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Lean six sigma in the healthcare sector: A systematic literature review

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ABSTRACT

Healthcare is a very important sector as our lives depend on it. During the novel corona virus pandemic, it was evident that our healthcare organizations still lack in terms of efficiency and productivity. Especially in the developing nations, the problems were much bigger. Lean Six Sigma (LSS) is a methodology which when implemented in an organization, helps to increase the process capability and the efficiency, by reducing the defects and wastes. The present study systematically reviews the research studies conducted on LSS in the healthcare sector. It was found that comparatively less studies are focused on improving the medical processes, most of the studies targeted the management processes. Moreover, lesser number of studies were being conducted for developing nations, but now it seems that the focus of research scholars has shifted towards the developing nations also. But it was observed that the studies in these nations were majorly empirical in nature, very few studies were conceptual or exploratory. There is a need for guiding healthcare professionals on creating a continuous improvement environment, which sustains the improvements achieved after LSS implementation.

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1. Introduction

There is little room for error when it comes to healthcare. Simple mistakes can impact hundreds of people and can lead to fatalities. According to the journal of healthcare finance, medical errors cost the US over nineteen point five billion dollars in 2008. The Institute of Medicine in 1998 estimated that 98 thousand deaths could have been prevented that year due to medical errors. While in 2008 that figure had ballooned to 200 thousand deaths a year, that's five hundred and forty-eight deaths a day or 1 death almost every two minutes in the US alone [1]. Lean Six Sigma can go in a long way in reducing these devastating preventable deaths. A healthcare practitioner who understands how to use the tools and methodology to systematically resolve problems and improve the quality of care is well-positioned to become a highly valued asset to their organization [2]. They not only prevent deaths but also improve the quality of patient care and reduce operating costs. There are plenty of opportunities for improvement in healthcare. Lean Six Sigma combines the strategies of Lean and Six sigma. Lean is famous for its ability to handle waste and Six sigma is known for

process improvement [3]. It is well known that six sigma stands for standard deviation. Therefore, to improve the efficiency and quality of the process combining these philosophies will eliminate waste and reduce variability [4]. First lean methodology is used to eliminate the waste then through six sigma tools we can improve process variation so these two methods go hand in hand in today's time [5]. Combination of lean and six sigma also gives good results in improving the process flow [6]. Principles of six sigma and lean have a lot of similarities, and that's why lean and six sigma has been practiced together. Both of them, at the end of the day deliver the same kind of value to the customer and to the businesses [7]. We know that lean and six sigma both sort of originated out of manufacturing, a lot of it from manufacturing of automotive. But today it's used in the public sector, in customer service, in healthcare and can be used everywhere. Lean thinking goes back a long way. Henry Ford kind of established it early on the first mass production system by combining standard parts conveyors and workflow. Later on, Kiichiro Toyota implemented new concepts, like they came up with things like value stream and Kanban, which become to known as Toyota production system in the 90 s [8]. It became more extensively recognized as a solution that works. Lean in manufacturing was introduced by James Womack who works at the lean institute. When taking a lean approach,

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the general focus is on the qualitative tools. This is one of the reasons that most lean six sigma activity begin with lean, as qualitative tools are little more intuitive. The concept of lean and six sigma is a little easier to understand than to implement [9].

Day to day rising in cost of healthcare and decrease in reimbursement rates what can hospitals do to ensure operational efficiencies, quality patient safety, and employee engagement while still meeting the bottom line. Lean and Six Sigma have a combine relationship with each other in improving the quality of services by reducing costs and wastes and gives a good result in healthcare improvement [10]. Lean six sigma is not just a methodology or not just having tools that are needed to make an improvement but it is having mentality and psychology to make change happen. As healthcare is people intensive and process driven industry so this is the perfect environment for lean and six sigma. Worldwide, LSS is being implemented in various service as well as manufacturing organisations. Still, healthcare sector is not much familiar with the sustainable benefits of LSS strategy, especially in developing nation like India, Pakistan, Sri Lanka etc. This study has presented a systematic literature review of LSS in developing nations healthcare organisations and the opportunities was explored. With this study, the healthcare professionals will be able to focus on grey areas to effectively improve their organization performance.

2. Literature review

Exploring the literature for a topic or a field is a very essential process. As soon as a person starts with reviewing the literature, a picture forms slowly with each step ahead. It represents all the major contributions for developing the field. Knowledge of various techniques, scientific methodologies and new technologies is gained as a result of the literature review [11]. Further, it navigates towards the direction where more research work and study are required, in order to achieve advancements in the sector. There are three steps in the research methodology for the current study. In the first step, the SLR is conducted. It includes three sub steps of accessing the articles from various sources, then excluding the articles according to the exclusion criteria of SLR and then finally categorizing them according to various parameters. In the second step, the articles are analysed and some of the trends are observed, like which department of a healthcare organization is given an utmost importance in research perspective. Lastly, the future implications are noted, which can act as a useful guide for healthcare professionals to look for in the upcoming time.

2.1. Systematic literature review

Systematic Literature Review (SLR) on the other hand, is different from the traditional literature review method. It is an exhaustive process, where the literature is explored in a systematic manner, as represented in Fig. 1. It was first introduced by Tranfield, Denyer, & Smart in their research paper published in the year 2003 [12]. SLR is carried out in 3 phases. The first phase deals with planning of the review, while in the second phase the review is conducted after defining few inclusion criteria. Finally, the articles are reviewed in the third phase [13]. To search for the articles, there is a criterion which is mainly focused on the topic related to lean six sigma methodology implication, LSS framework in healthcare and healthcare sector itself to include/exclude the articles. Moreover, the language of the articles is also considered for the inclusion/exclusion of the articles. In spite of this formal search and collection strategy, was needed to ensure the thoroughness of the literature review which is mainly focused on the topic (healthcare sector). As a result, articles that simply did not discuss the issue of lean six sigma in the healthcare sector were excluded.

So, for the current study, hundred and forty articles were analysed but some of them were extruded due to the following barriers:

- Language of the article (means articles must be only in English).
- Article must have the concept of lean six sigma.
- Article must be on healthcare sector.

The research articles can be identified according to three main characteristics, namely place, research category and time, as shown in Fig. 2. Place depicts the country where the research study is focused on. A country can be a developed nation, or a developing nation. While the research category means the type of article or the method used in the article. Research category can be categorized further into 4 types, namely conceptual, descriptive, empirical and exploratory. A conceptual research represents theories and ideas, which are developed using observations. A scholar may introduce a new concept or upgrade an existing methodology, but no experimentation work is generally required here [14]. Whereas a descriptive research study is an inclusive research work which represents all the major contributions, changes or things happening in relation to the field under scope of the project [15]. In order to collect data, surveys are conducted which makes it's obvious that the whole study is navigated solely by the data received and the research scholars have no control over it. Empirical research study is more of an experimental study, which uses observational methods to collect data and then experimentation is done to verify that observations [16]. While an exploratory study tries to address a new topic or a problem whose solution is not yet obtained or is at preliminary stage of development. Exploratory study helps in designing methods which may lead towards a solution or help better understand the field [17]. The time indicates the year in which the study was conducted or published.

2.2. Systematic literature review of LSS in healthcare

Healthcare is categorized as a service sector, where service in the form of medical aid is provided. It is very important to rigorously upgrade the healthcare system, in terms of efficiency and productivity. As the healthcare is not just merely a business, but a system which has an impact on all lives. After the introduction of Six Sigma (SS) methodology in 1986 by Bill Smith, and Lean methodology in 1988 by John Krafcik, it took nearly a decade for these individual methodologies to be introduced in the healthcare sector [18]. Very few research studies were conducted for the Lean and SS in healthcare during the early days. In the year 2001, Lean and Six Sigma integration was in the trend. Yet, the use of LSS methodology in healthcare was not seen before the year 2005 [19]. The integration of Lean with Six Sigma results in a method which can reduce wastes and improve productivity, as well as reduce errors and improve patient satisfaction level [20]. A total of 80 articles are considered for the present study. Table 1 lists 47 articles which addresses the developed nations, and the articles which were not written specifically for any nation. While Table 2 contains 33 articles whose main focus was on developing nations, and the healthcare organizations in that countries.

Empirical studies were conducted while focusing on a particular hospital or a particular department in a hospital, like Usha Manjunath et. al. 2007 [64] implemented LSS methodology in an Indian hospital, while Giovanni Improta et al 2019 [59] implemented LSS to reduce the length of stay of patients in an Italian hospital, as listed in the table 1. Research studies focusing on reviewing the literature plays a crucial part in the development of a field, because it shows the complete picture which tells about the overall advancements and the areas where still more study is required. Similarly, for the healthcare sector studies have been conducted to review the literature available. For an example, Peimbert-

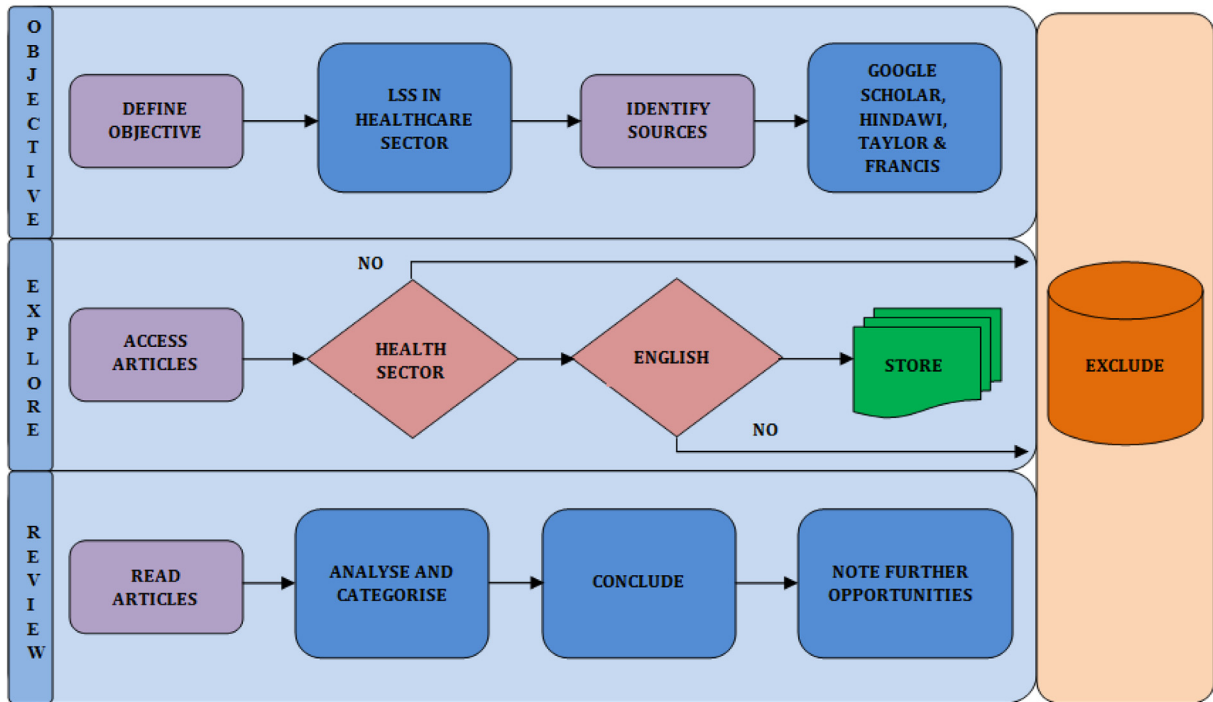


Fig. 1. Systematic Literature Review.

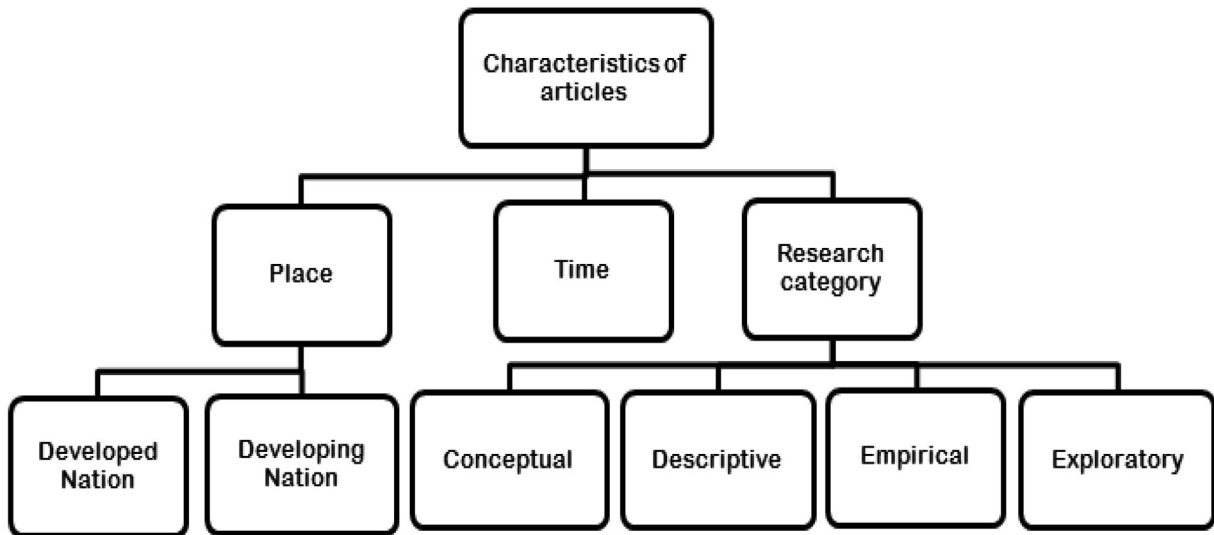


Fig. 2. Characteristics of research papers.

García et al 2019 [55] conducted a review and directed the research scholars towards the areas in healthcare which required more focus. Whereas, the scholars have also focused on topics which makes the implementation of LSS in healthcare much easier. Like, V. Vaishnavi et al 2020 [90] identified 16 readiness factors for LSS implementation in healthcare. These factors should be fulfilled by a healthcare organization before starting with the implementation phase of LSS[96]. Certain crucial factors which affect the implementation of LSS are -:

- Management willingness and effective leadership
- Resource capabilities
- Employee training and trust
- Financial capabilities

- Availability of expertise and knowledge

3. Results and discussions

LSS implementation in the healthcare began not earlier than 2005. A lot of research has already been done on LSS in healthcare all over the world, but when it comes to developing nations like India and Brazil, comparatively less research has been conducted [97]. The time constraint trend in categorisation of the articles, is crucial to indicate how the trends are changing over the year and how many researches are conducted in a year to overcome the problem. Moreover, the time also indicates the change of area of focus of the researchers with changing time. Until the year 2013, research scholars focused majorly on improving the healthcare

Table 1
LSS in Healthcare: Developed Nations and Global.

Reference	Sr.	Findings	Research Type	Country
[21]	1	Implemented Six Sigma in red cross hospital in Netherlands. 3 million euros are expected to be saved annually. (2005)	Exploratory	Netherlands
[22]	2	Integrated lean six sigma and listed its benefits. (2006)	Empirical	Netherlands
[23]	3	Integrated lean six sigma and provided the details where it can implement in healthcare organisation. (2006)	Conceptual	Global
[24]	4	Provided the details to describes the way how it can implement in drug discovery. (2008)	Exploratory	UK
[25]	5	Provided the information to improve the pharmaceutical industry and demonstrate the way how to enhance the efficiency and quality of it. (2009)	Descriptive	UK
[26]	6	Reviewed the implementation of LSS in R&D department of pharmaceutical industry. (2009)	Descriptive	UK
[27]	7	Applied Lean methodology in emergency department of healthcare organisation to make it more efficient. (2009)	Empirical	USA
[28]	8	Applied lean techniques in emergency ward in the hospitals to improve the quality and reduced the unusual fatalities.(2009)	Empirical	USA
[29]	9	To achieve clinical and organisational success, Bon Secours Health System applies Lean Six Sigma and technology transfer. (2009)	Empirical	USA
[19]	10	Perfection in trauma care unit where Lean Six Sigma is usingfor progress in hospital discharging process. (2010)	Empirical	Netherlands
[30]	11	An analysis of the researches on Six Sigma. (2010)	Exploratory	UK
[31]	12	To the improvement in healthcare organizations, evaluating the facts of Lean And six Sigma. (2010)	Conceptual	US
[32]	13	In an anaesthesiology residency clinic or hospital, Lean Six Sigma methods were used to achieve high performance, punctuality, and consistency of treatment. (2010)	Conceptual	US
[4]	14	An observational analysis of the use of lean six sigma to enhance the efficiency and quality of the healthcare. (2011)	Empirical	Taiwan
[33]	15	Study of the paper demonstrate that time has come to develop a system for enhancing the quality of healthcare organizations in India. (2011)	Conceptual	Global
[34]	16	In an elevated primary and secondary university hospital, lean and six sigma methods are being used to boost operating room performance. (2011)	Empirical	USA
[35]	17	In an intensive care unit, lean Six Sigma is being used to minimise linen failure. (2011)	Empirical	USA
[36]	18	A detailed analysis of lean technique is to be used in emergency ward. (2011)	Descriptive	Sweden
[37]	19	Study of the paper describes an interpretation of logistic clearance in a six-sigma project in healthcare. (2011)	Empirical	Belgium
[38]	20	A detailed review of the utility of Lean Six Sigma in healthcare organizations. (2012)	Descriptive	France
[39]	21	Cancer medication impact assessment and cost control through Lean Six Sigma techniques. (2012)	Empirical	Italy
[40]	22	Contrasting continuous quality improvement, Six Sigma, and lean management to enhanced outcomes in US hospitals. (2012)	Empirical	USA
[41]	23	To shorten patient shift times from the floor to emergency ward, six sigma technique is being used. (2012)	Empirical	USA
[42]	24	Lean techniques introduce to consolidated filtration to discuss the drug discovery bottleneck. (2012)	Empirical	USA
[43]	25	In a medical university, the effect of five years of lean and six sigma principles is evaluated. (2012)	Exploratory	Netherlands
[44]	26	In healthcare delivery department, the impact of six sigma methodology and its importance to enhance the quality in this particular field. (2013)	Empirical	US
[45]	27	Study of the article demonstrate the way to enhance the quality and discussed the various factor for What's taken too long to improve healthcare quality? (2013)	Conceptual	US
[46]	28	We could use six-sigma to its full extent throughout the healthcare management, here is the detailed review to improve the healthcare. (2013)	Descriptive	Global
[47]	29	By using Six Sigma technique, a pathology department being important to limit patient wait times. (2013)	Descriptive	Global
[48]	30	Utilizing Lean Six Sigma Approach to - Patient Queuing in Treatment Centres. (2013)	Empirical	Global
[49]	31	The application of lean six sigma to the establishment of a therapeutic pathway for bone fractures. (2013)	Empirical	Netherlands
[50]	32	Application of lean six sigma business practices to an Air Purifying Respirator process. (2013)	Exploratory	USA
[52]	34	Lean Six Sigma is being used to deliver high-quality, dependable paediatric service to the patient. (2014)	Descriptive	USA
[53]	35	It is all about an Indian hospital in which lean techniques are often used to increase value and decrease outpatient long waits. (2015)	Descriptive	US
[51]	36	A scientific study of utilizing the Lean and Six Sigma techniques in surgery and take it to next extent. (2015)	Exploratory	Global
[54]	37	A structured overview of relevant literature about Six Sigma in healthcare organizations. (2018)	Descriptive	Global
[55]	38	Different types of valuable reports on Lean and Six Sigma in healthcare sector is being studied and reviewed. (2019)	Descriptive	Global
[56]	39	A pre - feasibility review of process improvement with in the pharmaceutical supply chain. (2019)	Descriptive	Global
[57]	40	A worldwide outlook on Lean thinking in healthcare, a comprehensive analysis about the implementation of LT in the clinical units. (2019)	Conceptual	Global
[58]	41	An analysis of the use of lean six sigma in the Norwegian public healthcare sector to minimize medical errors. (2019)	Empirical	Norway
[59]	42	At the Antonio Cardarelli Centre, six sigma approach is playing a vital role to minimize the amount of time spent in the hospital prior to surgery. (2019)	Empirical	Italy
[60]	43	A detailed study of scientific research about the healthcare including Lean and Six Sigma. And describes the importance of lean six sigma approach is being used in healthcare sector. (2020)	Empirical	Global
[62]	45	The Preoperative centre of surgical quality experience using Lean Six Sigma concepts to increase the level of care delivery for total joints arthroscopic clients. (2020)	Empirical	Global
[63]	46	Multi-criteria strategic planning is used in a lean methodology to healthcare reform. (2020)	Descriptive	US
[61]	47	During the COVID-19 age, Lean Six Sigma can be used as an administrative stability tool in healthcare sector. (2021)	Descriptive	Global

sector of developed nations, as evident from Fig. 3. However, commencing from 2014 the focus shifted to developing nations, as they are the ones which require more efficient systems. 41 percent of the studies targeted the organizations in developing nations, and further 30 percent of articles from the developing nations category addressed the Indian healthcare organizations, as shown in Fig. 4. It

is important to note this trend because a study related to a particular place demonstrates the importance and need of the study for a unique problem and its solution related to that place. Because as the places differ problems also varies. So that it could be defined as per the requirement related to that particular place.

Table 2
LSS in Healthcare: Developing Nations.

Reference	Sr.	Findings	Research Type	Country
[64]	1	Study conducted in an Indian hospital on QM techniques. (2007)	Descriptive	India
[65]	2	Innovated a process using LSS for imaging section in a hospital. (2008)	Empirical	Mexico
[66]	3	Used the quality indicators in an Indian laboratory for assessing its performance. (2010)	Descriptive	India
[67]	4	Six Sigma is used for enhancing the efficiency of an operating room. (2011)	Conceptual	India
[68]	5	To boost the selenium analysis process, a Lean Six Sigma approach was used. (2012)	Empirical	South Africa
[69]	6	In designing a research management program, the business management techniques Lean Six Sigma and PMBOK were used. (2012)	Empirical	Brazil
[70]	7	The Lean Six Sigma approach is used to monitor inventory quality in clinical engineering. (2012)	Empirical	Brazil
[71]	8	Improved the patient discharge procedure with six-sigma (2012)	Conceptual	India
[72]	9	A case report of a hospital in India, where Six Sigma has been used to increase the health care quality. (2013)	Conceptual	India
[73]	10	In an Indian rural hospital, Lean Six Sigma technique was used to reduce the time required for out-patient department processes. (2014)	Empirical	India
[74]	11	In operation theatres, lean six-sigma was used to reduce wastes related to non-valuable actions and hence saving time. (2014)	Empirical	India
[75]	13	Examined the present situation and future of lean in healthcare during a decade. (2015)	Exploratory	India
[76]	14	In a hospital's medical records system, productivity and results are improved using Lean Six Sigma. (2016)	Empirical	India
[77]	15	LSS was used to enhance patient's care in a healthcare organization. (2017)	Empirical	India
[78]	16	Identified the problems and opportunities of Lean six sigma in health operations in resource-constrained environments. (2017)	Conceptual	India
[79]	17	Investigated how Lean Six Sigma methodologies would help the health-care sector. (2017)	Empirical	India
[80]	18	An ISM method for identifying factors that can influence lean adoption in healthcare sector. (2017)	Conceptual	India
[81]	19	A case study conducted to determine if healthcare organizations are ready to adopt lean. (2018)	Descriptive	India
[82]	20	Lean Six Sigma approach has been used to improve the hospital referral system. (2018)	Conceptual	KSA
[83]	21	A statistical model was developed to evaluate lean technique application in hospital systems. (2018)	Exploratory	India
[84]	22	Developed a framework for implementing Six Sigma in a healthcare organization's logistics department. (2019)	Descriptive	Jordan
[85]	23	A case study was undertaken to examine the application of Lean Six Sigma in various Indian healthcare organizations. (2019)	Descriptive	India
[86]	24	A systematic literature review was conducted on the Lean management methodology in the healthcare organizations. (2019)	Conceptual	Iran
[87]	25	Explored the use of Lean in healthcare organizations as an impetus for environmental sustainability. (2019)	Conceptual	UAE
[88]	26	An exploratory research was conducted for Lean methodology in Indian Healthcare sector. (2019)	Exploratory	India
[89]	27	In a mobile hospital, a Lean Six Sigma design-thinking intervention was used to improve the patient care quality and experience. (2019)	Exploratory	India
[90]	28	Readiness factors for Lean Six Sigma adoption were modelled for hospital systems. (2020)	Exploratory	India
[91]	29	Using a fuzzy logic approach, determined the degree of healthcare readiness for incorporating lean and agile techniques. (2020)	Descriptive	India
[92]	30	Using a fuzzy logic approach, the extent of readiness for incorporating lean six sigma in a healthcare enterprise was determined. (2020)	Descriptive	India
[93]	31	The critical failure factors for introducing a long-term lean six sigma system in an organisation were assessed. (2020)	Descriptive	India
[94]	32	In outpatient ophthalmology clinics, Lean Six Sigma methods have been used to increase the performance. (2021)	Empirical	India
[95]	33	A case report of a Thai hospital which used Lean Six Sigma to reduce medication errors. (2021)	Empirical	Thailand

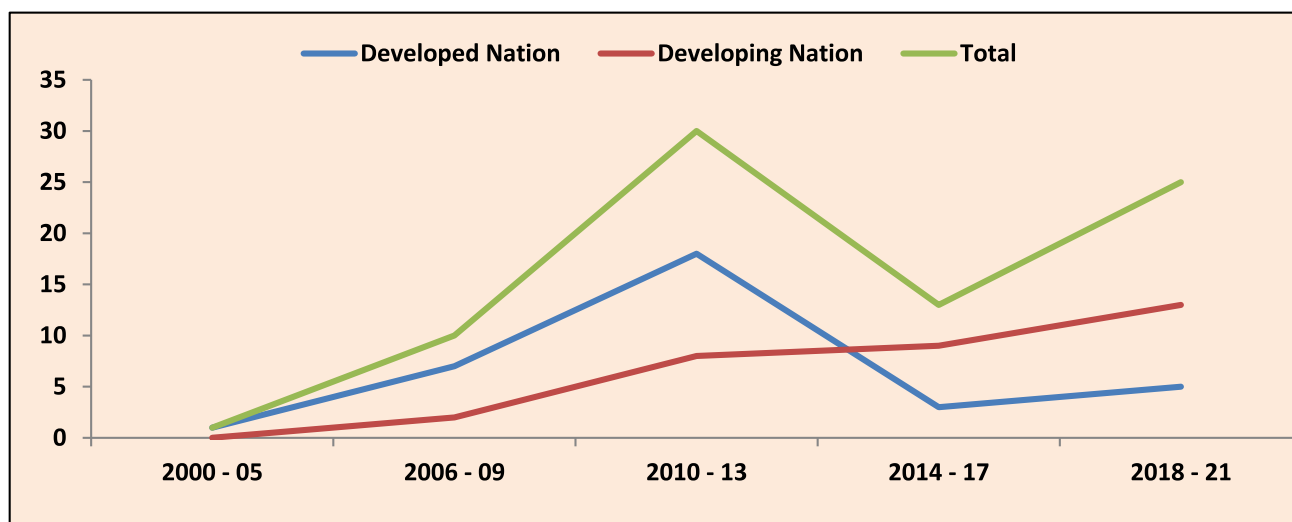


Fig. 3. Year wise distribution of the research articles.

Fig. 5 helps to distribute the articles according to the type of process in the healthcare organization they target, namely medical

processes, management processes and general processes. Further, the articles are also divided according to the place they have

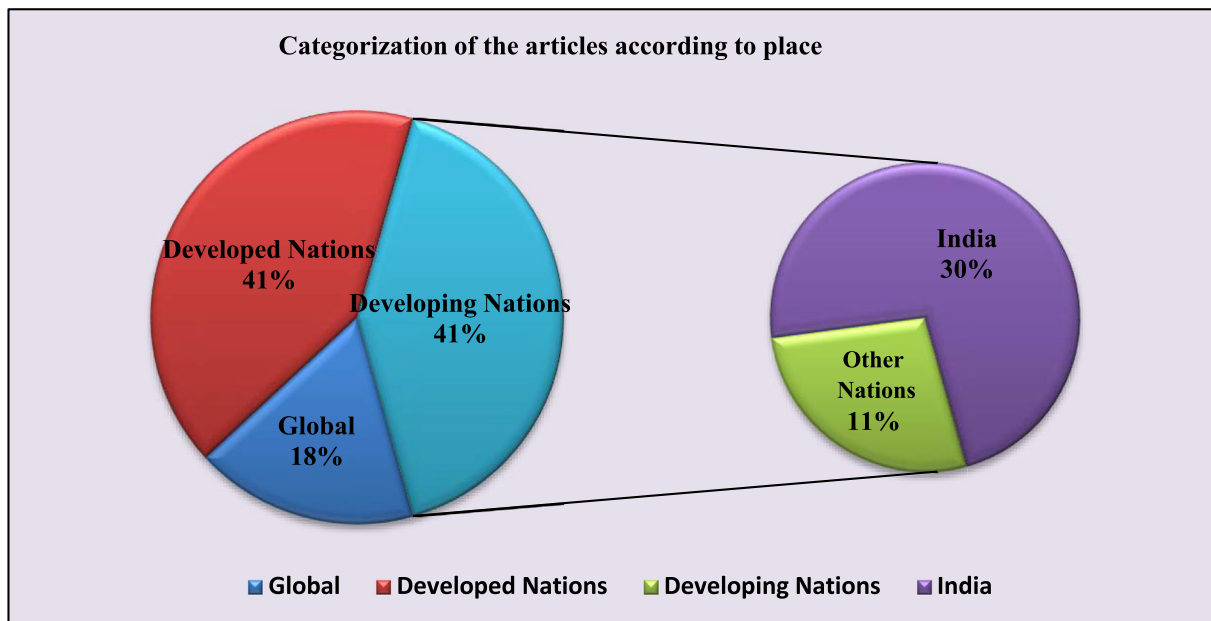


Fig. 4. Categorization of the articles according to place.

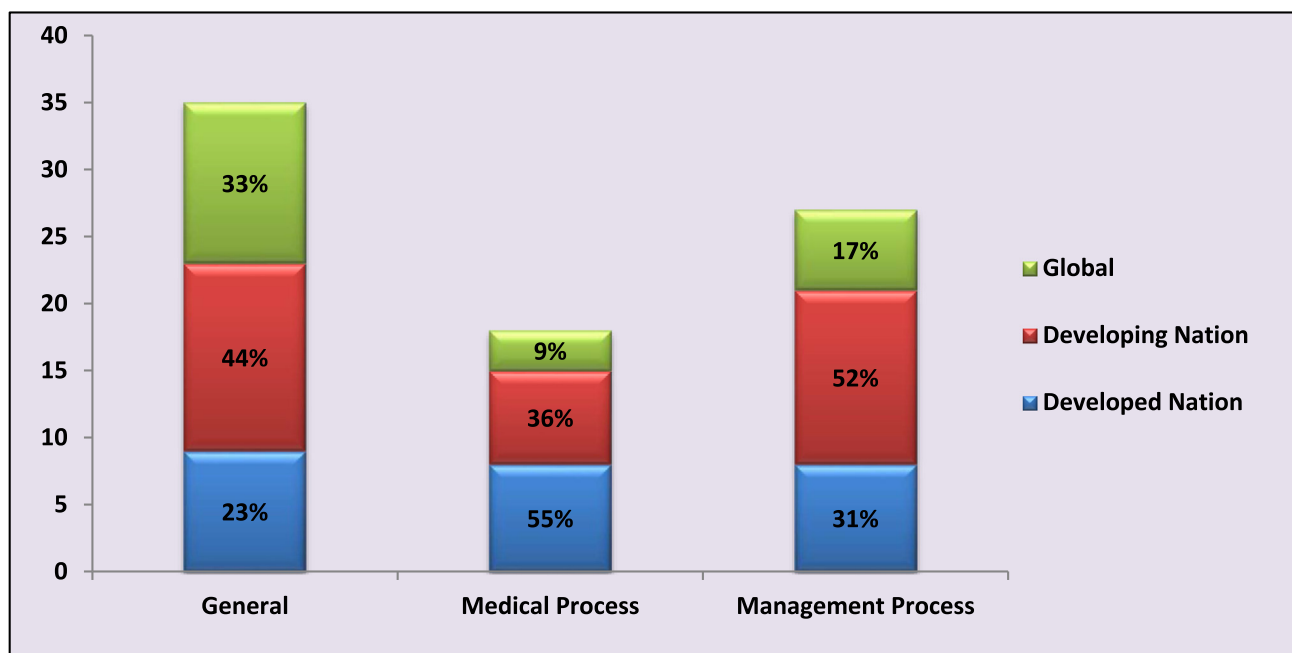


Fig. 5. Characteristics of articles according to process.

focused on. It is evident from the Fig. 5 that comparatively less articles have addressed the medical processes. Most of the research studies conducted in the developing nations were empirical, as depicted in Fig. 6. Whereas, there is a gap when it comes to exploratory studies and conceptual studies. This trend is significant because, if in a particular country there are less exploratory studies carried out, than the problems unique to that particular country won't be decomposed. So, there must be an exploratory study to demonstrate the simple and feasible solution. The researchers need to devise new concepts and address the problems which are still not solved yet, while targeting not just one organization but the whole nation. For an example, Sreeranga Bhatt et al 2014 [73] implemented the LSS methodology using DMAIC in a hospital, sim-

ilarly some other researchers have successfully implemented LSS in one or in some cases up to five hospitals. But this successful research work method cannot be applied to all the hospitals, as all have their own unique problems.

3.1. Implications and future opportunities

After analysing the articles included for the current study, some areas or topics were found which lacked in terms of research. Moreover, these can be taken as future opportunities for the research scholar and the healthcare professionals to work on. Healthcare practitioners may be able to identify fields that need more study and, as a result, better strengthen their organizations.

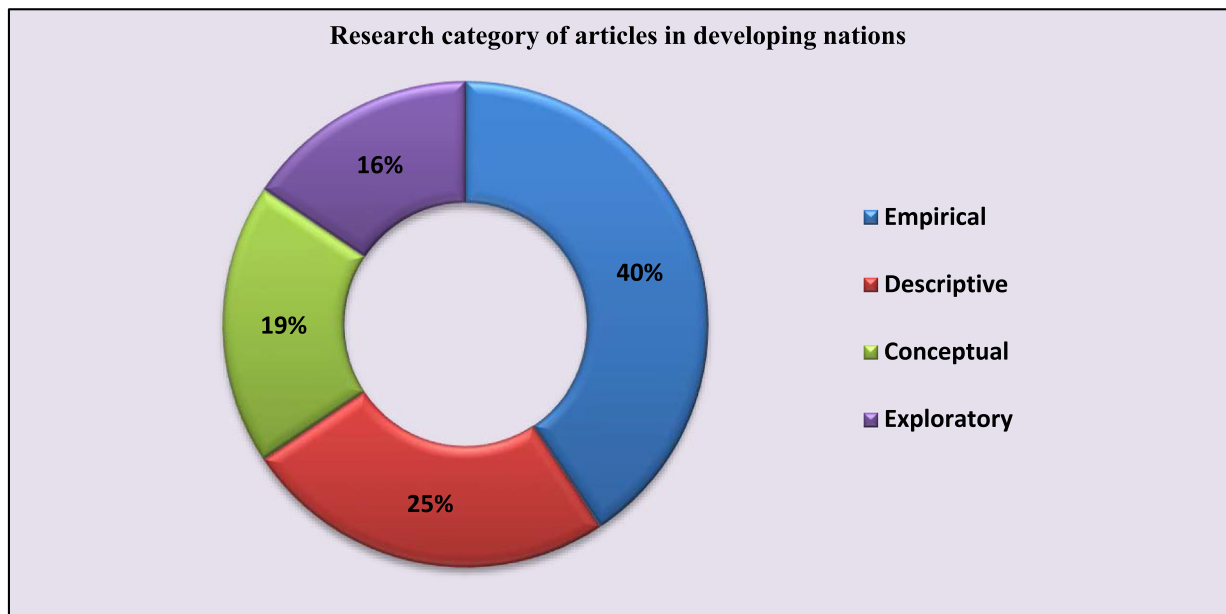


Fig. 6. Research category in developing nations.

The following are the topics which will set direction for future research:

1. Medical process: More study is needed to apply the LSS approach in order to minimize defects and wastes associated with surgical procedures such as therapies and operating rooms. The majority of studies were found to be either for managerial processes or were conducted aiming the whole organizational structure.
2. Continuous improvement culture: After the implementation of the LSS approach, healthcare managers must be motivated in developing a continuous improvement philosophy in order to sustain the gains made and identify potential prospects. As per the research done by the authors, no studies were found to address this topic.
3. Sustainability: It is important to understand environmental factors as well, as the healthcare industry generates bio hazardous wastes that harm the ecosystem. LSS can be integrated with green technologies to have a sustainable improvement framework.
4. Supply chain: As evident during the pandemic, the supply chain of the healthcare sector was not quite effective and ready for these kinds of uncertain situations. But the bad times always gives a lesson, and hence it is the best time to reflect on the problems and build an LSS framework which can help even during pandemic.
5. More research work is required in developing nations. Moreover, most of the studies were conducted in India, very less aimed at other developing nations like Sri Lanka, Pakistan, Bhutan, and Bangladesh.
6. Most of the studies in the developing nations were empirical in nature, more conceptual and exploratory are required. Because these types of studies have the potential to address the unique problems for each individual country. As each country has their own policies and rules, which could produce a challenge for a LSS model which was successful in other nation.

There is a need for improving the performance of healthcare organizations. These organizations faced a lot of difficulty during the corona virus pandemic. Therefore, to avoid such situations in

future it has become very critical for the healthcare managers to implement the process improvement methodologies like Lean Six Sigma. Moreover, the managers and their staff are motivated to implement LSS to reduce the defects and wastes related to medical processes like during the surgeries and in operation theatres. After the initiation of LSS methodology, the healthcare managers need to create a continuous improvement culture in their organization, so as to maintain the improvements done and find new opportunities. Lastly, the healthcare professionals and managers need to consider the environmental aspects too, as healthcare sector has bio hazardous wastes which has damaging effects on environment. Lean Six Sigma can be combined with green methodology in order to deal with this [98]. The integrated green lean six sigma could become an effective booster to enhance the quality, effectiveness and efficiency of a particular organisation. Therefore, the management of the healthcare organizations are motivated to implement this method to develop their organization in a sustainable manner [99]. Yet, it is evident that still the journey for LSS implementation in the healthcare sector is a long way ahead, especially for the developing nations.

4. Conclusion

Healthcare is a very crucial and complex sector, it involves several departments, and a failure in one department may have a negative impact on patient's care. It was also evident during the pandemic due to the Covid-19, that we need an operational excellence in healthcare operations. Lean Six Sigma is a methodology which can reduce wastes and variation in an organization with the help of lean and six sigma tool set. Lean Six Sigma is a well-established methodology, mostly used in the manufacturing sector [100]. However, in the past decade it is being extensively used for the non-manufacturing industry also, like the service sector. There has been a shift in number of studies being conducted according to place. The researchers have acknowledged the gap, when it comes to developing nations, and the number of studies conducted has increased for these nations [101]. Present study shows that till, in healthcare sector, LSS is mainly limited in management of operations, and more research is needed in eliminating waste and defects in surgical and operation theatre activities. Furthermore,

guidance should be provided to the healthcare professionals on how to create a continuous improvement culture, and then sustain the environment and the improved processes. Researchers are working tirelessly in order to make the healthcare organizations perfect and efficient, so that everyone's life can be improved. Indeed, it is the healthcare sector on which we are dependant for life support.

5. Limitations

An exhaustive systematic literature review was conducted for the present study. The major limitation of this study is that during the exhaustive literature review a number of articles were filtered out which are in language other than English, not related to the healthcare sector, not using the LSS methodology, and not yet published. As a result, a very clear scenario of LSS in the healthcare sector might not be presented. Secondly, the study has not included a LSS framework which can guide the healthcare professionals to implement the LSS methodology in their organizations, but this can be a part in a consecutive paper.

CRedit authorship contribution statement

Rajeev Rathi: Supervision, Conceptualization, Resources, Writing - review & editing. **Ammar Vakharia:** Conceptualization, Formal analysis, Investigation, Visualization, Validation, Writing - original draft. **Mohd. Shadab:** Data curation, Formal analysis, Investigation, Visualization, Validation, Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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