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# Lean Six Sigma in Healthcare: A Systematic Literature Review on Challenges, Organisational Readiness and Critical Success Factors

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**Abstract:** Lean Six Sigma (LSS) has been applied in many healthcare organisations, but there has been limited research on the evolution of LSS application in healthcare. This paper aims to present the challenges, critical success factors (CSFs), readiness factors and most common tools and techniques used for LSS deployment in healthcare. A systematic literature review (SLR) was utilised to research the study objectives. Peer-reviewed literature over a 16-year period was studied to understand the deliverables of LSS. The SLR process identified relevant articles and screened a final selection for those under study. The systematic literature review helped the authors to identify the challenges and tools/techniques used for LSS in healthcare. Several CSFs and readiness factors for LSS deployment in healthcare are also presented. This work informs healthcare managers and professionals on the important factors for successful LSS deployment before embarking on the LSS journey. In addition, this work is a valuable resource for healthcare LSS practitioners and academic researchers to learn about, investigate and deploy LSS in the healthcare sector. This study is one of the most comprehensive SLRs covering the importance and specificity of understanding challenges, CSFs and organisational readiness for LSS in healthcare. This study provides knowledge of the successful deployment of LSS in healthcare.

**Keywords:** lean; Six Sigma; healthcare; systematic literature review; challenges; critical success factors; organisational readiness; tools



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## 1. Introduction

Healthcare services have been under increased pressure in recent years with ageing populations, longer life spans and recent pandemics [1]. Increasing competitiveness within the healthcare sector has driven a focus on improved operational efficiencies [2]. Customer or patient expectations for improved quality healthcare services have driven the demand for continuously improving processes and a focus on Operational Excellence (OPEX) methodologies [1].

Six Sigma (SS) is a continuous improvement methodology which has been shown to have many benefits in healthcare in increasing patient capacity, reducing prescription errors, non-value administration, reducing waiting times for patients [2,3] and improving customer experience [4]. Six Sigma problem-solving techniques include data collection, Pareto analysis, cause and effect diagram, and process maps to aid in understanding healthcare processes and identifying root causes and the potential for variation [5]. On the other hand, Lean focuses on eliminating waste in the process and improving flow [6].

In 2002, George [7] proposed the integration of Lean and Six Sigma to improve business processes: Six Sigma can focus on process variation reduction, while Lean focuses on reducing waste, meaning that the two complement each other [8].

There are many critical success factors for deploying LSS, including leadership commitment, the alignment of LSS with strategy, allocating people to work on projects and providing adequate training and motivation [2,9]. 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, there is a mixture of professionals from differing backgrounds in healthcare, which has lent itself to the belief that some manufacturing industry practices are incompatible with healthcare environments [10,11]. Many critical failure factors (CFFs) and readiness factors have been highlighted for LSS in organisations identified as typical in healthcare. These include the lack of management commitment, lack of employee empowerment, poor access to training, poor organisational culture and lack of alignment with strategy [12].

One of the significant challenges facing LSS in healthcare is the complexity of healthcare system delivery with publicly government-funded and privately funded healthcare. Quality improvement methods can take longer to implement in the healthcare sector [2,11]; administrative procedures and cultural norms can constrain healthcare professionals from embracing quality [13]; the ever-changing nature of the clinical environment and variability in treatments and practices can restrict improvement initiatives [14]; and the complexity and diversity of the healthcare system can lead to different approaches and practices in methodology deployment. Thus, a comprehensive understanding of LSS challenges and organisational readiness is essential to deploy LSS and reduce failures.

A previous study by the authors of this paper McDermott et al. [14] researched the benefits and motivations for LSS in Healthcare. This study is the second part of that research on LSS in Healthcare. Thus, research questions (RQs) are formulated to understand how to deliver LSS in terms of the challenges, readiness, critical success factors and tools used.

***RQ1:*** *What are the challenges/limitations in deploying LSS in the healthcare sector, as noted in the literature?*
***RQ2:*** *What are the organisational readiness factors for deploying LSS in healthcare?*
***RQ3:*** *What are the critical success factors (CSFs) for LSS to succeed in healthcare?*
***RQ4:*** *What are the key LSS tools utilised in healthcare?*

The article is articulated in a structured manner. First, Section 2 provides the research methodology followed in the study. Then, the 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 [12], SLR is the selection of articles searched from different databases and sources and has been utilised by many researchers in Lean Six Sigma and other fields [5,13,14]. 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 [15,16]. The researchers systematically searched for articles relating to the subject matter published between 2005 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 literature search, extraction and synthesis are 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 all the databases mentioned above were as follows: “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.

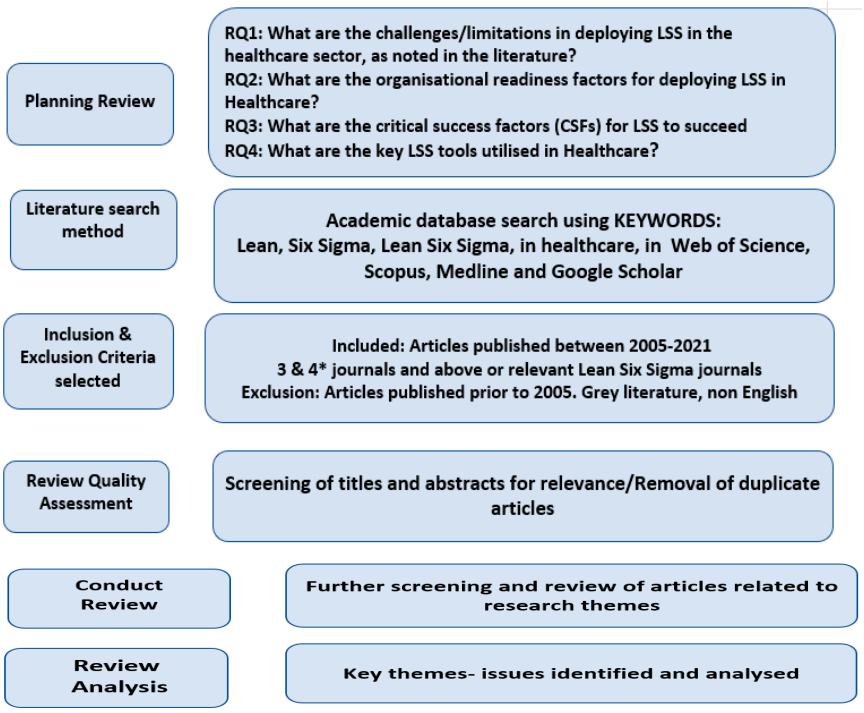


**Figure 1.** SLR research methodology flow chart with inclusion and exclusion criteria (* indicates star).

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 [19]. Upon review, an article was retained if it was 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 [20,21]. When reviewing the articles, discussions among the authors were carried out to gain consensus [22]. Studies published in peer-reviewed journals and the 3 or 4 categories in the ABS journal ranking [23] were included. At this review stage, 220 studies were yielded for final inclusion.

The management of data collation involved using 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 the errors [20]. A further analysis was conducted based on the research sub-themes 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 integration [17]. The findings were summarised by reviewing patterns of the publications and any emerging themes.

## 3. Results

The literature demonstrated that LSS in HC studies first appeared around 2003 as a theme, with a considerable rise in publications since 2017. As LSS in HC was a nascent area in the early 2000s, the SLR studies the period of 2011–2021.

### 3.1. Readiness Factors

Readiness factors encompass all organisational practices or structural features that facilitate transformation, by reducing or eliminating potential inhibitors to successfully implement continuous improvement paradigms [24,25]. Many articles have emphasised the prominent role of readiness factors in implementing continuous improvement paradigms. In particular, they have shown that the presence, assessment and activation of these factors is a critical prerequisite for the successful implementation of continuous improvement projects at the micro-level and the dissemination of continuous improvement culture in organisations at the macro-level [2,26]. Moreover, it is very interesting to note that for many of the readiness factors, most researchers recognise their absence as a challenge and a barrier to the implementation of Lean, SS, and LSS [27,28]. Many authors have tried to classify and describe readiness factors to better clarify their nature and offer insights into them. For instance, Vaishnavi and Suresh [24] provided a classification based on five macro enablers, 16 factors and 48 criteria attributes through a literature review focused on these factors. The five macro enablers represent the organisational level in which the 16 factors are distributed, while the 48 attributes explain the factors providing a detailed characterisation. Ajmera and Jain [29], through a survey in which 325 healthcare professionals participated, identified several reliability factors and classified them into autonomous and dependent. Autonomous factors are less influenced by organisational decisions but impose strict LSS implementation and decision-making constraints [29].

The autonomous factors are financial capability, patient involvement and time constraint for Lean implementation [24]. In contrast, dependent factors are Lean leadership, professional organisational culture, goal specificity, clarity of organisational vision, competency and expertise, Lean training and employee engagement [24,29]. The factors found and discussed by Ajmera and Jain [29] are all listed in the sixteen factors classified by Vaishnavi and Suresh [24].

Authors such as Ajmera and Jain [29] have identified reliability factors related to micro implementation (introduction phase, pilots, individual projects) and factors related to macro implementation (process integration, model dissemination in the organisation). While leadership and management commitment are crucial during micro and macro implementation [1,4], other factors take on different relevance in the two phases. While the main readiness factors related to implementation at the macro level are effectively a redistribution of time for hospital employees, cross-fertilisation, employee commitment and motivation, long-term plans for successful process improvements and project management skills, the factors related to micro-level implementation are statistical and non-statistical Lean tools knowledge, training and coaching activities, and teamwork management. Thus, the effective definition of implementation strategies requires the assessment of readiness factors.

Building on the work of Vaishnavi and Suresh [24] and utilising their same classification of macro factors, we reported the reliability factors that emerged from the literature in Table 1. The macro enablers are management, organisational, employee, LSS implementation and external environment management [27,28].

The reliability factors of the first macro enabler are top management commitment, effective leadership and effective communication. Top management commitment is critical because it provides the organisation with a meaningful understanding of the importance of initiatives and allows for the rapid elimination of organisational barriers during implementation [28,29]. In addition, management commitment positively impacts staff motivation and trust in the methodologies [1,6,30,31].

The importance of leadership is also extensively debated [32,33]. Some authors attempt to best characterise leadership by highlighting the importance of transformational and transactional perspectives, which are important in increasing staff motivation and engagement [34,35]. Horizontal and vertical communication is critical, as it enables the organisation to coordinate continuous improvement efforts and align operational goals with strategic objectives [36–38].

In addition, communication is a key factor in activating bottom-up decision making and better managing the decentralisation of decision making [37,38]. At the organisational level, six factors emerge [29]. They are improvement-oriented organisational strategy; decentralised decision-making approach; continuous change-oriented organisational culture; maturity in process improvement paradigms; and the organisational structure supporting multidisciplinary teamwork, infrastructure and resources [29,30,32].

Organisational strategy drives behaviours, and it is observed that where it is improvement-oriented, the entire organisation is more predisposed to change challenges [37–39]. The decentralisation of decision making allows the organisation to drive improvement projects quickly and based on the real needs felt by process owners, avoiding conflict with management [8,40]. In addition, the firm's decision-making autonomy is key in empowering staff and absorbing internal dynamics. In many cases, it also stimulates staff motivation and commitment [2,41].

Among the most commonly discussed topics is organisational culture [24]. It refers to the social and organisational dimensions that determine, along with motivations, how employees respond to change-making challenges. Change-oriented organisational culture means a shared vision of consistently challenging the status quo to explore organisational and operational improvement [30,42]. Organisational culture is also linked to employees' willingness to undertake greater efforts to create value for themselves and the organisation. This reflexively streamlines and encourages the development of new skills [40,43,44].

Organisational maturity in managing process improvement activities is an enabling factor, since having already trained staff requires less organisational effort to train, involve and overcome the mistrust of staff and managers [26,33]. This is true in cases where previous projects have led to positive results and, above all, been perceived as positive experiences by management and employees [26].

The horizontal organisation that allows functional silos to be overcome and facilitates interdepartmental teams creates projects that are more easily targeted for process improvement [24,41]. Lean, Six Sigma and LSS improvement paradigms require improvement projects conducted by multidisciplinary teams. A strong enabling factor is teamwork management skills [29]. Employee-level factors emphasise the critical role of trained, motivated and engaged employees in adopting organisational changing paradigms. In addition, some authors discuss the importance of employee dynamic capability and employee trust in the methodologies [24,45,46].

Most case studies show that these factors are closely related to organisational culture and human resource management strategy [24]. LSS implementation level factors refer to organisational maturity in using LSS tools and, more importantly, the organisation's project management capabilities [47]. Some authors emphasise designing the best Lean and Lean Six Sigma implementation strategies. It is essential to assess the degree of tool and paradigm employee expertise and the maturity of the management in managing time and resources [47,48]. Finally, external environmental readiness factors relate to supplier and partner network management, a customer-focused approach, and the effective use of technology [24,34].

The analysis shows that the most discussed readiness factors in the literature are management commitment [30], effective change-oriented leadership, employee commitment [49], training [26], teamwork [44], organisational emphasis on patient value, and organisational culture promoting continuous change [38,50]. The less-discussed factors—but no less impactful on the success of the implementation—are employee motivation and dynamic skills [49], knowledge and project management skills [38], financial resources, data availability, decentralised decision-making approach, time, and work management [1,2,8,30].

**Table 1.** Readiness factors for LSS in healthcare.

| Authors | Readiness Factors |
| --- | --- |
| Bhat et al. [2] | Effective leadership; statistical and non-statistical Lean tools knowledge; knowledge management (manage lessons learned, maturity); management of multidisciplinary teams; physicians and nurses' specialised training. |
| Trakulsunti and Antony [4] | Transformational style of leadership. |
| Vaishnavi and Suresh [24] | Management commitment and leadership; effective communication; customer-oriented; financial capabilities; supplier management; LSS tools and technique; coordinate improvement procedure; teamwork and execution technique; training and learning; effective use of technology; organisational strategy; accessibility of information; goal management culture; organisation infrastructure; employee trust and culture; recognition and reward system. |
| Hilton et al. [26] | Transformational leadership; employee commitment; training and coaching activities; maturity in quality initiatives; and effective management of multidisciplinary teams. |
| Ajmera and Jain [29] | Financial capability; patient involvement; time constraint; leadership; professional organisational culture; goal specificity; clarity of organisational vision; competency and expertise; training; and employee engagement. |
| Bowerman et al. [30] | Effective leadership and organisational culture. |
| Feng and Manuel [31] | Management commitment. |
| De Lima et al. [34] | Top management's vision should add value to the patient and embrace employee motivation. |
| Kahm and Ingelsson [32] | Managers must have time, support from the entire organisation, and clear and disseminated goals. |
| De Lima et al. [34] | Top management's vision should add value to the patient and embrace employee motivation. |
| Roemeling et al. [33] | Management motivation; alignment between strategy and operational goals; clear and effective communication within the organisation; implementation and dissemination strategy based on organisational maturity; and staff participation and widespread consensus. |
| Roemeling et al. [33] | Maturity in continuous improvement tools; and previous experience in process re-engineering projects. |
| Meyer [35] | Transformational style of leadership; pervasive communication across all organisational levels; widespread knowledge of project management; and training in data analysis and applied performance improvement methods. |
| Ahmed et al. [36] | Effective leadership; training programmes and continuing education; employee suggestion and feedback to improve their Lean implementation skills. |
| Ahmed et al. [36] | Good perception of LSS process improvement tools; trust in structural approach to managing quality improvement activities and planning to decide the major quality improvement projects; employees dedicated and motivated to improve the hospital's quality performance. |
| Ahmed et al. [36] | Transformational leadership; Lean implementation has to be aligned to organisational strategy; maturity in project management activities; and investment in ongoing training. |
| Hallam and Contreras [37] | Knowledge symmetry; clear communication; and multidisciplinary team management. |
| Holden and Hackbart [38] | Widespread consensus in the organisation; teamwork skills and coaching activities; and widespread and clear communication. |
| Dannapfel et al. [39] | Transformational style of leadership; LSS training; Lean dissemination strategies and organisational culture; and spreading positive results achieved in other departments. |
| Deblois and Lepanto [40] | Changes in the culture of a healthcare setting involving long-term organisational policies and strategic planning; implementation of multidisciplinary and multiskilled teams with decentralised decision making; clinical leaders and managers' commitment as well as the front-line commitment; recognition of a need for change; and implementation of a quality culture fostering continuous improvement. |
| Honda et al. [41] | Organisation structure and political hierarchy; infrastructure of the hospitals; multidisciplinary team approach coupled with Six Sigma training. |
| Niemeijer et al. [42] | Effective leadership; management commitment; project management skills; and change-oriented organisational culture. |
| McIntosh et al. [43] | Effective leadership; organisational culture; and training. |
| Ulhassan et al. [44] | Effective leadership and management commitment; continuous improvement of organisational culture; and teamwork. |
| Leite et al. [45] | Transformational leadership; staff motivational element (i.e., feeling of working in a constant emergency); and widespread consensus in the organisation. |
| Swarnakar et al. [46] | Top management participation; manager sponsorship and commitment; staff motivation; multidisciplinary team management; and social and organisational approval factors. |
| Abdallah [47] | Transformational leadership; project management skills; introduction strategy; employees' general understanding; empowering the Lean implementation team; and quality and learning culture |

**Table 1.** *Cont.*

| Authors | Readiness Factors |
| --- | --- |
| Hung et al. [48] | Leadership commitment; sensitivity to professional values and the culture of medicine; and perceived adequacy of organisational resources to fully support the change efforts. |
| Gowen et al. [49] | Employee commitment. |
| Robbins et al. [50] | High-performance work systems (engaging staff, aligning leaders, acquiring and developing talent, and empowering the front line). |
| Steed [51] | Shared reason to change; effective leadership determined by personal characteristics; behaviours and actions, and knowledge; and defining the key leadership strategy to successfully implement LSS in a hospital environment. |
| Dobrzykowski et al. [52] | Top-level management support; transformational leadership; staff dynamic capability; and comprehensive Lean orientation. |
| Walley et al. [53] | Organisation's orientation to patient values. |
| Peimbert-García [54] | Management support; staff commitment; customer focus; training; continuous improvement vision; cultural readiness; data; external support; and communication. |
| Dobrzykowski and McFadden [55] | Trust and physicians' commitment; and staff directly employed by the organisation. |
| Eamranond et al. [56] | Effective redistribution of time for hospital staff; cross-fertilisation; employees' commitment; long-term plans for successful process improvements; mutual commitment of managerial and clinical leaders; effective leadership; continuous improvement culture. |
| Henrique et al. [57] | Effective communication; managerial support; employee commitment; and organisational culture. |
| Henrique et al. [57] | Top management involvement; involvement of health professionals; IT support; dedicated implementation team; and effective leadership. |
| Khorasani et al. [58] | Importance of Lean in supply chain management in Healthcare |
| Hutton et al. [59] | Workplace violence prevention using Lean principles |
| Isack et al. [60] | Adoption of Lean principles in a medical lab; improved efficiencies |
| Narayanamurthy et al. [61] | Transformational leadership; staff commitment; staff have a comprehensive understanding of processes and operational and economic performance. |

### *3.2. Critical Success Factors (CSFs)*

CSFs are the stepping-stones to achieving organisational goals to enjoy a competitive advantage [2]. Therefore, organisations should pay attention to CSFs. They are not only facilitators (when they have a positive impact and enhance the implementation process), but also inhibitors (when they present as barriers to successful implementation) [5]. The summary of CSFs for the LSS in healthcare programmes from the academic literature is shown in Table 2. The literature shows that leadership and teamwork are prominent CSFs in deploying Lean in healthcare. Healthcare leadership is not only associated with charisma and inspiration at the highest levels, but also with safety culture. Teamwork in healthcare consists of information sharing, quality programme meetings, employee recognition and results sharing. In addition, empowerment plays a critical role in deploying improvement initiatives, which are in turn associated with job satisfaction, productivity, effectiveness and a lower propensity to leave [2,42,56].

The unique CSFs of LSS in healthcare compared to the manufacturing and service sector are the involvement and commitment of physicians [40,56], workload management and cross-functional collaboration [2,5]. It is reported that the involvement of physicians is critical, as improvement projects directly impact patient care and related treatments. Including physicians and medical interns ensures sustainable solutions to the problems and enhanced communication between the departments [13]. The involvement of physicians helps to overcome the typic healthcare perception of LSS that "It did not evolve here, thus not for us" [5].

Since the healthcare sector operates around the clock under dynamic pressure and stress to ensure quality treatment at an affordable cost, medical professionals cannot devote quality time to LSS projects. Heavy workload keeps employees and managers busy and away from their projects. In addition, shifts in the working system create challenges in establishing and executing multidisciplinary teams for operations excellence initiatives.

Thus, it is essential to strike a proper balance between workload, shifts and LSS projects among the medical personnel [56]. Moreover, it is observed that healthcare sectors have limited research collaboration with engineering, management and other institutions that practice and promote OPEX methodology for service quality improvement.

Most internal improvement projects are based on brainstorming in healthcare sectors, and inferences are drawn based on a limited structured scientific approach. However, it is observed that the cross-functional collaboration of healthcare professionals with LSS practitioners, academicians, and engineering and management institutions has helped to mentor and train the stakeholder for improvement initiatives. This has yielded substantial results with an optimal utilisation of resources [2,5].

Based on the review, CSFs can be classified as "Top Management", "Middle Management" and "Operational" for better LSS deployment in healthcare [2,8]. The CSFs such as top management leadership, involvement and support; follow-up; alignment with the organisation's vision and mission; culture, success celebration, benchmarking and best practice sharing; and empowerment, are essential at the top management level. However, at the middle management level, it is essential to pay attention to the CSFs such as teamwork; training and development; training manuals; project selection and prioritisation; metric of measurement; deployment strategies; team formation; cross-functional collaboration; the usage of tools and techniques; the involvement of process stakeholders; knowledge management; the voice of the internal and external customer; IT support; and effective communication. In addition, project management; multidisciplinary team; robust and reliable data; sustainment strategy; cross-functional team; quantifiable objectives; individual team member deliverables; and continual improvement strategy can be considered at the operational level [2,8,45].

**Table 2.** CSF's of LSS in Healthcare.

| Authors | CSFs |
| --- | --- |
| McDermott et al. [1] | Robust data; use of technology; supply chain optimisation; IT support systems; statistical process control techniques; risk management; and workplace management. |
| Bhat et al. [2] | Effective leadership; availability of data; involvement of cross-functional team; effective communication. |
| Ricciardi et al. [3] | Multidisciplinary team. |
| Trakulsunti et al. [4] | Improvement culture; structured deployment plan; sustainability plan; top management commitment; project selection; team formation; and training. |
| Trakulsunti et al. [4] | Understanding tools and techniques; understanding Lean philosophy; top management support; training; staff engagement; leadership capability; appropriate team formation; implementation infrastructure; and cultural change. |
| Trakulsunti and Antony [4] | Clear vision and support from top management; quality improvement culture; and adoption of information technology. |
| Gijo et al. [5] | Effective utilisation of statistical tools and techniques; project management; and cross-functional team. |
| Gonzalez-Aleu et al. [10] | Management support; goal clarity and alignment; commitment to change; team member time management; communication; and availability and reliable data. |
| Burgess and Radnor [19] | Leadership; management commitment; motivational strategies; system maturity; trust; knowledge management; training, Lean project results; project management; organisational culture; training; coaching; team management; and bottom-up approach. |
| Vaishnavi and Suresh [24] | 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. |
| Vaishnavi and Suresh [24] | Voice of customers; aligning project goals with organisation vision; management commitment; leadership; effective communication; supplier management; understanding tools and technique; effective use of technology; organizational strategy; organisational infrastructure; continuous performance measurement; employee commitment and trust; recognition and reward system; project selection; time and cost management. |

**Table 2.** *Cont.*

| Authors | CSFs |
| --- | --- |
| Hilton et al. [26] | Training; top management commitment; multidisciplinary team; maturity in the process; improvement initiatives; and project management. |
| Ajmera and Jain [29] | Lean leadership; professional organisational culture; teamwork; and interdepartmental cooperation. |
| Bowerman et al. [30] | Commitment and support from top management; infrastructure; training; effective communication; and effective leadership. |
| Feng and Manuel [31] | Top management leadership. |
| Kahm and Ingelsson [32] | Employee involvement; improvement culture; supportive and participative executive management; and effective communication. |
| Roemeling et al. [33] | Knowledge management; rigorous follow-up; and waste audit. |
| Roemeling et al. [33] | Employees' involvement in sustainment; standardisation; and maturity in methodology. |
| Meyer [35] | Stakeholder engagement; project management; action plans; effective communications; improvement culture; policy and procedures; and accreditation. |
| Ahmed et al. [36] | Continuous quality improvement; operational excellence initiatives; patient safety; and teamwork. |
| Hallam and Contreras [37] | Establishing clear definitions of Lean healthcare; implementing control plans; training; stakeholder involvement and support; multidisciplinary teams; concurrent involvement by all departments; executive commitment; and clear vision. |
| Holden and Hackbart [38] | Work standardisation; connections between people; seamless flow; problem solving; acceptance of new standard work; and teams in one work cell. |
| Dannapfel et al. [39] | Understanding adopter's perspective; effective communications; clear vision and objectives; patient participation; and multiple communication channels. |
| Deblois and Lepanto [40] | Empowerment of the front-line workers; continuous improvement; and leadership. |
| Honda et al. [41] | Multidisciplinary team approach; training; presence of an internal project leader and internal project champion; senior leadership involvement as champions; availability of Black Belts and Green Belts in the system; commitment from clinical management and steering committees; involving co-workers and physicians; and continuous communication. |
| Niemeijer et al. [42] | Training for doctors, nurses and support staff; and leadership. |
| Niemeijer et al. [42] | Project management skills; matrix organisational structure; staff and management commitment; directorate sponsorship; successful pilot projects; and continuous training. |
| McIntosh et al. [43] | Leadership; empowerment; teamwork; information sharing; quality programme meetings; employee recognition; results sharing; training, financial rewards, promotion opportunity; and learning ecosystem. |
| Leite et al. [45] | Clear communication; careful planning; visual management; standard operating procedures; and use of technology. |
| Swarnakar et al. [46] | Awareness of statutory policy; comprehensive information; qualified team for deployment; training; multidisciplinary team; and understanding of tools and techniques. |
| Abdallah [47] | Leadership; top management involvement and continuous support; prioritising quality initiative; training and education; empowerment; understanding of tools and techniques; teamwork; and quality and learning culture. |
| Hung et al. [48] | Front-line engagement; visual management; metric of measurement; professional values and culture; culture of innovation, collaboration, creativity; continuous improvement; organisational resources; training; and follow-up. |
| Gowen et al. [49] | Employee commitment; control initiatives; training; communication; performance evaluation; job redesign; and empowerment. |
| Robbins et al. [50] | Rigorous evaluation of improvement strategies in the context. |
| Dobrzykowski et al. [52] | Internal integration; clinical coordination and communication; comprehensive understanding of methodology; waste elimination; and voice of the customer. |
| Walley et al. [53] | Waste audit; and understanding tools and techniques. |
| Peimbert-García et al. [54] | Employee and management commitment. |
| Dobrzykowski and McFadden [55] | Trust between doctors and hospitals. |
| Eamranond et al. [56] | Quality improvement culture; strong leadership team; training; stakeholders' involvement; organisational stability; deployment strategy; metric of measurement; and reward systems. |

**Table 2.** *Cont.*

| Authors | CSFs |
| --- | --- |
| Henrique et al. [57] | Audit process; competition programs; work standards; A3 method; KPIs; Kaizen event; visual management; Gemba walks; 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; IT support; dedicated implementation team; and effective leadership. |
| Khorasani et al. [58] | Supply chain management; leadership; top management involvement; and organisational culture. |
| Hutton et al. [59] | Top management support; availability of data; voice of the customer; technology; human availability; and education. |
| Isack et al. [60] | Top management involvement; adequate training and proper planning; learning organisation; effective change management; internal and external customer satisfaction; and dissemination of Lean thinking culture in the organisation. |
| Narayanamurthy et al. [61] | A well-defined framework; dedicated team; training and education; value stream analysis; waste audit; and rigorous follow-up. |
| Polanski et al. [62] | Continuous improvement; and process optimisation. |
| McGrath et al. [63] | Involvement of patient and all relevant stakeholders; and sustainment strategies. |
| Ryan et al. [64] | Teamwork; and involvement of patients. |
| Al-Hinai and Shamsuzzoha [65] | Working environment; HR management, supply chain management; and sustainment plans. |
| Chang et al. [66] | Training; technology application; quality of service; and understanding process. |
| Gao et al. [67] | Strong leadership, training, time management, and teamwork. |
| Slade et al. [68] | Organisational culture; leadership; teamwork; staff involvement; effective communication; and HR policies. |
| Hundal et al. [69] | VSM, data analytics; and FMEA. |
| Lee et al. [70] | Multidimensional cultural orientations; patient involvement; and a structured approach. |
| Ramori et al. [71] | 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. |
| Taner et al. [72] | Lack of respect among the employees working in the sector; lack of teamwork; and lack of education (awareness of the methodology and the application of Lean tools). High workload and operational improvement are not a priority. |
| Laureani et al. [73] | Top management support; commitment of staff; regular communication with stakeholders; involvement of physicians; and clear project objectives. |
| Taner [74] | Education and training; organisational commitment; and tracking and reporting. |
| Taner et al. [74] | Extensive training of professionals; specialised training; and qualified professionals. |
| Ker et al. [75] | Use of digital technology; design of prescription system and workflow; and managing waste in the workflow. |
| Lorden et al. [76] | Communication; leadership; and workload. |
| Hicks et al. [77] | Engagement with stakeholders; and simulation. |
| Sanders and Karr [78] | Manager commitment; physician leadership; staff commitment; motivation; and training. |
| Chiarini and Baccarani [79] | Top management commitment; and investment and infrastructure. |
| Jayasinha [80] | Better communications; stakeholder engagement; and waste audit. |
| Jorma et al. [81] | Robust data; management and employee commitment; resource allocation; workload management; training; and communication. |
| Matthias and Brown [82] | Structured approach; cultural transformation; and deployment strategies. |
| Nayar et al. [83] | Innovative culture; education; redesign the process; and outreach to community providers. |
| Doğan and Unutulmaz [84] | Standardisation of operations; learning organisation; and training. |
| Ramadan et al. [85] | Top management support; people involvement; operational awareness; improvement culture; quality focus; and accreditation. |
| Barnabè and Giorgino [86] | A systemic approach to knowledge sharing; group decision making; and policy deployment strategies. |
| Kuwaiti and Subbarayalu [87] | Understanding of tools and techniques. |
| Nabelsi and Gagnon [88] | Managing the supply chain; project management; simulation and piloting; structured risk analysis; and measurable performance metrics. |

**Table 2.** *Cont.*

| Authors | CSFs |
| --- | --- |
| Stelson et al. [89] | Managerial decisions; communication; and project management. |
| Deara et al. [90] | Use of proven methods; supportive organisations; stakeholders' involvement; setting clear goals and objectives; financial support; project management; effective governance; competent project teams; commitment to success; aligned supply chains; appropriate standards; and capable sponsors. |
| Elamir [91] | Leadership; nurse and physician' involvement; multidisciplinary team; and training. |
| Ingelsson et al [92] | Adapting a Lean leadership-training program within a health care organisation |
| Swarnaker al [93] | Importance of prioritization of critical success factors for sustainable Lean Six Sigma implementation in Indian healthcare organisations |
| Rad [94] | Leadership and management; strategic planning; focus on customer and market; focus on employees; focus on suppliers, material resources, process management; and performance results. |
| Almutairi et al. [95] | Teamwork; patient orientation; organisational culture; consumer relationship; supplier relationship; hospital supply chain processes; and human resources. |
| Almutairi et al. [95] | Hospital leadership; organisational vision and strategic goals; organisational culture; streamlining business process; customer relationship; and supplier relationship. |
| Davies et al. [96] | Teamwork, organisational culture, and understanding of tools and techniques. |
| Isfahani et al. [97] | Teamwork; structured methodology; and management commitment. |
| Kaswan et al. [98] | Involvement of everyone in the organisation; top management support; relationship between supplier and hospital; quality circle; and teamwork. |

### *3.3. Challenges*

In healthcare, the challenges faced during the Lean implementation are quite important for senior managers, clinicians, medical directors and practitioners to understand prior to implementation. The authors have identified more than 40 challenges in the current literature (Table 3). Some of these challenges are correlated to each other. We also felt that these challenges could be people-related, cultural, financial, technology-related and operational/process-related. Under people-related there were challenges related to workload concerning resources to work on LSS projects [54,77], low morale [47,52,54,77] and receptiveness to change [30,54,79]. Under cultural challenges there were perceptions that LSS is manufacturing-related [54], and regulations in hospitals being prohibitive [31,46]. The financial challenges were related to resources to work on projects, acting as champions, limited budgets for process improvement and training opportunities [1,4,52,54,78,79]. In terms of technology-related challenges, these included a lack of automation, the highly regulated nature of the hospitals lending to manual repetitive steps [32,85]. Operationally, there were challenges related to day-to-day running and the busy nature of the healthcare system leaving "no time" [65,67,72].

**Table 3.** Challenges related to LSS in healthcare.

| Authors | Challenges |
| --- | --- |
| McDermott et al. [1] | Clinical staff are not trained in Lean thinking. |
| Trakulsunti and Antony [4] | Effective coaching and mentoring of Lean projects due to a lack of or no project champions in place. |
| Burgess and Radnor [19] | Implementation tends to be isolated rather than system-wide; Lean focuses on tools but fails to address its less-visible strategic elements and enabling factors relating to leadership and organisational readiness. |
| Woodnut [28] | Ambiguity in definition and implementation has contributed to the erosion of system-wide Lean implementation in many healthcare units. |
| Bowerman et al. [30] | Absence of baseline data for process improvement; psychology of the workforce towards change (receptiveness to change). |
| Lima et al. [32] | Excess of bureaucracy in the hospital field because of regulations, protocols, etc.; resistance to work standardisation by physicians. |
| Kahm and Ingelsson [32] | Insecurity about implementation in practice; lack of understanding of the underlying principles of Lean. |

**Table 3.** *Cont.*

| Authors | Challenges |
| --- | --- |
| Roemeling et al. [33] | No standard definition of Lean across the workforce, and implementation becomes a big challenge. |
| Niemeijer et al. [41] | Lack of project management skills; silo mentality across the organisation. |
| Swarnakar et al. [45] | Lack of reward and recognition system, which leads to poor motivation to pursue Lean. |
| Abdallah [46] | Low employee morale is a challenge in the healthcare sector; as physicians have more power than many employees in a hospital sector, managers struggle to persuade the use of process improvement initiatives such as Lean. |
| Peimbert-García et al. [54] | Lack of resources (workforce, financial, time, etc.). |
| Peimbert-García et al. [54] | Lack of training or inadequate training. |
| Peimbert-García et al. [54] | Resistance to cultural change with new initiatives (being complacent with the current culture). |
| Peimbert-García et al. [54] | Lack of employee commitment. |
| Narayanamurthy et al. [61] | Absence of a lean readiness framework and lack of organisational readiness culture. |
| Mcgrath et al. [63] | Lack of or no sustainability component considered in the initiative (i.e., the sustainability of improvement). |
| Taner et al. [72] | Lack of respect among the employees working in the sector; lack of teamwork; and lack of education (awareness of the methodology and the application of Lean tools). High workload and operational improvement are not a priority. |
| Laureani et al. [73] | Budget constraints. |
| Jorma et al. [81] | Understanding process metrics (what to measure and how to measure accurately) has been challenging in many hospitals. |
| Sanders and Karr [84] | Low level of initial trust among employees to adopt Lean across the organisation. |
| Ramadan and Arafeh [85] | Senior managers do not dedicate resources to quality improvement, and quality improvement practices are primitive and superficial; lack of communication or poor communication between Lean professionals and staff in the hospital setting (nurses, doctors, clinicians, etc.). |
| Jayasinha [86] | Lack of automation. |
| Almutairi et al. [95] | Lack of commitment from senior management; poor leadership. |
| Elbireer et al. [99] | Processes are human-driven with some automation, which results in high-output variability. |

### *3.4. Tools Used*

This section discusses Lean, Six-Sigma and LSS tools across diverse healthcare applications. Overall, thirty tools have been commonly used in healthcare. Table 4 below presents the classification. The most commonly used Lean healthcare tools include process mapping; value stream mapping; 5S; PDCA/PDSA; Kaizen; spaghetti charts; Ishikawa diagrams; hazard analysis; Gemba walk; A3 reports; brainstorming; Heijunka tools; process indicators such as cycle time; takt time improvement; kata; the voice of the customer; and Hoshin Kanri. As information and process steps in healthcare are generally opaque, VSM and process mapping are the most popular due to the visual representation of the flow.

**Table 4.** Classification of various tools/techniques in healthcare.

| Tools/Techniques | Lean | Six Sigma | Lean Six Sigma |
| --- | --- | --- | --- |
| Process mapping | X | X | X |
| Value stream mapping | X | | X |
| Ishikawa/fishbone diagram | X | X | X |
| Checklist | | X | |
| Pareto chart | | X | X |
| Failure mode effect analysis | | X | X |
| Decision trees | | X | X |
| Hazard analysis | X | | |

**Table 4.** *Cont.*

| Tools/Techniques | Lean | Six Sigma | Lean Six Sigma |
|---|---|---|---|
| Balanced scorecard | | X | X |
| 5S (sort-set in order-shine-standardize-sustain) | X | | X |
| SIPOC (supplier, input, process, output, customer) | | X | X |
| PDCA/PDSA | X | | |
| Kaizen | X | | |
| DMAIC/DMADV | | X | X |
| Poke-yoke | | X | X |
| Spaghetti chart | X | X | X |
| A3 report | X | | |
| Quality function deployment | | X | X |
| Gemba walks | X | | X |
| Brainstorming | X | X | X |
| Runs chart | | X | X |
| Heijunka | X | | |
| Cycle time/Takt time/workload balance | X | | X |
| Hoshin Kanri | X | X | X |
| Kata | X | | |
| Voice of the customer | X | X | X |
| Process capability analysis | | X | X |
| Control charts | | X | X |
| Statistical process control | | X | X |
| Design of experiments | | X | X |

Popular Six Sigma tools in healthcare include process mapping; Ishikawa diagrams; checklists; Pareto charts; FMEA; decision trees; SIPOC; DMAIC/DMADV; poke-yok; spaghetti charts; brainstorming; runs; control charts; Hoshin Kanri; the voice of the customer; and process capability analysis. Popular quantitative techniques QFD and balanced scorecard have been used in healthcare Six Sigma projects.

Hoshin Kanri is a strategic planning methodology used to drive strategic goals and actions at every organisation level. Commonly used in large corporations to drive value and continuous improvement, it is critical to establish the sustainable success of Lean, Six Sigma and LSS healthcare projects. There are six standard tools used in Lean and Six Sigma implementations: process mapping, Ishikawa/fishbone diagrams, brainstorming, spaghetti charts, Hoshin Kanri and the voice of the customer.

## 4. Discussion

The literature concerning LSS in HC, as well as its deployment, has increased considerably in the last 20 years. At the same time, there are many benefits and motivations for deploying LSS in HC, as well as many challenges. As the ultimate objective of any healthcare organisation is for patient treatment and safety, LSS can enhance the operational excellence of healthcare quality [4].

The challenges related to LSS deployment in healthcare were related to the challenges observed in other sectors (RQ1). The challenges can be classified into people, cultural, financial, technology and operational/process-related challenges.

The literature analysis shows that the most discussed readiness factors were management commitment, effective leadership, employee commitment and involvement, adequate

training, teamwork, and organisational culture promoting continuous change and patient focus and value (RQ2). These readiness factors would be aligned with the literature on LSS readiness in other sectors such as manufacturing [12]. However, the less cited factors about readiness factors for LSS implementation in healthcare were employee motivation and dynamic skills, knowledge and project management skills, financial resources, data availability, decentralised decision-making approaches and time and work management.

Leadership and teamwork are prominent CSFs in deploying LSS in healthcare. Leadership direction and commitment and the allocation of resources and time for training are important CSFs in LSS deployment [30,100] (RQ3). Healthcare leadership is not only associated with motivation and inspiration at the highest levels, but also with promoting a safety culture. Teamwork in healthcare was a recurring theme, as a CSF reiterated the importance of information sharing, meetings to promote and improve quality, employee recognition, and communication and sharing results. In addition, employee autonomy and empowerment play a critical role in deploying improvement initiatives which improve job satisfaction.

More than thirty LSS tools or methods have been commonly used in healthcare (RQ4). These tools range from a wide variety of basic Lean and Six Sigma tools. However, there are a lot of administration and information flow and process steps in healthcare; value stream mapping and process mapping were very popular for identifying waste and visually presenting information flows and people. Nevertheless, the wide variety of tools can make it challenging to know which tools to select [43].

## 5. Conclusions

Lean Six Sigma (LSS) is a proven methodology for improving operational excellence in the manufacturing and service sectors, but it has also been proven in healthcare. The increased deployment of LSS within healthcare has helped to analyse and understand its service deliverables in this sector. By reviewing the LSS literature, this study answered the four research questions raised at the beginning of this paper and provided an understanding of the challenges to LSS in HC.

To answer RQ1, the various challenges facing the deployment of LSS in the healthcare sector were presented. Next, the CSFs (RQ2) and readiness factors (RQ3) presented in the literature for LSS in healthcare were reviewed. Finally, for RQ4, the essential LSS tools were reviewed to ascertain their use in LSS HC project applications.

The limitations of this study were that, despite the literature that was available, every healthcare setting is different, and thus, the authors would like to carry out a more longitudinal case study on a hospital starting on a Lean journey and study its deployment of LSS over time. Future research opportunities include developing a model for Lean Six Sigma in healthcare readiness.

This study will help healthcare professionals and senior managers understand the challenges, organisational readiness and critical success factors related to the deployment of LSS in HC, in order to improve healthcare operational efficiencies and drive enhanced patient, staff and safety outcomes. Understanding the readiness factors and challenges before commencing an LSS journey will help healthcare professionals and management teams to be more prepared for a successful deployment of LSS. The studies cited demonstrate the readiness requirements for LSS in HC, 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.

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