information to assess the

applicability, results and the area of expertise in the health of Lean tools in general. We conclude that it is possible to apply the tools, even though some adaptations and considerations were made by the authors who published their results. With this research, he found that in 2017 there was a greater number of publications on the theme.

Authors, with the largest number of publications, were highlighted about the theme Lean Healthcare who brought in their studies means for the implementation of tools in the health sectors such as workshops, team training workshop, team engagement, simulation project, meetings with the team, information gathering and among other less mentioned ways.

Concomitantly, a limited number of publications were found on the use of certain tools and barriers to the adoption of tools by health services. Most articles showed acceptance and good results with the implementation of Lean Healthcare or Lean in health services.

Lean methods and tools (value stream mapping, work standardized, rapid improvement events / Kaizen events and process mapping) and results (reduced waiting time, reduced cost, reduction in patient's stay time and increased capacity) are similar to works previously found. However, in previous work it resulted in that the Lean implementation was done in a superficial way and with simple techniques. The current study showed that Lean Healthcare has been more accepted in health over the years, promoting greater training for health professionals. Furthermore, the implementation of Lean Thinking in health services has been carried out, through the implementation of several techniques of Lean Healthcare and is an alternative to improve care in health services in times of pandemic. However, techniques that require a greater degree of knowledge and maturity from the health institution are seldom used, such as Jidoka and Leveling Production (Heijunka). Thus, we can analyse that there has been an evolution in the research and applicability of Lean Healthcare in the world.

List Of Abbreviations

5S: *Seiri* - Classification, *Seiton* - Order, *Seiso* - cleaning, *Seiketsu* - standardization, *Shitsuke* – Discipline; DMAIC: Define, Measure, Analyse, Improve and Control; SLR: Systematic Literature Review (SLR); ICU: Intensive Care Unit; UPA: Unidade de Pronto Atendimento (i.e emergency care unit); SUS: Sistema Único de Saúde (i.e Health Unique System); VSM: Value Stream Mapping; PDCA: Plan-Do-Check-Act; PNH: Política Nacional de Humanização (i.e. National Humanization Policy); TQM: Total Quality Management; ANOVA: Analysis of variance; TQC: Total Quality Control; TOC: Theory of constraints; FMEA: Failure Mode and Effect Analysis; 5W1H: What, Where, When, Who, Why and How.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent to publish

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this article.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was funded by the Ministery of Health of Brazil and Euclides da Cunha Foundation.

Authors’ contributions

LA conducted all data collection and analyses, wrote the first draft of the manuscript and rewrote new drafts following feedback and input from MS, HC, SB and RC. MS was responsible for keeping the text easy to understand. HC conceptualised, designed the paper and helped union of data from databases Web of Science and Scopus to use in VOS Viewer software. SB and AT research about covid-19 data and wrote on the manuscript. RC planned and reviewed the analyses and gave input on all manuscript drafts. All authors read and approved the final manuscript.

Acknowledgements

Universidade Federal Fluminense and Fundação Euclides da Cunha, which made possible the project financed by the Ministry of Health of Brazil; TED 125/2019, Number: 25000191682201908

Authors' information

LA Researcher at LabDGE – Laboratório de Design Thinking, Gestão e Engenharia Industrial (i.e Laboratory of Design Thinking, Management and Industrial Engineering) – UFF (laryssaamaral@id.uff.br)

MS and RC Professor at the Institute of Science and Technology at Universidade Federal Fluminense - UFF.

HC Professor at the Engineering Department at Universidade Federal Fluminense - UFF.

SB Director of the Institute of Biology and Professor of the Graduate Program in Science and Biotechnology (PPBI) at the Institute of Biology - UFF.

AT Secretaria de Atenção Especializada à Saúde/SAES (i.e Specialized Health Care Secretariat) - Departamento de Atenção Hospitalar, Domiciliar e de Urgência - DAHU (i.e Department of Hospital

attention, Home and Emergency Care of the Brasilian Ministry of Health).

References

1. Alnajem, M., Garza-Reyes, J. and Antony, J. (2019), "Lean readiness within emergency departments: a conceptual framework", Benchmarking: An International Journal, Vol. 26 No. 6, pp. 1874-1904. https://doi.org/10.1108/BIJ-10-2018-0337
2. Barnabè, F., Giorgino, M. C., Guercini, J., Bianciardi, C., & Mezzatesta, V. (2017). Engaging professionals with serious games: the Lean Healthcare Lab at Siena University Hospital. Development and Learning in Organizations: An International Journal, 31(3), 7–10. doi:10.1108/dlo-06-2016-0051
3. Barnabè, F., Giorgino, M. C., Guercini, J., Bianciardi, C., & Mezzatesta, V. (2018). Management simulations for Lean healthcare: exploiting the potentials of role-playing. Journal of Health Organization and Management, 32(2), 298–320. doi:10.1108/jhom-07-2017-0191
4. Barnabè, F., Guercini, J., & Perna, M. D. (2019). Assessing performance and value-creation capabilities in Lean healthcare: Insights from a case study. Public Money & Management, 1–9. doi:10.1080/09540962.2019.1598197
5. Boronat, F., Budia, A., Broseta, E., Ruiz-Cerdá, J. L., & Vivas-Consuelo, D. (2018). Aplicación de la metodología Lean healthcare en un servicio de urología de un hospital terciario como herramienta de mejora de la eficiencia. Actas Urológicas Españolas, 42(1), 42–48. doi:10.1016/j.acuro.2017.03.009
6. Brandao de Souza, L. (2009). Trends and approaches in lean healthcare. Leadership in Health Services, 22(2), 121–139. doi:10.1108/17511870910953788
7. Cheng, S. Y., Bamford, D., Papalexi, M., & Dehe, B. (2015). Improving access to health services – challenges in Lean application. International Journal of Public Sector Management, 28(2), 121–135. doi:10.1108/ijpsm-05-2014-0066
8. Coelho de Azevedo, M., & Costa, H. G. (2001). Métodos para avaliação da postura estratégica ensaio. Caderno de Pesquisas Em Administração (USP) (Cessou Em 2005. Cont. ISSN 1809-2276 REGE. Revista de Gestão USP), 8(2), 1–18.
9. Colldén, C., Gremyr, I., Hellström, A., & Sporraeus, D. (2017). A value-based taxonomy of improvement approaches in healthcare. Journal of Health Organization and Management, 31(4), 445–458. doi:10.1108/jhom-08-2016-0162
10. Coronavirus // Brazil. https://covid.saude.gov.br/.Accessed 13 July 2020.
11. Costa, L. B. M., & Godinho Filho, M. (2016). Lean healthcare: review, classification and analysis of literature. Production Planning & Control, 27(10), 823–836.
12. Costa, L. B. M., Filho, M. G., Rentes, A. F., Bertani, T. M., & Mardegan, R. (2015). Lean healthcare in developing countries: evidence from Brazilian hospitals. The International Journal of Health Planning and Management, 32(1), e99–e120. doi:10.1002/hpm.2331

13. Demosthenes, Lauren D. Lane, Andrew S. Blackhurst, & Dawn W. (2015). Implementing High-Value Care, 108(11). doi: 10.14423/SMJ.0000000000000360
14. DiGioia, A. M., Greenhouse, P. K., Chermak, T., & Hayden, M. A. (2015). A case for integrating the Patient and Family Centered Care Methodology and Practice in Lean healthcare organizations. Healthcare, 3(4), 225–230. doi:10.1016/j.hjdsi.2015.03.001
15. Drotz, E., & Poksinska, B. (2014). Lean in healthcare from employees' perspectives. Journal of Health Organization and Management, 28(2), 177–195. doi:10.1108/jhom-03-2013-0066
16. Ohno, T. (1998) Toyota Production System. Productivity Press, New York.
17. Efe, B., & Efe, Ö. F. (2016). An Application of Value Analysis for Lean Healthcare Management in an Emergency Department. International Journal of Computational Intelligence Systems, 9(4), 689–697. doi:10.1080/18756891.2016.1204117
18. Eiro, N. Y., & Torres-Junior, A. S. (2015). Comparative study: TQ and Lean Production ownership models in health services. Revista Latino-Americana de Enfermagem, 23(5), 846–854. doi:10.1590/0104-1169.0151.2605
19. Filser, L. D., da Silva, F. F., & de Oliveira, O. J. (2017). State of research and future research tendencies in lean healthcare: a bibliometric analysis. Scientometrics, 112(2), 799–816. doi:10.1007/s11192-017-2409-8
20. Fisher, A. M., Ding, M. Q., Hochheiser, H., & Douglas, G. P. (2016). Measuring time utilization of pharmacists in the Birmingham Free Clinic dispensary. BMC Health Services Research, 16(1). doi:10.1186/s12913-016-1787-6
21. Fogliatto, F. S., Anzanello, M. J., Tonetto, L. M., Schneider, D. S. S., & Muller Magalhães, A. M. (2019). Lean-healthcare approach to reduce costs in a sterilization plant based on surgical tray rationalization. Production Planning & Control, 1–13. doi:10.1080/09537287.2019.1647366
22. Fournier, P.-L., & Jobin, M.-H. (2018). Medical commitment to Lean: an inductive model development. Leadership in Health Services, 31(3), 326–342. doi:10.1108/lhs-02-2018-0015
23. Gomes, P. Vieira, A. Reis. (2017). Simulation of operational processes in hospital emergency units as lean healthcare tool. Independent Journal of Management & Production. 8(5): 812-827 doi: 10.14807/ijmp.v8i5.607
24. Graban, M. 2012. Lean Hospitals – Improving Quality, Patient Safety, and Employee Engagement. 2nd ed. Boca Raton, FL: Taylor & Francis Group.
25. Gupta, S., Kapil, S., & Sharma, M. (2018). Improvement of laboratory turnaround time using lean methodology. International Journal of Health Care Quality Assurance, 31(4), 295–308. doi:10.1108/ijhcqa-08-2016-0116
26. Haddad, M. G., Zouein, P. P., Salem, J., & Otayek, R. (2016). Case Study of Lean in Hospital Admissions to Inspire Culture Change. Engineering Management Journal, 28(4), 209–223. doi:10.1080/10429247.2016.1234896
27. Henrique, D. B., Rentes, A. F., Godinho Filho, M., & Esposto, K. F. (2015). A new value stream mapping approach for healthcare environments. Production Planning & Control, 27(1), 24–48.

doi:10.1080/09537287.2015.1051159

28. Holden, R. J., Eriksson, A., Andreasson, J., Williamsson, A., & Dellve, L. (2015). Healthcare workers' perceptions of lean: A context-sensitive, mixed methods study in three Swedish hospitals. Applied Ergonomics, 47, 181–192. doi:10.1016/j.apergo.2014.09.008
29. Kahm, T., & Ingelsson, P. (2017). Lean from the First-line Managers' Perspective – Assuredness about the Effects of Lean as a Driving Force for Sustainable Change. Management and Production Engineering Review, 8(2), 49–56. doi:10.1515/mper-2017-0017
30. Kanamori, S., Sow, S., Castro, M. C., Matsuno, R., Tsuru, A., & Jimba, M. (2015). Implementation of 5S management method for lean healthcare at a health center in Senegal: a qualitative study of staff perception. Global Health Action, 8(1), 27256. doi:10.3402/gha.v8.27256
31. Leite, H., Bateman, N., & Radnor, Z. (2019). Beyond the ostensible: an exploration of barriers to lean implementation and sustainability in healthcare. Production Planning & Control, 1–18. doi:10.1080/09537287.2019.1623426
32. List of Predatory Journals // https://predatoryjournals.com/journals/.Accessed 21 July 2020.
33. Mazzocato, P., Savage, C., Brommels, M., Aronsson, H., & Thor, J. (2010). Lean thinking in healthcare: a realist review of the literature. BMJ Quality & Safety, 19(5), 376–382. doi:10.1136/qshc.2009.037986
34. McCann, L., Hassard, J. S., Granter, E., & Hyde, P. J. (2015). Casting the lean spell: The promotion, dilution and erosion of lean management in the NHS. Human Relations, 68(10), 1557–1577. doi:10.1177/0018726714561697
35. Mehdi, I., Al Bahrani, B. J. (2017). Are we prepared to implement a Lean philosophy within cancer-care service in Oman?. Saudi Medical Journal.38(7). 691-698. doi: 10.15537/smj.2017.7.17712
36. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097.
37. Paim, R., Costa, A., Carvalho, J., & Lima, I. (2016). Lean Healthcare application in a surgical procedures appointment scheduling center in a maternity. Brazilian Journal of Operations & Production Management, 13(4), 452-461.doi:10.14488/BJOPM.2016.v13.n4.a5
38. Pareeyawadee Ponanake, Sunpasit Limnararat, Manat Pithuncharurnlap and Woranat Sangmanee, 2014. Path Analysis of the Core Competency of Thai Private Hospitals in the ASEAN Economic Community. Research Journal of Business Management, 8: 157-172.
39. Patri, R., & Suresh, M. (2017). Factors influencing lean implementation in healthcare organizations: An ISM approach. International Journal of Healthcare Management, 11(1), 25–37. doi:10.1080/20479700.2017.1300380
40. Poksinska, B. B., Fialkowska-Filipek, M., & Engström, J. (2016). Does Lean healthcare improve patient satisfaction? A mixed-method investigation into primary care. BMJ Quality & Safety, 26(2), 95–103. doi:10.1136/bmjqs-2015-004290

41. Rees, G. H., & Gauld, R. (2017). Can lean contribute to work intensification in healthcare? Journal of Health Organization and Management, 31(3), 369–384. doi:10.1108/jhom-11-2016-0219
42. Régis, T. K. O., Gohr, C. F., Santos, L. C. (2018), Lean healthcare implementation: Experiences and lessons learned from brazilian hospitals. RAE Revista de Administracao de Empresas, 58(1), 30-43. doi: 10.1590/S0034-759020180103
43. Régis, T., Santos, L. and Gohr, C. (2019), "A case-based methodology for lean implementation in hospital operations", Journal of Health Organization and Management, Vol. 33 No. 6, pp. 656-676. https://doi.org/10.1108/JHOM-09-2018-0267
44. Romano, E., Guizzi, G., & Chiocca, D. (2015). A decision support tool, implemented in a system dynamics model, to improve the effectiveness in the hospital emergency department. International Journal of Procurement Management, 8(1/2), 141. doi:10.1504/ijpm.2015.066291
45. Sarantopoulos, A., Spagnol, G. S., Newbold, D., & Li, L. M. (2017). Establishing face validity of the EPLIT questionnaire. British Journal of Healthcare Management, 23(5), 221–227. doi:10.12968/bjhc.2017.23.5.221
46. Schonberger, R. J. (2018). Reconstituting lean in healthcare: From waste elimination toward “queue-less” patient-focused care. Business Horizons, 61(1), 13–22. doi:10.1016/j.bushor.2017.09.001
47. Singh, P. (2019). Lean in healthcare organization: an opportunity for environmental sustainability. Benchmarking: An International Journal. doi:10.1108/bij-04-2018-0104
48. Siqueira, C. L., Siqueira, F. F., Lopes, G. C., Gonçalves, M. de C., & Sarantopoulos, A. (2019). Enteral diet therapy: use of the Lean Healthcare philosophy in process improvement. Revista Brasileira de Enfermagem, 72(suppl 1), 235–242. doi:10.1590/0034-7167-2017-0746
49. Tortorella, G. L., Fogliatto, F. S., Anzanello, M., Marodin, G. A., Garcia, M., & Reis Esteves, R. (2016). Making the value flow: application of value stream mapping in a Brazilian public healthcare organisation. Total Quality Management & Business Excellence, 28(13-14), 1544–1558. doi:10.1080/14783363.2016.1150778
50. Toussaint, J., and R. A. Gerard. 2010. On the Mend – Revolutionizing Healthcare to save Lives and Transform the Industry. Cambridge, MA: Lean Enterprise Institute.
51. Trzeciak, S., Mercincavage, M., Angelini, C., Cogliano, W., Damuth, E., Roberts, B. W., Zanotti, S., Mazzarelli, A. J. (2018). Lean Six Sigma to Reduce Intensive Care Unit Length of Stay and Costs in Prolonged Mechanical Ventilation, Journal for Healthcare Quality, 40(1), 36-43. doi: 10.1097/JHQ.0000000000000075
52. Van Rossum, L., Aij, K. H., Simons, F. E., van der Eng, N., & ten Have, W. D. (2016). Lean healthcare from a change management perspective. Journal of Health Organization and Management, 30(3), 475–493. doi:10.1108/jhom-06-2014-0090
53. Vasconcelos Ferreira Lobo, C., Damasceno Calado, R. and Dalvo Pereira da Conceição, R. (2018), "Evaluation of value stream mapping (VSM) applicability to the oil and gas chain processes", International Journal of Lean Six Sigma, Vol. 11 No. 2, pp. 309-330. https://doi.org/10.1108/IJLSS-05-2018-0049

54. Vashi, A. A., Lerner, B., Urech, T. H., Asch, S. M., & Charns, M. P. (2019). Lean Enterprise Transformation in VA: a national evaluation framework and study protocol. BMC Health Services Research, 19(1). doi:10.1186/s12913-019-3919-2
55. Vavrušová, Veronika. (2015). LEAN: 4W & 1H of lean in medical facilities. Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration, 22(34), 125-136.
56. White, M., Butterworth, T., & Wells, J. S. (2017). Healthcare Quality Improvement and “work engagement”; concluding results from a national, longitudinal, cross-sectional study of the “Productive Ward-Releasing Time to Care” Programme. BMC Health Services Research, 17(1). doi:10.1186/s12913-017-2446-2
57. White, M., Wells, J. S. G., & Butterworth, T. (2014). The impact of a large-scale quality improvement programme on work engagement: Preliminary results from a national cross-sectional-survey of the “Productive Ward.” International Journal of Nursing Studies, 51(12), 1634–1643. doi:10.1016/j.ijnurstu.2014.05.002
58. White, M., Wells, J. S., & Butterworth, T. (2014). The transition of a large-scale quality improvement initiative: a bibliometric analysis of the Productive Ward: Releasing Time to Care Programme. Journal of Clinical Nursing, 23(17-18), 2414–2423. doi:10.1111/jocn.12585
59. Womack, J. P., D. T. Jones, and D. Roos. 1990. The Machine That Changed the World: The Story of Lean Production. 1st ed. Philadelphia, PA: HarperCollins.

Tables

Due to technical limitations the Tables are available as downloads in the Supplementary Files.

Figures

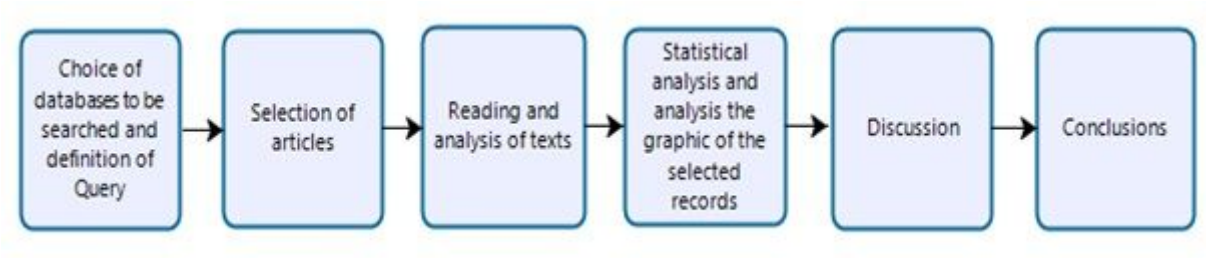

Figure 1

Systematic Literature Review steps. Adapted from Leite et al., (2019, p.8).

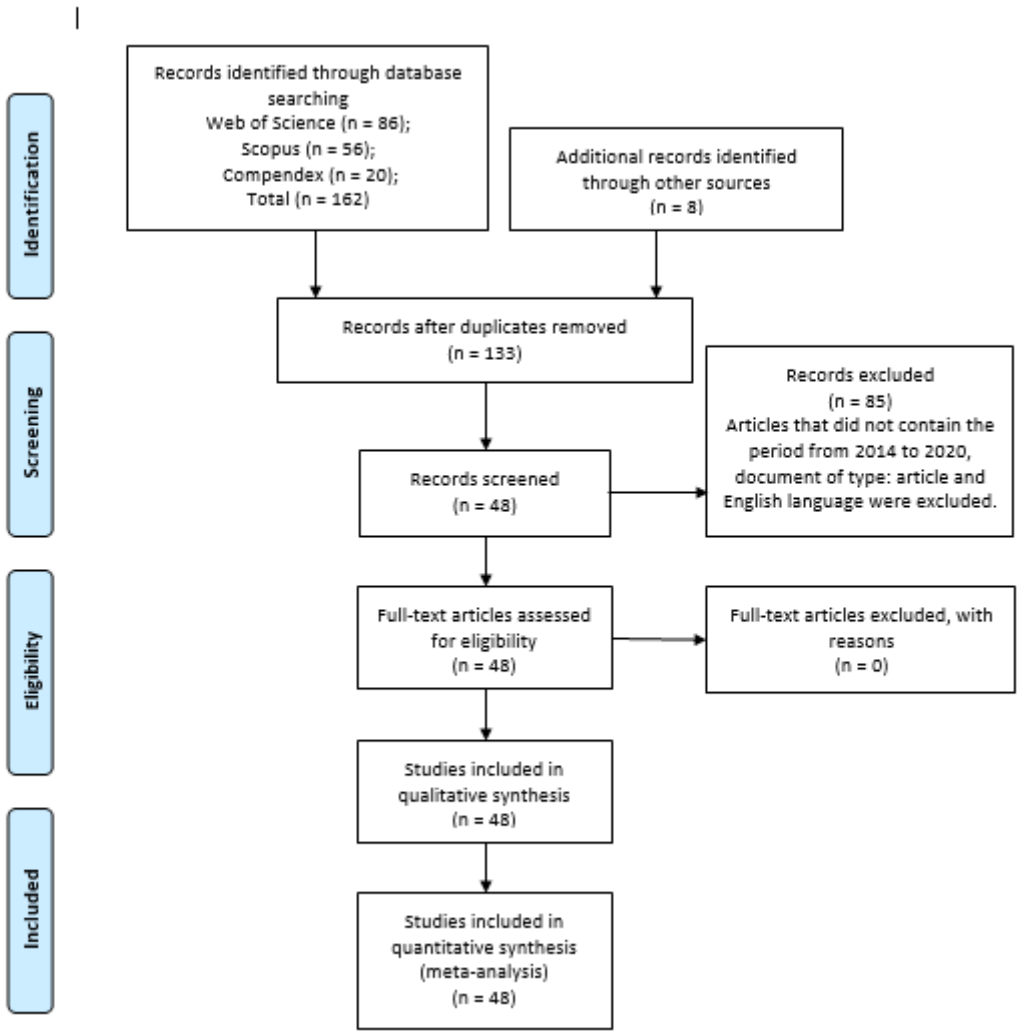

Figure 2

Flow of information through the different phases of a systematic review and number of papers selected. Adapted from Moher et al (2009)

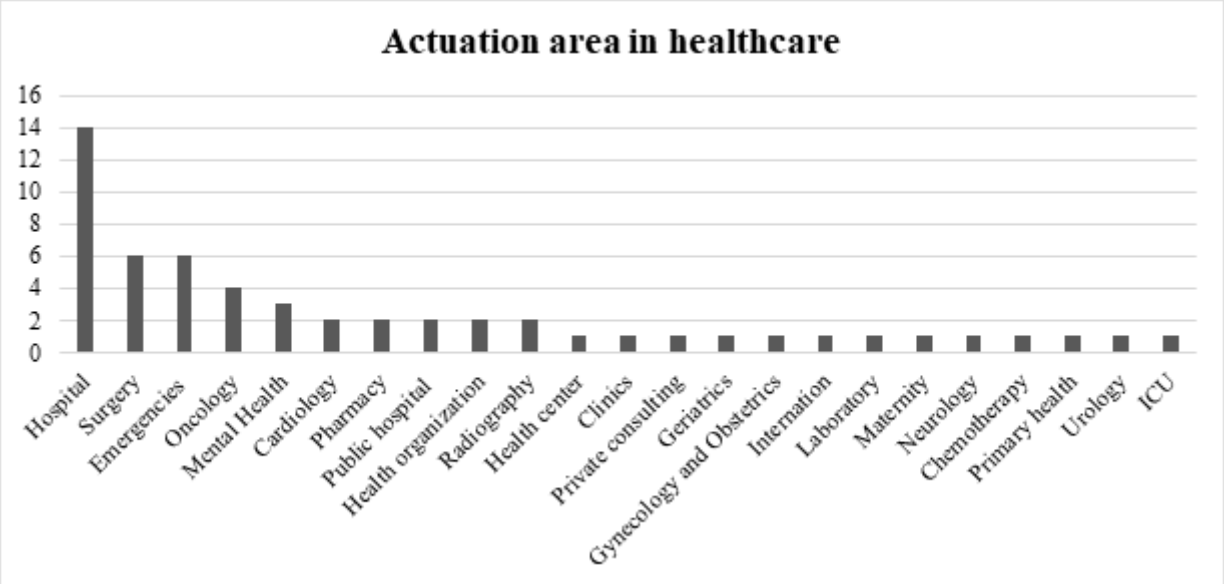

Figure 3

Actuation health area in healthcare services

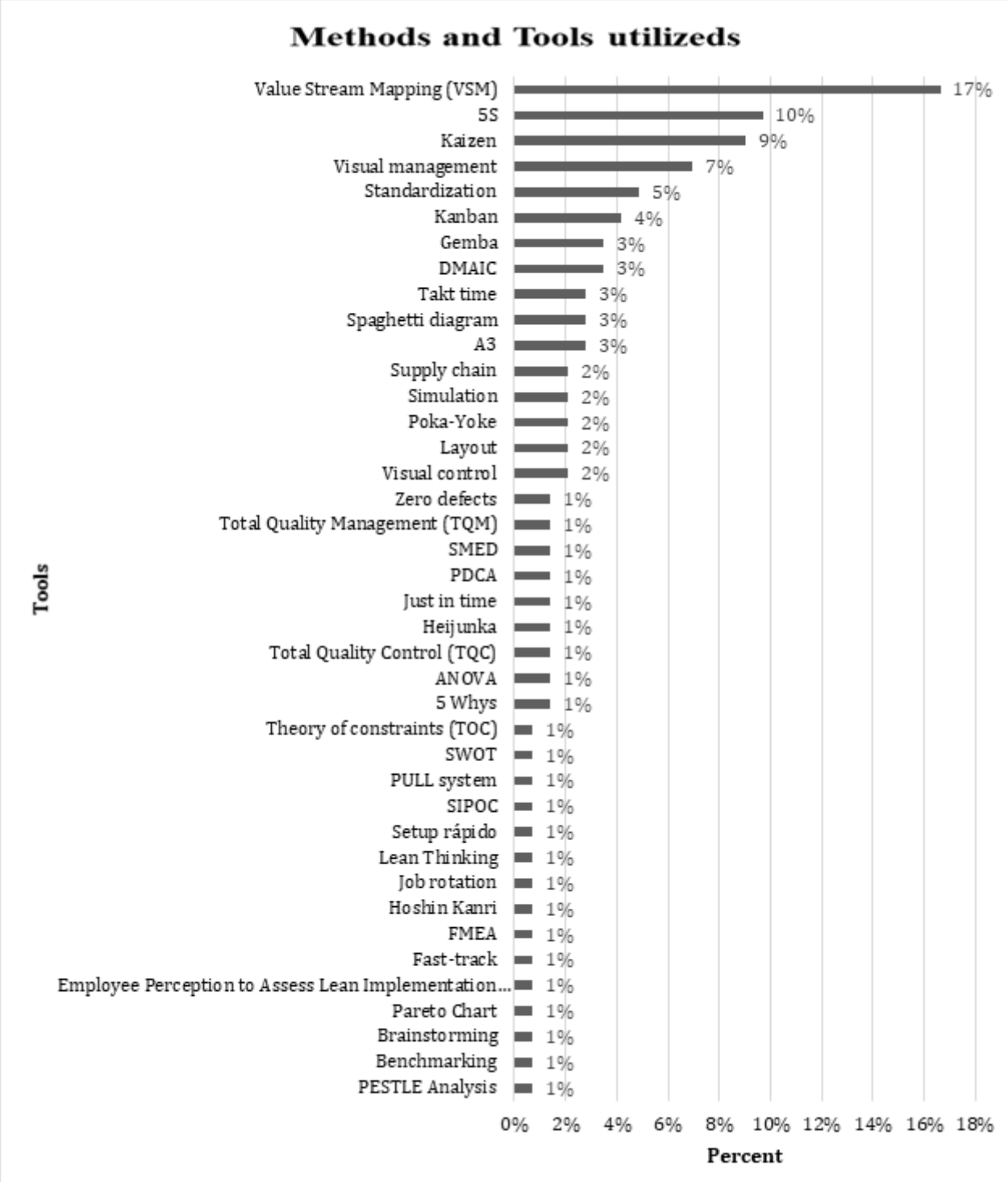

Figure 4

Percent of Lean methods and tools addressed on the selected studies.

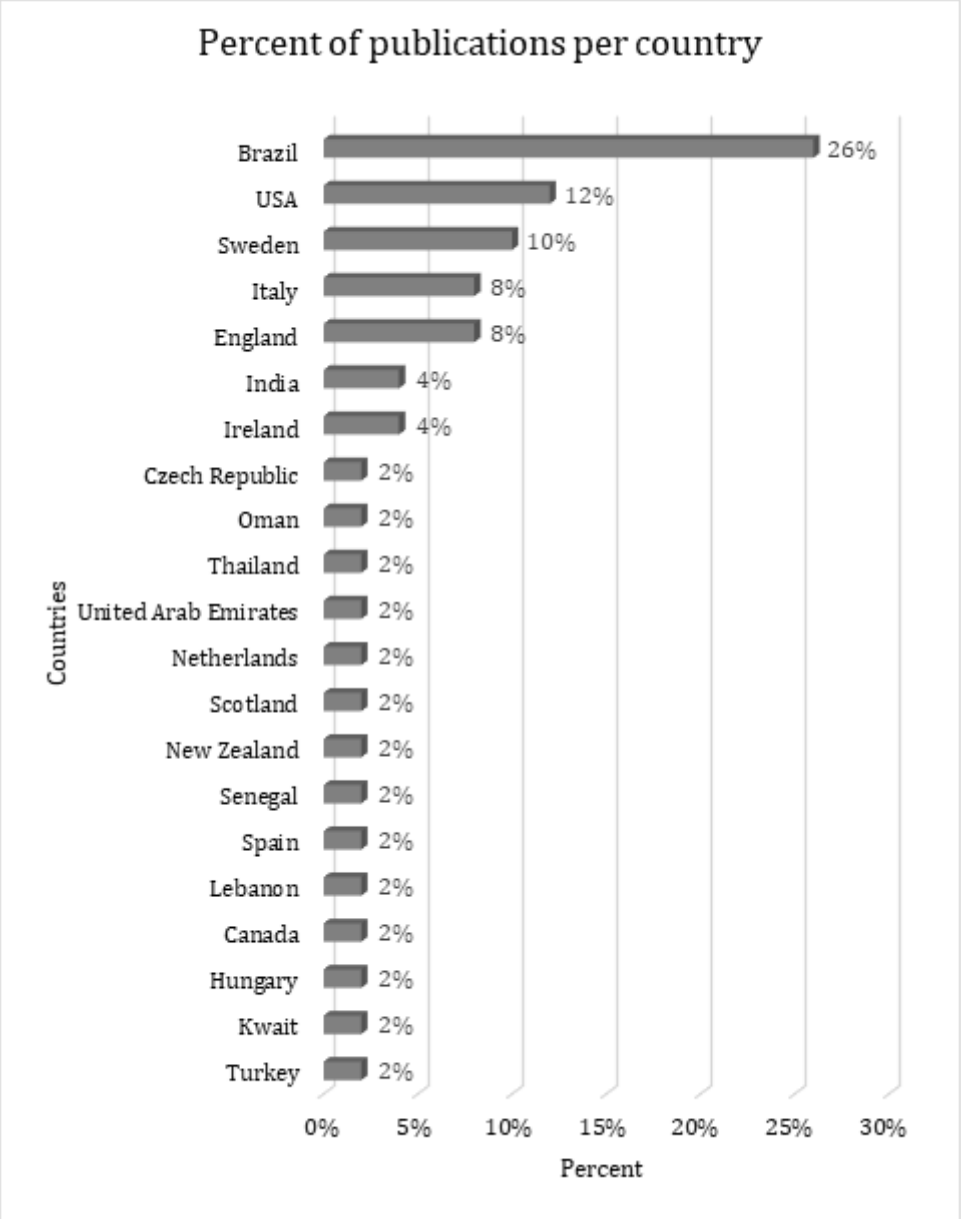

Figure 5

Percent of publications per country related theme Lean Healthcare.

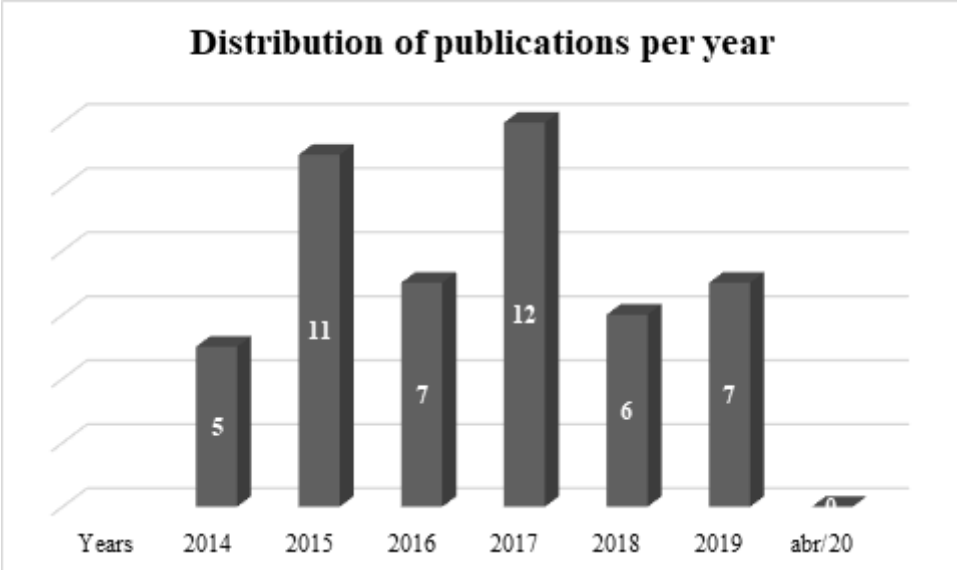

Figure 6

Distribution of publication over the period from 2014 to April 20, 2020, selected in the present work.

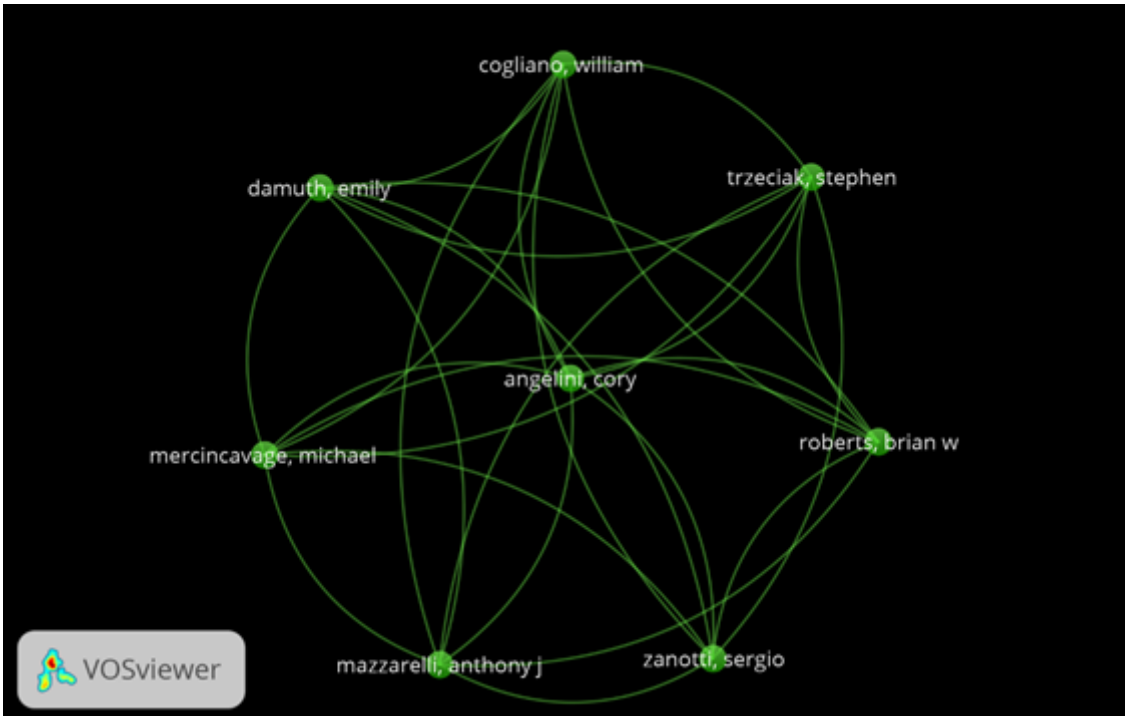

Figure 7

co-citation map.

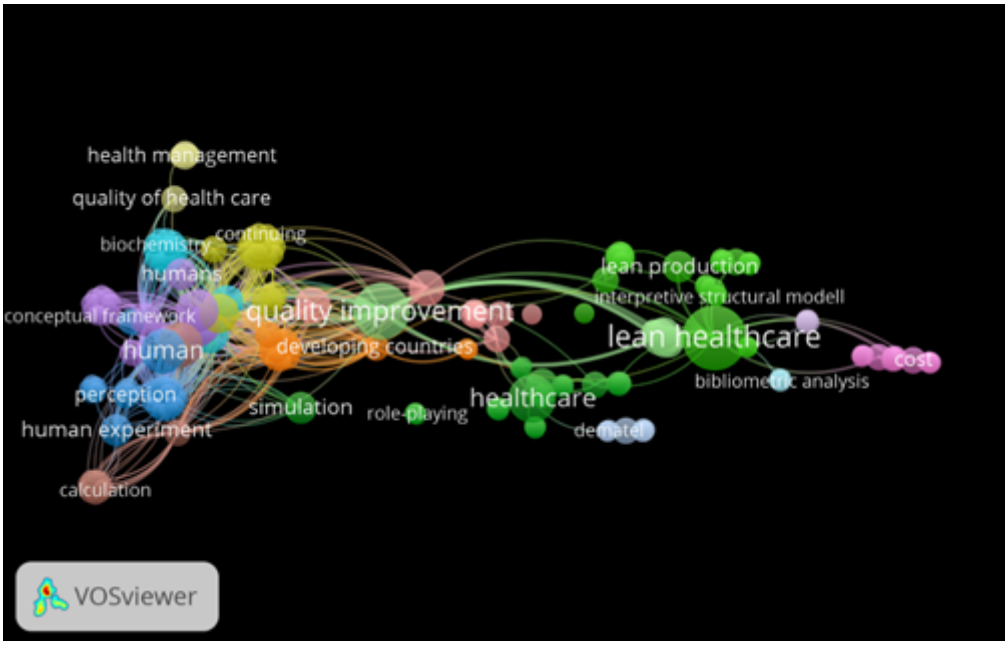

Figure 8

keyword co-occurrence map found in selected articles this work. VOS Viewer.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.xls
- Table2.xls
- Table3.xls
- Table4.xls
- researchdata.xlsx