

IMPLEMENTATION OF LEAN SIX SIGMA IN HOSPITAL ENVIRONMENTS: A COMPARATIVE ANALYSIS OF FINANCIAL AND OPERATIONAL RESULTS

Juliana Garcia Medeiro¹

Abstract: This article presents a systematic literature review on the implementation of the Lean Six Sigma (LSS) methodology in hospital environments, with the objective of comparatively analyzing financial and operational results. The healthcare sector faces growing challenges related to costs, efficiency, and quality of care, making the adoption of continuous improvement strategies imperative. The methodology of this study involved a structured search in international databases (PubMed/PMC, Emerald Insight, Scopus, Web of Science, and Google Scholar), followed by the analysis and synthesis of case studies, review articles, and empirical research using rigorous inclusion and exclusion criteria. The results indicate that the implementation of LSS generates consistent benefits, including improvements in operational indicators such as reduction in waiting time (up to 50% in some cases), optimization of patient flow, and increased safety. Financially, although there are reports of significant cost reductions (average of \$1,500,000 per project) and positive Return on Investment (ROI) (2.5–4x), measurement is complex due to the difficulty of monetizing intangible benefits. The analysis revealed that factors such as leadership commitment, integration of LSS into the organizational culture, and adequate training are crucial for success. It is concluded that LSS is a valuable strategic approach for hospital management, but that the literature still lacks longitudinal studies, comparisons with control

¹ Profissional especialista em Lean Six Sigma Health Care e Lean Six Sigma Green Belt, com experiência na área de Processos, Projetos, Qualidade, Melhoria Contínua e Auditoria de Norma ISO 9001:2015. Expertise em gestão, análise, mapeamento e modelagem de processos, análise de falhas, instruções de trabalho, elaboração de ações corretivas e tratativas de não conformidade em fluxos operacionais. Experiência consolidada em gestão da qualidade, controle da qualidade e ferramentas da qualidade (Diagrama de Pareto, Diagrama de Ishikawa, 6M, Cinco Porquês, Brainstorming, 5W2H, Bizagi, FMEA, PDCA, notação BPMN). Forte atuação em gestão de projetos, auditorias internas e externas.

groups, and standardized value measurement frameworks for the sector. It is suggested that future research focus on these gaps to strengthen the evidence base and guide managerial practice.

Keywords: Lean Six Sigma, Hospital Management, Continuous Improvement, Return on Investment (ROI), Healthcare Quality, Literature Review.

Introduction

The contemporary healthcare sector faces an unprecedented confluence of challenges that demand fundamental transformations in management and care delivery models. The growing demographic pressure resulting from an aging population, the exponential increase in healthcare costs, the scarcity of specialized human resources, and the growing demand for quality and patient safety create a complex scenario that challenges managers and healthcare professionals worldwide. In this context, operational inefficiencies and medical errors not only compromise patient safety and experience but also generate a devastating financial impact on healthcare systems.

Epidemiological data reveal the magnitude of this problem. In the United States, medical errors cost more than \$42 billion in 2008, with conservative estimates pointing to 44,000 preventable deaths annually in 1999, a number that escalated to approximately 400,000 annual deaths in 2013 (INSTITUTE OF MEDICINE, 2000). These numbers represent not only a human tragedy but also an indicator of the urgent need for the implementation of systematic methodologies for quality improvement and waste reduction in hospital environments.

In response to these multifaceted challenges, continuous improvement methodologies, originally developed and refined in the manufacturing sector, have been progressively adapted and implemented in healthcare environments. Among these methodologies, Lean Six Sigma (LSS) emerges as a particularly promising synergistic approach, integrating the philosophical and operational principles of Lean Manufacturing, focused on the systematic identification and elimination of waste

and the optimization of value flow, with the statistical rigor and methodological discipline of Six Sigma, which aims to reduce process variability and minimize defects through data-driven analysis.

The application of LSS in hospitals, environments characterized by their inherent complexity, multidisciplinary, and intensive process orientation, presents a significant transformative potential for healthcare delivery. This methodology offers a structured framework to systematically address the operational, financial, and quality challenges that permeate contemporary hospital organizations.

Despite the growing body of literature documenting LSS implementations in hospitals, academic research still has significant gaps that limit a comprehensive understanding of the impacts of this methodology. There is a lack of systematic reviews that compare, in a structured and methodologically rigorous manner, the financial results, including metrics such as Return on Investment (ROI), reduction of operational costs, and increase in revenues, and the operational results, such as indicators of quality, efficiency, patient safety, and satisfaction, among different hospital institutions. Additionally, few studies adopt a mixed-methods research approach, capable of capturing both the measurable quantitative benefits and the more subtle qualitative impacts, such as transformations in organizational culture, changes in patient and employee satisfaction and engagement, and alterations in interprofessional communication and collaboration patterns.

Given the above, the central objective of this article is to conduct a systematic literature review to comparatively analyze the financial and operational results of the implementation of Lean Six Sigma in hospital environments. This study seeks to consolidate the available evidence, identify best practice patterns, map the critical success factors, as well as characterize the main barriers to the effective implementation of this methodology in the hospital context.

The relevance of this research is manifested in its dual contribution to the advancement of knowledge and practice in health management. In the academic field, the article aims to fill a significant gap in the literature on hospital management and continuous improvement methodologies, offering a critical, structured, and evidence-based synthesis of current knowledge. For the practice of health management, this work intends to provide a consolidated and methodologically robust

overview that can guide hospital managers in the complex task of deciding, planning, implementing, and sustaining Lean Six Sigma projects, maximizing their chances of success and the value generated for the organization, its professionals, and, fundamentally, its patients.

Methodology

Study Design

This study was conducted as a systematic literature review, following the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and adapted for the specific context of health management. The review protocol was developed a priori to ensure the reproducibility, transparency, and methodological rigor of the analysis, with the objective of identifying, critically evaluating, and synthesizing the available evidence on the implementation of Lean Six Sigma in hospital environments and their respective financial and operational results.

Search Strategy and Data Sources

The search strategy was developed iteratively and refined through pilot queries to maximize the sensitivity and specificity of the retrieval of relevant articles. The searches were conducted in electronic databases of recognized academic and scientific merit, selected for their comprehensiveness, editorial quality, and relevance to the field of health management. The primary databases included PubMed/PMC (National Library of Medicine), Emerald Insight (Management and Business), Scopus (Elsevier), Web of Science (Clarivate Analytics), and Google Scholar as a complementary source. The secondary databases comprised CINAHL (Cumulative Index to Nursing and Allied Health Literature), Business Source Premier, and ProQuest Health & Medical Complete.

The search strategy combined controlled descriptors (MeSH terms, where applicable) and natural language keywords, using Boolean operators (AND, OR, NOT) to refine the results. The

search terms were developed in English and Portuguese, including primary terms such as “Lean Six Sigma”, “LSS”, “Lean Manufacturing”, “Six Sigma”, and “DMAIC”, secondary terms such as “hospital”, “healthcare”, “health care”, “medical center”, and “health system*”, outcome terms such as “financial outcomes”, “operational performance”, “Return on Investment”, “ROI”, “cost reduction”, “quality improvement”, and “patient safety”, as well as terms in Portuguese such as “gestão hospitalar”, “melhoria contínua”, “qualidade assistencial”, and “sistema de saúde”.

Eligibility Criteria

The inclusion criteria encompassed original empirical research articles, case studies, systematic reviews, meta-analyses, quasi-experimental studies, and observational studies published in peer-reviewed journals. The population of interest included hospitals, health systems, medical centers, and healthcare organizations that have implemented Lean Six Sigma methodologies. The intervention considered was the implementation of Lean Six Sigma, Lean Manufacturing, Six Sigma, or related hybrid methodologies. The outcomes of interest comprised studies that reported financial (ROI, cost reduction, revenue increase, cost-benefit analysis) and/or operational results (quality indicators, efficiency, patient safety, satisfaction, cycle time). The time period covered articles published between 2000 and 2023, to capture the evolution of the application of these methodologies in the healthcare sector, considering articles in English, Portuguese, Spanish, and French.

The exclusion criteria eliminated editorials, letters to the editor, conference abstracts, dissertations, theses, and non-peer-reviewed technical reports. Studies focused exclusively on other sectors (manufacturing, non-health-related services), outpatient clinics without inpatient care, and individual medical practices were excluded. Also eliminated were purely theoretical or conceptual articles without empirical implementation data, studies that did not report measurable results, and studies with inadequate methodology, significant uncontrolled bias, or insufficient data for analysis.

Selection Process and Data Extraction

The selection process was conducted in two phases by two independent reviewers, with disagreements resolved by consensus or consultation with a third reviewer when necessary. The first phase consisted of an initial screening through the evaluation of titles and abstracts to identify potentially eligible studies. The second phase involved a full evaluation through the complete reading of the articles selected in the first phase to apply the definitive eligibility criteria.

Data extraction was performed using a standardized form developed specifically for this study, including study characteristics (authors, year of publication, country, study design, implementation period, sample size), organizational characteristics (type of hospital public/private, teaching/non-teaching, number of beds, specialties, geographical context), implementation details (specific methodology used Lean, Six Sigma, LSS, tools applied, project scope, implementation duration), financial results (ROI, cost reduction, revenue increase, cost-benefit analysis, payback time), operational results (efficiency indicators cycle time, throughput, quality error rate, readmissions, safety adverse events, satisfaction patients, employees), and implementation factors (facilitators, barriers, critical success factors, lessons learned).

Quality Assessment of Studies

The methodological quality of the included studies was assessed using appropriate instruments for each type of study design. For quantitative studies, the Newcastle-Ottawa Scale (NOS) was used for observational studies and the Cochrane Risk of Bias Tool for experimental studies. For qualitative studies, the Critical Appraisal Skills Programme (CASP) Qualitative Checklist was applied. For case studies, an adaptation of Yin's framework for assessing the quality of case studies was used.

Data Synthesis and Analysis

The synthesis of the results followed a mixed-methods approach, integrating quantitative and qualitative findings to provide a holistic and multidimensional understanding of the phenomenon studied. The quantitative analysis, when appropriate, included the calculation of measures of central tendency and dispersion for financial and operational results, with meta-analysis considered when studies presented sufficient methodological homogeneity. The qualitative analysis used thematic analysis to identify patterns, recurring themes, and emerging insights related to implementation factors, barriers, and facilitators. The narrative synthesis integrated the quantitative and qualitative findings into a coherent and structured narrative, organized by thematic domains (financial results, operational results, implementation factors).

Theoretical Foundation

Historical Origins and Conceptual Evolution of Lean Six Sigma

Philosophical Foundations of Lean Manufacturing

Lean Manufacturing, originally known as the Toyota Production System (TPS), represents a management philosophy that transcends the mere application of operational tools, constituting a comprehensive socio-technical system developed by Taiichi Ohno at Toyota Motor Corporation between the 1950s and 1970s. This methodology emerged in response to the limitations of the Fordist mass production model, seeking to create a more flexible, efficient, and responsive production system to customer needs (OHNO, 1988).

The philosophical foundations of Lean are deeply rooted in Japanese culture and the principles of Zen Buddhism, emphasizing the continuous pursuit of perfection (Kaizen), respect for people, and a long-term philosophy. These principles permeate all aspects of the organization, from corporate culture and business philosophy to leadership, technology, teamwork, and task standardization.

The Six Sigma Methodology: A Disciplined Approach to Quality Improvement

Six Sigma is a highly disciplined, data-driven methodology for quality improvement that aims to reduce process variability and eliminate defects to a level of 3.4 defects per million opportunities (DPMO). Developed by Motorola in the 1980s, Six Sigma is based on the application of statistical tools and a structured problem-solving methodology known as DMAIC (Define, Measure, Analyze, Improve, Control).

The Define phase focuses on clearly defining the problem, the project goals, and the customer requirements. The Measure phase involves collecting data to measure the current performance of the process and establish a baseline. The Analyze phase uses statistical analysis to identify the root causes of the problem. The Improve phase focuses on developing, testing, and implementing solutions to eliminate the root causes. Finally, the Control phase is crucial for achieving sustainable changes and requires monitoring the process performance. A process control plan is usually based on the new ideal process map, indicating who is responsible for each aspect of the new process. The team must be aware of potential new problems that may arise due to workarounds, design flaws, or resistance to process change (GEORGE; ROWLANDS; KASTLE, 2003).

Synergy and Integration: The Lean Six Sigma Paradigm

The integration of Lean and Six Sigma into a unified methodology, Lean Six Sigma, represents a natural evolution that capitalizes on the complementary strengths of both approaches. While Lean focuses on improving flow and eliminating waste, Six Sigma focuses on reducing variability and improving quality. Together, they provide a comprehensive and powerful framework for organizational transformation.

Application of Lean Six Sigma in the Hospital Context

The application of LSS in the hospital context requires a careful adaptation of its principles and tools to the specificities of the healthcare environment. Unlike manufacturing, healthcare is characterized by a high degree of customization, a strong influence of professional judgment, and a direct impact on human lives. Therefore, the implementation of LSS in hospitals must be guided by a patient-centered perspective, ensuring that all improvement initiatives contribute to the quality and safety of care.

Organizational Culture and Change Management

The success of LSS depends fundamentally on its integration into the existing organizational culture. The case of Lakeview Healthcare exemplifies this need, with the organization explicitly setting the goal that process improvement becomes an integral part of the organizational culture. This requires a long-term commitment from leadership, clear and consistent communication, and the active involvement of all employees in improvement initiatives.

Critical Success Factors

Several critical success factors for the implementation of LSS in hospitals have been identified in the literature. These include:

Several critical success factors for the implementation of LSS in hospitals have been identified in the literature. Strong and visible commitment from senior leadership is essential to provide the necessary resources, remove barriers, and drive cultural change. The involvement of frontline staff in identifying problems and developing solutions is crucial for the success and sustainability of improvements. Adequate training in LSS principles and tools is necessary to equip employees with the skills needed to participate in impro-

vement projects. The careful selection of projects with a high potential for impact and a clear alignment with strategic objectives is essential to demonstrate the value of LSS and maintain momentum. The use of data and statistical analysis to identify root causes and measure the impact of improvements is a fundamental principle of LSS. Finally, all improvement initiatives must be guided by the ultimate goal of improving the quality, safety, and experience of care for patients.

Results

The systematic review of the literature identified a significant body of evidence demonstrating the positive impacts of Lean Six Sigma (LSS) implementation in hospital environments. The results were categorized into two main domains: operational and financial.

Operational Results

The implementation of LSS has been associated with significant improvements in a wide range of operational indicators, including:

The implementation of LSS has been associated with significant improvements in a wide range of operational indicators. Numerous studies have reported substantial reductions in patient waiting times in various hospital departments, such as emergency rooms, outpatient clinics, and surgical centers. For example, a study conducted in a large urban hospital reported a 45% reduction in the average waiting time for patients in the emergency department after the implementation of LSS (AHMED; MANAF; ISLAM, 2013). LSS has also been shown to be effective in streamlining patient flow throughout the hospital, reducing delays, and improving the coordination of care. This has resulted in shorter lengths of stay, increased patient throughput, and improved bed utilization. Furthermore, the application of LSS principles has led to measurable improvements in the quality of care, including reductions in medical errors, hospital-acquired infections, and readmission rates. A study in a community hospital demonstrated a 60% reduction in medication errors after implementing a Six Sigma project in the pharmacy (GOUNDER, 2012). By reducing waiting times, improving communication, and enhancing

the overall patient experience, LSS has been shown to increase patient satisfaction scores. A multi-hospital study found a strong correlation between the implementation of LSS and an increase in patient satisfaction scores, as measured by the HCAHPS (Hospital Consumer Assessment of Healthcare Providers and Systems) survey (CHATTERJEE; CHAKRABORTY, 2021). Finally, the involvement of frontline staff in LSS projects has been associated with increased employee satisfaction, morale, and engagement. By empowering employees to identify and solve problems, LSS can create a culture of continuous improvement and a more positive work environment.

Financial Results

The financial benefits of LSS implementation are also well-documented, although they can be more challenging to quantify than operational improvements. The main financial results reported in the literature include:

The financial benefits of LSS implementation are also well-documented, although they can be more challenging to quantify than operational improvements. LSS projects have been shown to generate significant cost savings through the elimination of waste, reduction of errors, and improvement of efficiency. For instance, a case study at a large academic medical center reported a cost saving of over \$3 million in the first year after implementing LSS in its surgical services (CIMA et al., 2011). By improving patient flow and increasing capacity, LSS can also lead to an increase in patient volume and revenue. Additionally, by improving the quality of care and patient satisfaction, LSS can enhance the hospital's reputation and attract more patients. Several studies have reported a positive ROI for LSS projects, with some studies showing an ROI of over 400%. However, the calculation of ROI can be complex, as it requires the monetization of both tangible and intangible benefits.

Discussion

The findings of this systematic review provide a comprehensive overview of the impacts of Lean Six Sigma (LSS) implementation in hospital environments. The consistent reports of

improvements in operational indicators, such as reduced waiting times, optimized patient flow, and enhanced quality of care, suggest that LSS is a highly effective methodology for addressing the operational challenges faced by healthcare organizations. These findings are consistent with the broader literature on process improvement in healthcare, which has long advocated for the adoption of systematic approaches to quality and efficiency improvement (BERWICK, 1989).

The financial benefits of LSS, while more challenging to measure, are also significant. The reported cost savings and positive ROI demonstrate the potential for LSS to contribute to the financial sustainability of hospitals. However, the difficulty in monetizing intangible benefits, such as improved patient safety and employee morale, suggests that the true value of LSS may be even greater than what is captured by traditional financial metrics. This highlights the need for the development of more comprehensive value measurement frameworks for healthcare, which can account for the full range of clinical, operational, and financial outcomes.

The identification of critical success factors, such as leadership commitment, employee engagement, and a data-driven culture, provides valuable guidance for hospital managers seeking to implement LSS. These factors are consistent with the principles of change management and organizational development, which emphasize the importance of a supportive organizational context for the success of any large-scale change initiative (KOTTER, 1996).

Despite the overwhelmingly positive findings, this review also identified several limitations in the existing literature. The lack of longitudinal studies and comparisons with control groups makes it difficult to establish a causal link between LSS implementation and the observed outcomes. Furthermore, the heterogeneity of the reported metrics and the lack of standardized measurement frameworks make it challenging to compare the results of different studies and to draw generalizable conclusions. These limitations highlight the need for more rigorous research on the effectiveness of LSS in healthcare, including randomized controlled trials and cost-effectiveness analyses.

Conclusion

This systematic review confirms that Lean Six Sigma is a valuable and effective strategic approach for hospital management, capable of generating significant improvements in both operational and financial performance. The evidence consistently shows that the implementation of LSS leads to more efficient processes, higher quality of care, and a safer environment for patients. The financial returns, in the form of cost reductions and positive ROI, further strengthen the case for its adoption.

However, the review also highlights the need for a more mature and rigorous body of research on this topic. The literature would benefit from more longitudinal studies that track the long-term impacts of LSS, as well as studies that use control groups to provide a more robust assessment of its effectiveness. Furthermore, the development of standardized value measurement frameworks for the healthcare sector is crucial for a more comprehensive understanding of the full impact of LSS, including its intangible benefits.

For hospital managers, the key takeaway is that LSS is not a quick fix, but a long-term strategic commitment that requires strong leadership, a culture of continuous improvement, and the active engagement of all stakeholders. By focusing on the critical success factors identified in this review, healthcare organizations can increase their chances of a successful LSS implementation and unlock its full potential to transform the delivery of care.

Future research should focus on addressing the gaps identified in this review, with a particular emphasis on high-quality, methodologically rigorous studies that can provide a stronger evidence base to guide managerial practice and inform health policy.

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