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Review

Lean Six Sigma in Healthcare: A Systematic Literature Review on Motivations and Benefits

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Abstract: While Lean Six Sigma (LSS) has been applied extensively in healthcare organisations, there has been limited research on the trends of LSS application in healthcare in recent years. This paper aims to present the key motivations and benefits of LSS in healthcare with a view to highlighting the types of problems that LSS in healthcare can aid in solving. The authors used a systematic literature review (SLR) approach to achieving the article's purpose. Peer-reviewed journal articles published between 2011 and 2021 are considered to achieve the study objectives. The systematic review helped the authors to identify the evolution, benefits, and motivations for LSS in healthcare. This work includes directions for managers and healthcare professionals in healthcare organisations to embark on a focused LSS journey aligned with the strategic objectives. This study is perhaps one of the most comprehensive SLRs covering a vital agenda of LSS in healthcare. This study provides all the deliverables of LSS for its successful deployment in healthcare.

Keywords: Lean; Six Sigma; healthcare; systematic literature review; benefits

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1. Introduction

The importance and applicability of healthcare services have evolved as a significant constituent of the services sector in recent years. Moreover, increasing competitiveness within the healthcare sector and a drive to improve operational efficiencies have been a huge focus of healthcare organisations [1]. In addition, increasing customer expectations for high-quality healthcare services has warranted continuous process improvement and implementation of the operational excellence (OPEX) methodologies [2].

Six Sigma (S.S.) is one such OPEX methodology which has many proven benefits in healthcare sectors in terms of increasing capacity, reducing errors in prescription administration [3], reducing waiting times for patients [1,4] and improving customer experience [5]. Six Sigma problem-solving techniques include data collection, Pareto analysis, cause and effect diagrams, and process maps to aid in understanding healthcare processes and identifying the root causes and potential for variation [6]. Lean focuses on eliminating waste in the process and improving flow [7]. Six Sigma, coupled with Lean, can improve profits and increase customer satisfaction [8]. George suggested the integration of Lean and Six Sigma in 2002 to improve business processes. This is because the LSS approach aims to improve the business's productivity and efficiency by removing waste and reducing variation [9].

Continual pressures on healthcare budgets coupled with increasing demands and evidence of poor performance have led national and local healthcare organisations to look for methods to improve quality, safety and value in health service delivery [10].

In addition, applying LSS in healthcare may face unique challenges compared to other industries. These challenges include capacity surges due to seasonal issues or pandemics, e.g., flu, COVID-19, and ageing populations. Furthermore, hospitals can contain a mix of professional backgrounds compounding the belief that some traditional management practices from other industries are incompatible with hospital environments [11,12].

Considerable health literature has focused on the results achieved using Lean; individual motivations and healthcare social factors are important to understand why LSS should be implemented. The increased focus and spread of safety, quality and value improvements in healthcare organisations may proceed expediently in the future if all healthcare organisation members are given the opportunity to understand the benefits of LSS motivations to implement [10].

The complexity and diversity of the healthcare system can lead to different motivations for approaches and practices in LSS methodology deployment. Thus, a comprehensive understanding of why to implement LSS and the benefits of such LSS deployments is essential to aid in embracing LSS. Furthermore, an understanding of LSS tools and techniques utilised in healthcare and the types of tools used is important for LSS practitioners in healthcare. Thus, the following research questions (R.Q.s) are formulated to understand the critical delivery of LSS.

RQ1: How has the study of LSS in healthcare evolved in the literature?

RQ2: What are the motivating factors and reasons for healthcare practitioners and managers to engage in utilising LSS in healthcare?

RQ3: What are the benefits for healthcare organisations to deploy the LSS program in terms of quality, safety, clinical and patient outcomes?

The article is articulated in a structured manner. First, Section 2 provides the research methodology followed in the study. Then, results are presented in Section 3, and discussions are delivered in Section 4. Finally, the conclusion and future research directions are enumerated in Section 5.

2. Research Methodology

A systematic literature review (SLR) was utilised in this study. According to [13], SLR is the selection of articles obtained from different databases and sources, and has been utilised by many researchers in Lean Six Sigma and other fields [5,14,15]. The systematic process of searching the literature and the subsequent extraction and synthesis is prioritised in SLRs more than in other literature review forms, resulting in more scientific and replicable work [16,17]. The researchers systematically searched for articles relating to the subject matter published between 2011 and 2021, using the academic search engines of the Web of Science, Scopus, Google Scholar and MEDLINE databases. As the emphasis on the systematic process of the literature search, extraction and synthesis is higher in SLRs than in other forms of review, the resulting work is more scientific and replicable [17]. The search strings that were applied to search the databases mentioned above comprised of the following: “Lean” and “Six Sigma” AND “healthcare”, “hospitals”, and “health services”. Figure 1 summarises the SLR method with a summary of the inclusion/exclusion criteria. In addition, each researcher checked the citations and bibliographies of the selected studies to identify any additional relevant studies that were missed in the database search. Finally, grey literature (conference papers, magazine-related articles, workshops, books, editorials, prefaces) was excluded.

Flowcharts within SLRs ensure and improve review transparency [18], and a flowchart was utilised to draw out and map the steps within the SLR process (Figure 1). In addition, the flowchart allows future researchers to follow, replicate and draw implications from the research findings. Initially, the search identified just over 14,200 articles, after which duplicate articles were removed. Subsequently, a review was carried out of the remaining articles. Upon review, the article was retained if related to Lean, Six Sigma, or LSS and their application within a healthcare environment and context. The authors reviewed the articles to assess the eligibility for inclusion based on the search criteria [19]. When reviewing

the articles, discussions among the authors were carried out to gain consensus. Studies published in peer-reviewed journals and the 3 or 4 categories in the ABS journal ranking [20] were included. At this review stage, 220 studies for final inclusion were yielded.

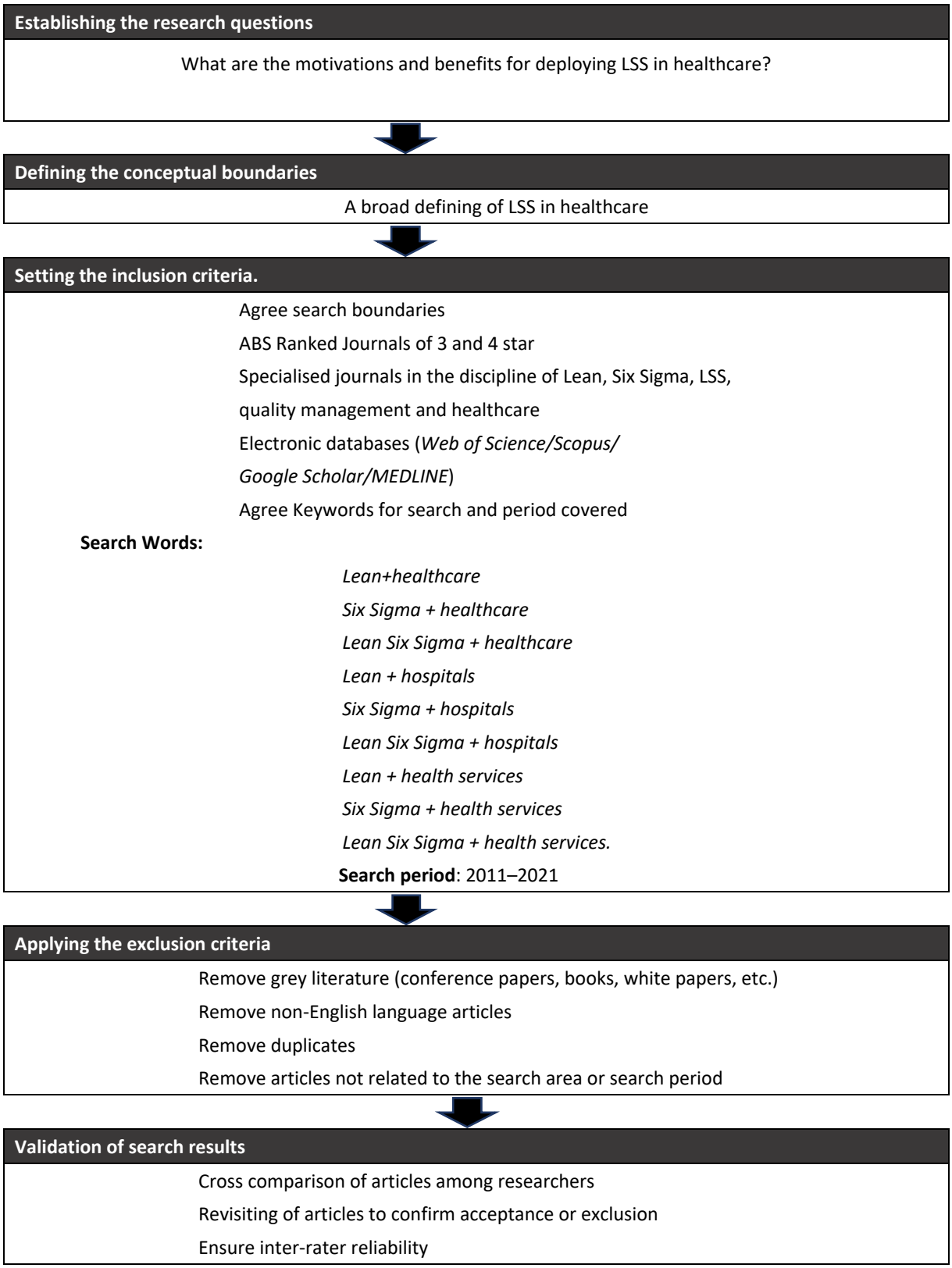

Figure 1. SLR Research Methodology Flow Chart with Inclusion and Exclusion Criteria.

Management of data collation was via Zotero to save relevant citations and Excel to record information concerning the articles under review and subsequently selected. The authors conducted an independent review of each paper, and coding was carried out utilising a meta-framework. After extracting the final articles and recording these in Excel, coding minimised errors. Further analysis was conducted based on the research subthemes under investigation about the research questions. This analysis included the year of publication, authors, journals, benefits of LSS in healthcare, and motivations for LSS in healthcare. At this final stage, utilising the SLR methodology, 126 articles or relevant research papers resulted in a more exploratory analysis of the sub-themes of LSS in Healthcare (H.C) integration. The findings were summarised by reviewing patterns of publications and emerging themes in these publications

3. Results

In answer to RQ1, "How has the research for Lean six sigma in healthcare evolved in the literature?", the authors analysed publication timelines for research regarding LSS in H.C., the journals where the research was published, and also the author types.

3.1. Publications Timeline

While the search criteria for this study were from 2001 to 2021 (inclusive)—twenty years—initial articles in LSS started to appear around 2003. As shown in Figure 2, there has been a steady increase in articles related to LSS in healthcare since 2003, with a peak in publications mainly in the last four years.

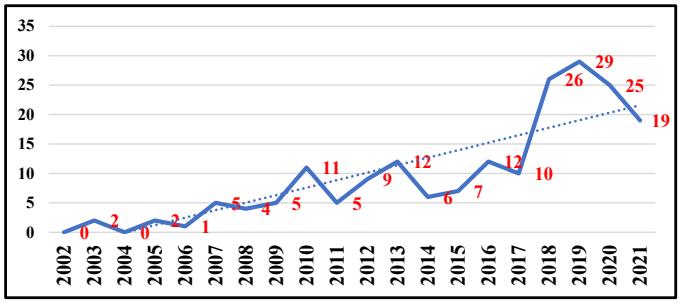

Figure 2. Publication by Year (Trendline = dotted line; Data series pattern = solid blue line).

Evidence of increased collaboration regarding LSS in healthcare research is demonstrated by analysing the number of authors per paper, with 43% of papers having Three authors and 25% having two authors (Figure 3). These data correlate with the increasing trend in publications within the research area in recent years.

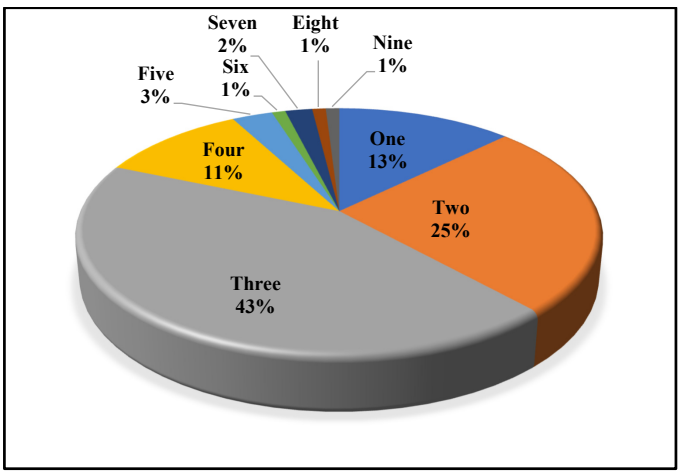

Figure 3. Number of authors per publication.

3.1.1. Publications by Journal

Three journals accounted for over 50% of the articles related to LSS in healthcare (Figure 3). These were the journals *Leadership in Health Services* (23%), the *International Journal of Healthcare Quality Assurance* (17%) and the *International Journal of Lean Six Sigma* (14%). In addition, other journals related to quality management and LSS, such as *Quality Management in Healthcare*, *The TQM Journal*, *International Journal for Quality in Healthcare* and the *Total Quality Management and Business Excellence Journal*, also made up many of the articles cited (Figure 4).

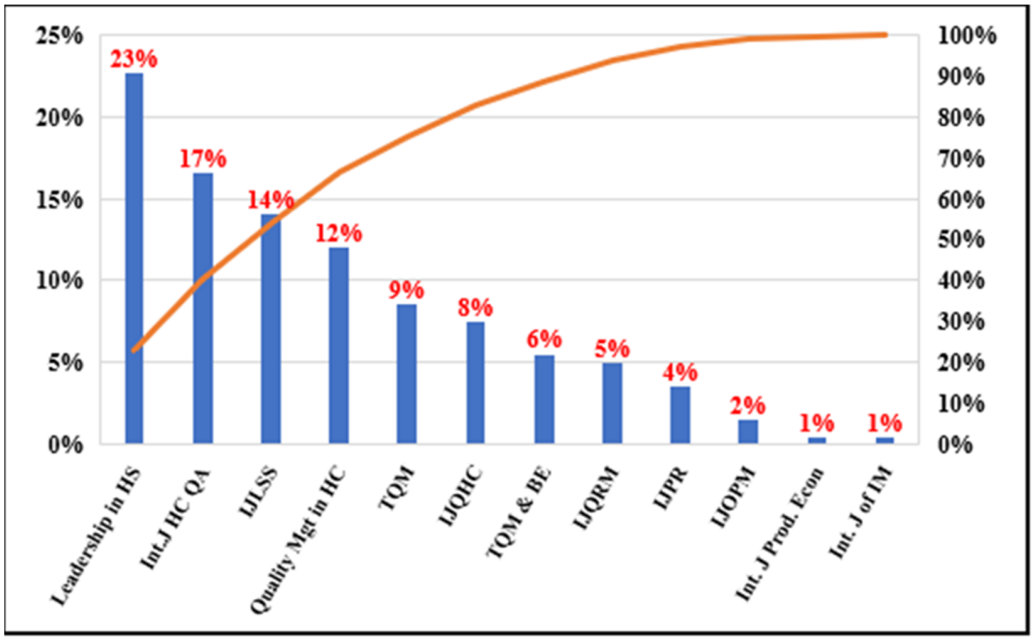

Figure 4. Journals with the majority of articles related to Lean in Healthcare. *(orange bar = pareto line, blue bar = % contribution (visual) red number = % contribution (numerical).*

3.1.2. The Motivational Factors

The review of the selected articles reveals multiple motivations for healthcare providers to implement Lean, Six Sigma and Lean Six Sigma paradigms [21]. However, these motivations are not always well clarified and, in many cases, are improperly confused with objectives. Moreover, most articles do not explicitly state the organisational level at which the motivation arises. In this respect, very few articles discuss the organisational level from which the motivation to change is triggered. The following analysis will be somewhat affected by the gaps starting from these considerations. In other words, although from the literature review it is possible to determine the nature of the motivations that drive healthcare providers to implement continuous improvement paradigms, it is particularly complex to fully understand the causal relationships between motivations and organisational behaviours. The cross-tick table obtained from the literature review (Table 1) briefly describes motivating factors that emerge from the articles and shows the main motivating factors discussed in each article.

The first evidence emerging from the articles reviewed is the multidimensional and dynamic nature of motivations. In addition to the motivations determined by the external context and the strategic objectives of sustainability and competitiveness, which are generally associated with these paradigms, other forms of motivation are related to the vision and sponsorship of management and self-reinforcement.

It is vital to emphasise that the adoption of continuous process improvement paradigms can be supported by multiple motivations simultaneously. The coexistence of different motivations stems from the organisation's ability to exploit multiple opportunities and the different sensitivities of several organisational actors: management, staff and leader-

ship. The latter phenomenon is particularly relevant because it explains organisational members' different approaches and commitments. Thus, understanding, managing and driving motivation in the organisation is a critical success factor (CSF) in implementing these methodologies.

Motivations related to external factors include the willingness and, in some cases, the need to comply with national health authority regulations, standards and guidelines [22–25]; respond effectively to epidemiological changes and evolving demand [26–28]; achieve sustainability in a context of reduced public funding [21,29,30]; emulation of other providers [22,31,32]; and competitive issues [33–35].

Motivations related to the strategic goals of sustainability and competitiveness relate to improving operational performance and profitability [36]. Reducing lead times, increasing workflow, safety and quality of care, and patient satisfaction are the most discussed motivations regarding operational performance [36–39], while reducing costs and increasing revenues are also considered in references [21,40,41]. Motivations related to managers' vision and sponsorship can be determined by either methodological knowledge or perceptions and a belief in reliability [1,3,42–44]. However, it is interesting to note that these motivations are related to organisational issues such as developing organisational knowledge and skills to manage organisational change and orient the organisation to the patient value. In particular, the adoption of Lean, S.S. and LSS methodologies is motivated to improve staff and management cross-functional skills [3], to improve the working environment [43], to manage the adoption of new technological solutions [34], to design a new process [45,46], to implement risk management [47] effectively and finally to focus organisational effort on patient value [1,28,48,49].

Finally, the dynamic nature of motivation is demonstrated by self-reinforcement; this phenomenon occurs when the benefits of implementing methodologies at a micro- and, in some cases, macro-level drive management and staff to spread the methodologies throughout the organisation, overcoming the boundaries of primary processes to also impact on secondary and supporting processes in the value chain [1,50].

Among the most revealing results of the analysis is the profound difference in motivational drivers between public and private providers, especially regarding external factors [40]. However, both actors are equally oriented toward using these paradigms to comply with national guidelines and regulations. Furthermore, benchmarking based on the performance of other providers is also adopted by both public and private organisations, but while the former use it to increase their competitiveness, the latter resolves organisational issues. On the other hand, the articles do not show any evident differences between public and private organisations regarding the motivation related to management vision and sponsorship.

In conclusion, while it is possible to glean from the literature review the nature of motivation and related organisational goals, the gap in determining where motivation arises does not allow for a complete understanding of organisational behaviour. This gap could represent a new topic to be explored as it would add value to the debate on implementing Lean, Six Sigma, and LSS in healthcare.

Table 1. Motivations for LSS in Healthcare.

Authors	Motivating Factors to Adopt LSS
Holden and Hackbart (2012) [34]	Manage the implementation of I.T. solutions and new technologies. Understand customer needs. Will need the leadership to improve process.
Feng and Manuel (2008) [37]	Six Sigma is a ready-to-implement choice if an organisation is trying to adopt a data-driven, systematic approach to process improvement. High return on investment (ROI) is the most relevant motivation for organisations committed to implementing Lean Six Sigma with a top-down approach.

Table 1. *Cont.*

Authors	Motivating Factors to Adopt LSS
Gowen, et al. (2006) [38]	The authors discuss qualitative and quantitative motivations. Quantitative motivations are quality improvement, increased customer satisfaction, net cost savings, decreased error frequency and reduced severity. Qualitative motivation is increased understanding of errors, heightened awareness of errors and reduced impact of errors.
Taner (2013) [39]	Staff had complained about the hospital cataract unit's image as perceived by Turkish society.
Bowerman, et al. (2007) [51]	Embrace opportunities for process and organisational improvement.
Ballé and Régnier (2007) [52]	Build a learning environment for staff and management.
Schattenkirk (2012) [53]	Guide the organisation toward continuous improvement. Create the internal dynamic capacity to deal with continuous improvement.
Taner, et al. (2012) [39]	Hospital administration considered the application of Six Sigma to improve clinical process performance.
Niemeijer, et al. (2012) [54]	Improve clinical process quality and reduce cost. Senior management decided to use the LSS methodology because there were positive experiences in the hospital.
Niemeijer, et al. (2011) [55]	Reduce costs, increase revenues and improve the quality and safety of clinical pathways.
Laureani, et al. (2013) [45]	Evaluate the learning outcomes of organisation members who participated in a Master's program, funded by the organisation, focused on continuous improvement.
Nayar, et al. (2016) [56]	Assess the compliance with the hospitals dual care policy. Provide high-quality care and facilitate medication co-management for dual care veterans.
Elbireer, et al. (2013) [25]	Effectively address the increased demand challenge because it has increased data entry and triage errors.
Ulhassan, et al. (2013) [31]	Effectively adopt Swedish National guidelines of cardiac emergency pathways. Improve patient satisfaction. Managers believe that Lean is a practical approach to improving the organisation's ability to deal with change.
Dannapfel, et al. (2014) [26]	The Lean improvement programme was introduced to tackle challenges such as an ageing society, rising care expectations and budgetary and economic constraints.
McIntosh, et al. (2014) [48]	Comply with U.K. National Health Service (NHS) efficiency savings guidelines. Improve patient value.
Bowerman, et al. (2007) [50]	Improvement in financial and operational performance.
Fillingham (2007) [57]	Productivity improvement, mortality reduction, fast recovery, length of stay
Kumar and Steinebach (2008) [58]	Minimised clinical errors in surgical activities, increased the hospital's profitability overall, and ensured patient safety.
Taner, et al. (2012) [59]	Improve high patient safety and diagnostic efficiency.
DelliFraine, et al. (2013) [60]	Organisations' motivations for implementing the methodology are unclear and must be deduced from the methodological implementation choices, the tools used and the stated objectives. Moreover, in many cases, motivations are confused with objectives.
Chiarini, et al. (2013) [61]	Improved lead time from the emergency department to hospitalisation or discharge.
Hicks, et al. (2015) [62]	Develop a new endoscopy facility on an existing site that fully complied with the Joint Advisory Group requirements (JAG, 2011) and would likely score highly in the global rating scale (GRS) standards.
Crema and Verbano (2015) [46]	Improve the effectiveness of clinical risk management.
Jayasinha (2016) [47]	Increase the quality provided to the patients.
Dobrzykowski, et al. (2016) [32]	Reach internal processes integration. Cost reduction.
Matthias and Brown (2016) [40]	Lean projects are motivated to improve performance and comply with national regulations and guidelines.

Table 1. *Cont.*

Authors	Motivating Factors to Adopt LSS
Deblois and Lepanto (2016) [35]	Process improvement tends to emerge as the primary purpose justifying the implementation of Lean in the healthcare sector.
Roemeling, et al. (2017) [27]	Address the challenges of increasing demands for excellent performance.
Crema and Verbano (2017) [44]	Lean healthcare management (LHM) can support Choosing Wisely implementation.
Polanski, et al. (2018) [63]	Define a standardised and validated outcome analysis method.
Trakulsunti and Antony (2018) [3]	Top management vision. Leaders realise the opportunities arising from business process re-engineering and the culture of continuous change.
Isack, et al. (2018) [42]	Effectively respond to the pressure from national authorities. Two categories of reasons co-exist: proactive (i.e., self-desire by the company) and reactive (response to customer requirements and threats, whereby failure to comply may result in adverse effects). Internal motivators (i.e., safe working conditions, reasonable salary and job rotation) are used more than external motivators (rewards and performance review) to motivate employees.
Woodnutt (2018) [24]	NHS hospitals adopt several quality improvement ideologies, often originally described or discovered outside the health sector, to address the crisis in funding and efficiency.
Hallam and Contreras (2018) [64]	Address the demands for higher quality standards associated with the increased demand.
Ahmed, et al. (2018) [39]	Private hospital staff are more motivated than public hospital staff to implement Lean management initiatives, Six Sigma initiatives, patient safety and teamwork because staff perceive these paradigms and tools as more favourable.
Peimbert-García, et al. (2019) [28]	Lean implementation is motivated by the desire to increase the safety and quality of patient care (the financial motivation is also present, but it has less effect on adopting the methodology).
Kahm and Ingelsson (2019) [65]	Drive quality and safety process improvements.
Ahmed, et al. (2019) [21]	Improve the quality performance of hospitals.
Ryan, et al. (2019) [66]	Design new processes that incorporate innovative solutions for remote patient monitoring.
Ahmed, et al. (2019) [21]	Ensure compliance with national regulations and guidelines, i.e., The Care Quality Commission (CQC) and NHS Foundation Trust (F.T.). Benchmarking. Address financial difficulty or crisis.
Walley, et al. (2019) [29]	Reduce primary care system costs, overproduction and errors in managing patient flow.
Antony, et al. (2019) [67]	Explore opportunities to improve the quality of clinical pathways.
Slade, et al. (2020) [68]	Adopt best practices provided by national agency guidelines.
Gao, et al. (2020) [22]	Address the request of the Chinese government that creates significant demands for improving efficiency and effectiveness.
Eamranond, et al. (2020) [69]	Improve clinical process safety using the implementation of interprofessional, multitiered Lean daily management (LDM).
Bhat, et al. (2020) [1]	The desire to experiment with models for process optimisation was the key motivation. Subsequently, successful pilots, processes, and organisation-wide benefits prompted the organisation to commit to implementing the LSS model at the macro level.
Leite, et al. (2021) [70]	Adopt models that provide organisations with the tools to deal with emergencies effectively.
Swarnakar, et al. (2021) [23]	The hospital management was motivated to improve the service quality and reduce the harmful wastes that impact society and the environment. In addition, hospital managers were highly motivated to adopt effective techniques to overcome patient waiting time and waste disposal problems.
Narayanamurthy, et al. (2018a) [30]	The adoption of Lean is motivated by the quantum of benefits harvested by several hospitals in developed countries.

Table 1. *Cont.*

Authors	Motivating Factors to Adopt LSS
Lima, et al. (2021) [20]	Lean is considered a key factor in driving business strategies, reducing costs, improving patient value, and enhancing the quality and safety of business processes.
Ramori, et al. (2021) [34]	Reduce waste and costs and improve overall patient care and satisfaction. Sustain competitive advantage for accountable care organisations.
Hundal, et al. (2021) [71]	The key motivation is personal safety, followed by process redesign and effective implementation of telemedicine.

3.1.3. Benefits of Deploying LSS in Healthcare

The benefits of using LSS are multi-fold. The healthcare sector uses various LSS tools and strategies to prepare itself better to mitigate the current challenges while speeding up the identification and isolation of an outbreak. This section highlights the benefits of using LSS in the healthcare sector in Table 2. The benefits are presented as real benefits or potential benefits. Some of the key benefits are overall operational and financial performance, improved customer satisfaction, reduction in waiting time of patients, cycle time, reduction in medical errors, improvement in quality of service, minimised turnaround time, improvement in communication between the stakeholders, etc. As per the systematic review, it has been found that operational benefits are well achieved with the use of LSS. However, there are other benefits which may be achieved with the LSS emerging trends, such as applying big data analytics in each phase of DMAIC, integration of the Internet of Things (IoT), robotic process automation (RPA) and radio frequency identification (RFID) systems for real-time monitoring and tracking of the patients and performing repetitive tasks [3,72]. LSS, in combination with these Industry 4.0 technologies in healthcare, will aid in the sustainable functioning of the healthcare system. In addition to direct benefits, there are quite a number of indirect benefits derived from the use of LSS. Healthcare, being unique in its kind, focuses on zero-tolerance mechanisms in clinical and non-clinical processes. The successful implementation of LSS across the organisation improves the healthcare service efficiency and effectiveness, thereby imbibing stakeholders' participation towards building a continuous culture change. This has to be incorporated from a strategic perspective that includes improving employee morale through training and education, sharing a financial benefit among the members, upskilling the team members, consistent communication, defining the right metrics for each strategic objective, etc.

Table 2. Benefits of LSS in Healthcare.

Authors	Benefits (Real Benefit or Potential Benefits)
Gowen, et al. (2006) [37]	Quality improvement, customer satisfaction increase, net cost savings, reduced error frequency, reduced error severity, increased understanding of errors, heightened awareness of errors, and reduced the impact of errors.
Fillingham (2007) [57]	Reduced staff dissatisfaction and frustration, productivity improvement, mortality reduction, fast recovery, length of stay, paperwork reduction, and better teamwork.
Bowerman, et al. (2007) [50]	Improvement in financial and operational performance.
Kumar and Steinebach (2008) [58]	Minimised clinical errors in surgical activities, increased the hospital's profitability overall, and ensured patient safety.
Feng and Manuel (2008) [37]	Reduced cycle time, streamlined process flow and reduced medical errors.
Hundal, et al. (2021) [73]	VSM, data analytics; and Failure Mode Effect Analysis (FMEA).
Farrokhi, et al. (2015) [74]	Adopt best practices of operating room management.
Gupta, et al. (2018) [72]	Reduction of the average TAT from 180 to 95 min in the haematology lab, and from 268 to 208 min in the biochemistry lab.

Table 2. *Cont.*

Authors	Benefits (Real Benefit or Potential Benefits)
Setijono, et al. (2010) [75]	Reduction in resource utilisation, reducing the cost of care, reduction in patient waiting time.
Yamamoto, et al. (2010) [76]	Increased communication and restricted the scheduling of inpatient procedures during mealtimes reduced disruptions to insulin administration. On-time meal delivery and increased the proportion of patients taking insulin scheduled for radiology tests during appropriate times. Optimised insulin delivery and patient safety.
Al-Araidah et al. (2010) [77]	A thorough investigation of the drug dispensing process revealed unnecessary complexities contributing to delays in delivering medications to patients. As a result, the average cycle time was reduced from 158 to 82 min, a time saving of 76 min, or 448% of the original cycle time.
LaGanga (2011) [78]	Increased capacity to admit new patients into a healthcare service operation system. Analysis of 1726 intake appointments for the year preceding and the full year following the Lean project showed a 27% increase in the service capacity to intake new patients and a 12% reduction in the no-show rate due to the transformation of service processes the Lean project.
Kuo, et al. (2011) [79]	Reduced waiting time for patients waiting for orthopaedic surgery.
Soriano-Meier, et al. (2011) [80]	Improved non-clinical service operations in the U.K.'s NHS.
Taner, et al. (2012) [59]	Reduction in delays, reduction in repeats, achieving targets, high patient safety, low bias, high efficiency, high diagnostic efficiency.
Schattenkirk (2012) [53]	Reduced time in process improvement, high return on investment.
Holden and Hackbart (2012) [34]	Improved mean first call resolution; improvement of timely completion performance for high-urgency calls and timely completion performance for medium- and low-urgency (follow-up six months). Improved teamwork: communication, coordination, workload distribution.
Robbins, et al. (2012) [54]	Strengthened communication within departments, aligning mission, goals and tactics, generated a culture of change and improved working conditions.
Niemeijer, et al. (2012) [55]	Reduced cost and improved quality. LSS aided the organisation's transition from purely problem-oriented to more process-oriented.
Taner (2013) [39]	Improved patient access to care, lowered complication rate, and increased skills transfer.
Laureani, et al. (2013) [46]	Reduction in in-hospital falls, more complete medical records and reduction in prescription lead times.
Burgess and Radnor (2013) [13]	45% reduction in turnaround time; 60% increase in productivity; 53% increase in efficiency; 98% reduction in errors.
Elbireer, et al. (2013) [26]	After initiating the Six Sigma project, there was a 60.5% reduction in data entry errors from 423 errors a month (i.e., 4.34 Six Sigma) in the first month to 166 errors/month (i.e., 4.65 Six Sigma) over 12 months. The team estimated the average cost of identifying and fixing a data entry error to be USD 16.25 per error. Thus, reducing errors by an average of 257 errors per month over one year has saved the laboratory USD 50,115. In addition, the project developed awareness among the laboratory staff about continuously improving their work processes.
Gijo, et al. (2013) [6]	Reduced patient waiting time in a pathology department of a super-speciality hospital attached to a manufacturing company.
Ulhassan, et al. (2013) [32]	Enhanced staff and resource utilisation; improved workflow for patient discharge process, enhanced communication, as well as better coordination.
Farrokhi, et al. (2015) [74]	Potential institutional annual cost savings of USD 2.8 million. Reduction in unnecessary instruments delivered to the operating room; reduced the number of instruments for minimally invasive spine surgery by 70%; setup time decreased by 37%.
DelliFraine, et al. (2013) [60]	Patient satisfaction and improved organisational performances.

Table 2. *Cont.*

Authors	Benefits (Real Benefit or Potential Benefits)
Chiarini, et al. (2013) [61]	Reduce costs related to patient transportation and other kinds of waste. The results have reduced the patient's average lead time from the emergency department to hospitalisation or discharge.
Dannapfel, et al. (2014) [27]	Improving staff experience and working environment, increasing job satisfaction and creating development time.
McIntosh, et al. (2014) [49]	Waste and cost reduction, increasing care quality and applying techniques to reduce turnaround time in critical services.
Hicks, et al. (2015) [62]	Improved patient flow, increased number of beds and toilets, reduced distance travelled, reduced process steps and accommodated the increase in demand.
Sanders and Karr (2015) [81]	Reduction of turnaround times for E.D. specimens. Indirect results: The project results included: a 50% decrease in vials used for testing, a 50% decrease in unused or extra specimens, a 90% decrease in E.D. specimens without orders, a 30% decrease in complete blood count analysis (CBCA) median turnaround time (TAT) a 50% decrease in CBCA TAT variation, a 10% decrease in troponin TAT variation, an 18.2% decrease in URPN TAT variation, and a 2–5-min decrease in E.D. registered nurses rainbow draw time.
Crema and Verbano (2015) [47]	Safety improvements.
Wang, et al. (2015) [82]	The patients' average waiting time was reduced from 78 to 38 min. The service level increased from 54.86 to 88.55%. Moreover, the number of nurses was reduced from nine to six.
Nayar, et al. (2016) [56]	Reduced clinic waiting time for veterans, reduced the time taken to fill non-VA prescriptions, reduced veterans' clinic visits for unnecessary/non-urgent non-VA prescriptions, improved veterans' satisfaction, improved provider satisfaction and improved compliance.
Jayasinha (2016) [48]	Improved discharge process efficiency, reduced number of steps in the process, less interruption for the physician, fewer order entry errors/corrections, and improved patient satisfaction.
Dobrzykowski, et al. (2016) [33]	Direct and positive impact on patient safety; it impacts financial performance through internal integration—improving operations (internal coordination; increased teamwork; knowledge management, waste reduction).
Deblois and Lepanto (2016) [36]	Health outcomes, processes, quality and economic aspects.
Moraros, et al. (2016) [83]	Patient flow and safety.
Jorma, et al. (2016) [84]	Cost reduction.
Roemeling, et al. (2017) [28]	Reduced direct waste (most projects) (preventive and proactive intervention).
Polanski, et al. (2018) [63]	Evidence-based therapeutic success rates in terms of quality of earnings.
Narayanamurthy, et al. (2018a) [31]	Appropriate delivery model, matching patient and organisational expectations, smoothed the flow of patients, medicines, information, equipment, etc.
Trakulsunti and Antony (2018) [3]	Patient safety, improved internal and external customer satisfaction, effective communication, improved team dynamics, enhanced employee morale and quantifiable cost savings.
Gonzalez-Aleu, et al. (2018) [11]	Achieved continuous improvement projects in hospitals.
Narayanamurthy, et al. (2018b) [71]	Improvement in total lead time, average value-added time, the total waiting time of a patient, the average turnaround time for reports, physical space usage, worker absenteeism, walking distances of staff, percentage of cases rescheduled due to late starts and number of reports with errors.
Isack, et al. (2018) [43]	Positive impact on operational performance, shortened turnaround time (TAT), employee motivation and cost reduction.
Honda, et al. (2018) [50]	Improved process performance, including waiting for time reduction and patient flow with the subsequent impact of increasing patient satisfaction. Reduced operating costs and inventories.

Table 2. *Cont.*

Authors	Benefits (Real Benefit or Potential Benefits)
Sánchez, et al. (2018) [85]	Significant reductions in process time of discharges, length of stay (389 vs. 329 min, $p < 0.001$), and waiting time (71 vs. 48 min, $p < 0.001$) were achieved after Lean implementation, improving workplace well-being.
Hallam and Contreras (2018) [64]	Lean tools resulted in reducing Ohno's seven wastes.
Bancroft, et al. (2018) [86]	Significant improvements in productivity, patient care and cost reduction.
Ahmed, et al. (2018) [40]	Patient safety, teamwork and quality performance of the hospitals are based on demographics such as gender, types of hospital and working experience.
Dobrzykowski and McFadden (2020) [87]	Increase the competitiveness of organisations.
Dobrzykowski and McFadden (2020) [87]	Trust between doctors and hospitals.
Dobrzykowski and McFadden (2020) [87]	Lean improved process integration, and process integration impacted on operational efficiency and patient satisfaction.
Regattieri, et al. (2018) [88]	Space optimisation (reduction of space dedicated to material stock); time reduction for the material handling process (check of inventory level, place in stock, picking and procurement); immediate reduction of the average material inventory level.
Hutton, et al. (2018) [89]	Standardisation in threat assessment and education of workplace violence streamlines and standardises processes to free up clinician time for other responsibilities, while simultaneously improving internal and external customer satisfaction.
Almutairi, et al. (2019) [90]	Patient safety, patient care, improved quality and reduced cost.
Peimbert-García, et al. (2019) [29]	Financial saving, increased productivity, a better quality of care, few errors and better patient safety.
Almutairi, et al. (2019) [90]	Improved supply chain framework.
Vaishnavi and Suresh (2020) [91]	Reduced the medical error, waiting time, delivery of medical reports, unnecessary medical cost and continuous improvement.
Vaishnavi and Suresh (2020b) [92]	Voice of customers; aligning project goals with organisation vision; management commitment; leadership, effective communication, supplier management, understanding tools and technique; effective use of technology; organisational strategy; organisational infrastructure; continuous performance measurement; employee commitment and trust; recognition and reward system; project selection; time and cost management.
Al-Hinai and Shamsuzzoha (2021) [93]	Improved the efficiency of the staff flow and storage management and reduced the noise level.
Ricciardi, et al. (2020b) [94]	Identified which antibiotic treatment influences the outcome of LOS.
Chang, et al. (2020) [95]	Reduced the total waiting time and reduced variations in the surgical room process. Reduced the average time from 22.8 min to 15.6 min, and increased the satisfaction level of surgical patients, surgeons and staff in the surgical room.
Souza, et al. (2020) [96]	Operational wastes can be identified.
Henrique, et al. (2021) [97]	Patient rescheduling rate, reduction of 50% in total inventory, reduction of 66% in medication delivery delays, reduction in general costs, increased billing rate, reduction in the stock of materials and medicines.
Rocha and Vasconcelos (2021) [98]	Reduction of time wasted in the patient's journey, increased employee productivity and efficiency in patient care during the work shift are considered.
Lee, et al. (2021) [99]	A strong multidimensional culture with more Lean and Six Sigma implementation in hospitals. Better patient safety and satisfaction level for better quality performance of U.S. hospitals.
Khorasani, et al. (2020) [100]	Supply chain management; leadership; top management involvement; and organisational culture.
Davies, et al. (2019) [101]	Significant improvements in service performance and patient and staff satisfaction. Significant added value includes a reduction in PTTs, an increase in nursing care time and an improvement in the nurse–patient ratio.

Table 2. *Cont.*

Authors	Benefits (Real Benefit or Potential Benefits)
Improta, et al. (2019) [102]	The average LOS was reduced from 10.66 to 7.8 days (−26.8%).
Meyer (2019) [103]	Process improvement, competency-based job posting.
Feibert, et al. (2019) [104]	Traceability, degree of automation, security of supply.
Kahm and Ingelsson P. (2019) [65]	Decreased dissatisfaction at work, stress and poor or insufficient health.
Ryan, et al. (2019) [66]	Reduced the number of unscheduled attendances to the clinic, safer, more timely responses to cardiac events and enhanced care quality.
Walley, et al. (2019) [30]	Reduced the pressure on other health services, acted promptly and increased patient safety.
Al-Zain, et al. (2019) [105]	Reduction in waiting time. A cost–benefit analysis estimated the present project value at USD 656,459, leading to USD 5,820,319 in savings by 2025.
Isfahani, et al. (2019) [106]	The rate of providing care and services at the right time significantly increased, intervals between the reception and getting the service were also significantly reduced, and patients' length of stay in all studies was considerably reduced.
Slade, et al. (2020) [68]	Zero cases of delays, reduction of variability in standard work.
Leite, et al. (2021) [70]	Potential to reduce mental stress during the pandemic.
Ricciardi, et al. (2020a) [4]	The corrective action consisted of applying fast-track surgery and improving the care process's effectiveness and efficiency.
Lima, et al. (2021) [21]	Time gains, reduction of lead time, reduction of patient waiting time, improvement of cycle time, improvement of hospitalisation time, reduction of waiting lists, reduction of errors, identification and reduction of waste, reduction of stocks, reorganisation of physical space and reduction of costs, improved organisational culture, increased team spirit and communication, employee and supplier satisfaction, improved workload for nurses and reduced overtime, efficiency and productivity gains, bottleneck identification, improved patient and information flow, capacity levelling, positive impact on quality and safety indicators, reduced number of complaints, increased customer satisfaction (patient).
Eamranond, et al. (2020) [69]	Decreased severe safety events (SSEs), with a lower observed to the expected length of stay (O/E LOS).
Trakulsunti, et al. (2021) [3]	Customised LSS tool kit for reducing medication errors.
Vaishnavi and Suresh (2020) [91]	Eliminated waste during the process and ensured quick delivery of service.
Trakulsunti, et al. (2020) [3]	Reduction of errors in the medication process, such as missing medication, expired medication errors and order entry errors; reduced the estimated labour cost of USD 550,000 in a mid-sized hospital; can save the hospital inpatient pharmacy USD 82,650 annually by reducing the number of errors and missing doses; improved staff working performance.
McDermott, et al. (2021) [2]	Minimised WIP, overproduction, medical error, and cycle time, effectively utilised the employee's abilities through up-skilling and reskilling activities; minimised length-of-stay, quicker bed assignment and lab results.
Ramori, et al. (2021) [35]	A Lean change transfers knowledge and creates a learning organisation. Reduced waste and costs, and improved customer (patient) satisfaction.
Walley, et al. (2019) [30]	Waste audit; and understanding tools and techniques.
Al-Hinai and Shamsuzzoha (2021) [93]	Working environment; H.R. management, supply chain management; and sustainment plans
Bhat, et al. (2020) [1]	Effective leadership; availability of data; involvement of cross-functional team; effective communication.
Chang, et al. (2020) [95]	Training; technology application; quality of service; and understanding process.
Eamranond, et al. (2020) [69]	Quality improvement culture; strong leadership team; training; stakeholders' involvement; organisational stability; deployment strategy; metric of measurement; and reward systems.

Table 2. *Cont.*

Authors	Benefits (Real Benefit or Potential Benefits)
Gao, et al. (2020) [23]	Strong leadership; training, time management, and teamwork.
Henrique, et al. (2021) [97]	Audit process; competition programs; work standards; A3 method; KPIs; Kaizen event; visual management; Gemba walks; Value stream Mapping (VSM); structured approach; deployment strategy; training; follow-up; effective communication; continuous improvement culture; data-based decisions; aligning project goals with strategic objectives; risk analysis and piloting; information; involvement of physicians; top management involvement; involvement of health professionals; I.T. support; dedicated implementation team; and effective leadership.
Leite, et al. (2021) [70]	Clear communication; careful planning; visual management; standard operating procedures; and use of technology.
Ricciardi, et al. (2020a) [4]	Multidisciplinary team
Slade, et al. (2020) [68]	Organisational culture; leadership; teamwork; staff involvement; effective communication; and H.R. policies.
Swarnakar, et al. (2021) [24]	Awareness of statutory policy; comprehensive information; qualified team for deployment; training; multidisciplinary team; and understanding of tools and techniques.
Trakulsunti, et al. (2021) [3]	Improvement culture; structured deployment plan; sustainability plan; top management commitment; project selection; team formation; and training.
Trakulsunti, et al. (2020) [3]	Understanding tools and techniques; understanding Lean philosophy; top management support; training; staff engagement; leadership capability; appropriate team formation; implementation infrastructure; and cultural change.
Vaishnavi and Suresh (2020a) [91]	Information about methodology; trust among employees; quality improvement culture; acceptance of change; organisational structure, availability of resources; employee empowerment; employee spirit and cooperation; working environment; and waste audit.
Lee, et al. (2021) [99]	Multidimensional cultural orientations; patient involvement; and a structured approach.
McDermott, et al. (2021) [2]	Robust data; use of technology; supply chain optimisation; I.T. support systems; statistical process control techniques; risk management; and workplace management.
Ramori, et al. (2021) [35]	Business strategy; organisational design and structure; quality culture; understanding entire value stream; trust; mindfulness; needfulness; respectful, interaction, diverse team; social and task relatedness; effective communication; data availability; and leadership.

4. Discussion

The extent of the growth of literature in the area of Lean, Six Sigma and LSS in healthcare in recent years has demonstrated the spread and use of these methodologies within the healthcare system. Since the early 2000s, LSS has been increasingly deployed in healthcare, and has been demonstrated to have many benefits in the sector; additionally, there are increasing motivations to deploy LSS in the sector (RQ1). As the aims of any healthcare organisation are ultimate patient treatment and safety, LSS can offer many enhancements to healthcare quality [3].

There are many motivating factors for implementing LSS methods within the healthcare system (RQ1). Reducing medication errors is one such driver of LSS implementation. The danger to patient lives and potential illnesses and harm caused by such errors is a critical issue internationally regarding the human impact and the economic implications [107]. However, the literature shows that there can be differences in the overall healthcare organisational motivations for deploying LSS between public and private providers [40]. While many of the motivations for deploying LSS are common to private and public healthcare organisations, there are differences. For example, the motivations for private organisations to adopt Lean, Six Sigma and LSS are to increase their competitiveness by acting on cost

and profitability elements. On the other hand, public providers are more motivated by the need to respond to the challenges related to the treatment at hand and reduce national expenditure on healthcare. Safety, however, as a theme—i.e., the safety of patients, ensuring safe treatments, and preventing harm or illnesses—was mentioned in the LSS in healthcare literature as an overarching motivator compared to research on motivators for LSS in other sectors.

Implementing LSS in healthcare improved operational and financial performance, improved customer satisfaction and service quality, reduced patient waiting times, reduced medical and prescription errors, and minimised turnaround times (RQ2). Safety was a recurring theme in the literature related to LSS benefits in healthcare. The safety theme was cited in all the literature as a benefit for healthcare.

5. Conclusions

Lean Six Sigma (LSS) is a proven OPEX methodology in the manufacturing and service sectors, and healthcare is not an exception. Increasing applications of LSS within healthcare have helped to provide comprehensive insights on the essential deliverables of LSS in healthcare, which has paved the way for its further use in other areas of the healthcare sector. By reviewing the LSS literature, this study answered the research questions raised at the beginning of this paper.

The initial analysis in this study classified the literature across variants, namely year, journals, and the number of authors (RQ1). To answer RQ2 and RQ3, the motivations and benefits for LSS deployment in healthcare were presented and evaluated.

This study will help healthcare professionals to understand the many benefits of LSS methodology in improving operational efficiency and driving positive patient, staff and safety outcomes. The studies cited demonstrate the broad application of LSS tools and the types of LSS projects deployed across different health care treatments and processes. This study could also serve as a resource for researchers as it provides directions for future research. This paper is the first paper of an extensive study on LSS in healthcare. The authors are conducting further research into the readiness factors, challenges and critical failure factors for Lean Six Sigma in healthcare. The future research opportunities are that, having understood the motivation and benefits for LSS in healthcare, healthcare organisations must next understand the readiness factors and challenges to implementing LSS, and thus prepare accordingly to avoid the critical failure factors for LSS.

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