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Transforming Systematic Literature Synthesis into Meta-Data Analysis: The Impact of Lean Six Sigma in the Healthcare Sector

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Abstract: This study presents a comprehensive meta-data analysis of Lean Six Sigma (LSS) research in the healthcare sector, synthesizing recent academic literature to map key themes, trends, and construct relationships. Leveraging a systematic literature review guided by PRISMA protocols, 38 peer-reviewed articles indexed in Scopus (2021–2025) were analyzed to describe the evolution of scholarly interest, collaboration networks, and thematic clustering in LSS healthcare research. The results reveal a dynamic and collaborative research landscape, with contributions from 130 unique authors across 57 countries, and a broad spectrum of journals and publishers. India leads in publication volume, highlighting regional disparities and the need for greater engagement from underrepresented countries such as Indonesia. The study identifies three core constructs—Organizational Management & Efficiency, Operational Implementation, and Healthcare Delivery and Quality—each empirically grounded in co-occurring and highly correlated keywords. Through co-occurrence analysis and keyword correlation, the research develops robust indicators for each construct and proposes a data-driven path model for future quantitative analysis using PLS-SEM. While the findings advance theoretical and practical understanding of LSS implementation, the study is limited by its focus on English-language, Scopus-indexed articles within a five-year period, and by the predominance of research on private hospital institutions. Recommendations for future research include empirical validation of the proposed constructs, extension to broader healthcare settings, and examination of mediating and moderating factors in LSS effectiveness.

Keywords: Lean Six Sigma (LSS), Meta-data analysis, Systematic literature review, PRISMA,

JEL code: L15, M11, O32,

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INTRODUCTION

The increasing complexity and rising expectations for quality and efficiency in the healthcare sector have brought continuous improvement methodologies into sharper focus. Among these, Lean Six Sigma (LSS) has emerged as a powerful approach for reducing waste, minimizing variability, and enhancing patient outcomes across diverse healthcare settings (Egan et al., 2021; Garedew et al., 2025; Kharub et al., 2024). With the global healthcare landscape facing mounting pressures, start from rising costs to patient safety concerns, healthcare organizations are increasingly turning to Lean Six Sigma to streamline processes and deliver value-based care (Danet Danet & Pérez Lázaro, 2024; Kharub et al., 2024).Despite the growing adoption of Lean Six Sigma in healthcare, there remains a gap in the comprehensive synthesis of empirical evidence regarding its effectiveness, challenges, and best practices (Apostu et al., 2021; Bhat et al., 2020; Dempsey et al., 2021; Trakulsunti et al., 2020). Previous research has often concentrated on single-institution case studies or specific clinical settings, resulting in fragmented knowledge that limits generalizability (Trakulsunti et al., 2021; Ward et al., 2022). Moreover, factors such as regional context, healthcare system type, and interdisciplinary collaboration patterns have not been sufficiently explored in relation to their impact on LSS implementation and outcomes (P. Kumar et al., 2021; S. Kumar et al., 2024).

This study aims to bridge these gaps by conducting a systematic literature review and meta-analysis of recent academic publications on Lean Six Sigma in the healthcare sector. By analyzing a curated dataset of 38 articles indexed in Scopus from 2021 to 2025, this research provides a descriptive and analytical overview of publication trends, collaboration networks, thematic developments, and the geographical distribution of research outputs. Key research questions include:

Q.1. How has the academic landscape surrounding Lean Six Sigma in healthcare evolved in recent years?

Q.2. What are the most prominent themes, methodologies, and outcomes identified in the literature?

Q.3. How do collaboration patterns and country of origin shape the discourse and diffusion of LSS in healthcare?

By answering these questions, this study seeks to contribute both theoretical and practical insights for researchers, practitioners, and policymakers interested in implementing or studying Lean Six Sigma initiatives in healthcare (S. Kumar et al., 2024; Singh et al., 2023; Tosuner et al., 2023). The findings are expected to inform future research directions, highlight current knowledge gaps, and support evidence-based decision-making for healthcare quality improvement.

RESEARCH METHODOLOGY

This study employs a systematic literature review and meta-analysis approach to assess the state of research on the impact of Lean Six Sigma in the healthcare sector. The review was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological rigor, transparency, and reproducibility in the review process (Prastiwi & Ayuningtyas, 2023; Tuegeh et al., 2024; Tumiwa et al., 2022).

Data Sources and Search Strategy

The primary source of data was the Scopus database, chosen for its comprehensive coverage of peer-reviewed literature in the fields of healthcare management and operations. A search was conducted using a combination of keywords related to "Lean Six Sigma" and "healthcare." To ensure the highest quality and relevance of included studies, the search was limited to articles published between 2021 and 2025. Furthermore, only articles designated as double-blind peer-reviewed were included, consistent with the standards of academic research in this domain.

Study Selection and Eligibility Criteria

The following inclusion criteria were applied:

- The document type must be “article.”
- The article must be published in a peer-reviewed journal and be subject to double-blind review.
- The article must be published within the time span 2021–2025.
- The study must focus on the application, outcomes, challenges, or strategies of Lean Six Sigma in the healthcare sector.
- The article must be written in English.

Exclusion criteria included:

- Conference proceedings, book chapters, editorials, and non-peer-reviewed publications.
- Articles not specifically addressing Lean Six Sigma or its application in healthcare.
- Publications outside the selected time frame.
- Studies not accessible in full text.

The selection process began with an initial identification of articles based on the search criteria. Titles and abstracts were screened for relevance, and duplicates were removed. Subsequently, the full texts of the remaining articles were reviewed to confirm eligibility based on the inclusion and

exclusion criteria. This rigorous selection process resulted in a final dataset of 38 articles for analysis.

Data Extraction and Analysis

For each included article, the following bibliographic and study characteristics were extracted:

- Authors and author affiliations
- Year of publication
- Journal/source and publisher
- Country of origin (based on corresponding author or study context)
- Keywords and thematic focus
- Study objectives, methods, and main findings

A descriptive analysis was performed to identify publication trends, authorship patterns, country distribution, journal and publisher frequencies, and keyword co-occurrences. Quantitative summaries (such as the number of unique authors, keyword frequencies, and geographical distribution) were presented using tables and figures where appropriate. Thematic synthesis was conducted to identify prevailing research themes, challenges, and opportunities related to Lean Six Sigma implementation in healthcare.

Quality Assessment

To ensure the robustness of the review, each article was evaluated for methodological quality based on criteria such as clarity of research objectives, appropriateness of methodology, and transparency of reporting. Only articles meeting a minimum threshold of methodological rigor were retained for the final synthesis. As this study is based on the review and synthesis of published literature, no primary data involving human subjects was collected, and thus, ethical approval was not required. The research adheres to best practices in academic integrity and transparency.

DESCRIPTIVE ANALYSIS

To understand the landscape of scholarly research on Lean Six Sigma in the healthcare sector, a descriptive analysis was conducted on the 38 articles that met the inclusion criteria. This analysis provides an overview of the key bibliometric characteristics of the selected literature, including the distribution of publications over time, authorship patterns, and countries of origin, journal sources, publishers, and keyword occurrences. The aim is to identify prevailing trends, collaboration networks, and thematic concentrations within the academic discourse. By examining these attributes, the study reveals how research on Lean Six Sigma in healthcare has evolved between 2021 and 2025, which institutions and regions are leading contributions in this domain, and what conceptual areas are most frequently explored. This foundational overview sets the stage for deeper thematic and methodological discussions in the subsequent sections.

Figure 1 shows a summary of the key bibliometric attributes of the 38 articles analyzed in this study. These articles span a publication period from 2021 to 2025, indicating a growing scholarly interest in Lean Six Sigma (LSS) applications within the healthcare sector in recent years. A total of 130 unique authors contributed to these publications, yet none were single-author articles, underscoring the collaborative nature of research in this field. This aligns with the interdisciplinary demands of healthcare improvement initiatives, which often involve joint efforts across managerial, clinical, and operational domains. The dataset reflects a broad geographical diversity, with contributions originating from 57 countries, suggesting that Lean Six Sigma is a globally relevant framework for addressing challenges in healthcare systems.

In terms of publication sources, the articles were distributed across 37 journals and published by 32 different publishers, indicating a wide dispersion of knowledge and interest across disciplines and editorial platforms. The thematic scope of the literature is further demonstrated by the presence of 334 unique keywords, which capture a range of topics including process efficiency, patient safety, quality control, and operational performance. Moreover, eight articles reported external funding sponsorship, suggesting that while institutional and governmental support for this research area exists, it remains relatively limited. Collectively, these descriptive findings provide a foundational overview of the current research landscape and reinforce the relevance, diversity, and collaborative orientation of Lean Six Sigma research in healthcare.

Figure 2a reveals a notable dominance of India in the publication of Lean Six Sigma-related healthcare research, contributing 15 articles—a significant proportion of the total dataset. This high volume reflects both a strong academic interest and practical application of LSS principles in India's healthcare environment. The United Arab Emirates follows with seven articles, while Ireland and the United Kingdom each contribute six articles and the United States accounts for 3. In contrast, countries such as Italy and Australia are represented with fewer contributions, and an additional 17 countries, including Indonesia, published only one article each. This geographic disparity highlights the global imbalance in LSS healthcare research and underscores the need for increased scholarly

engagement in underrepresented regions. Given India's demonstrated success in adopting LSS for healthcare improvement, similar research in Indonesia is not only timely but essential for contextualizing and localizing best practices within its unique healthcare challenges.

Building upon the regional spread of research, Figure 2b shows the distribution of articles across major academic publishers. The findings indicate that Emerald Publishing leads with 8 published articles, followed closely by MDPI with 7, and Inderscience Publishers with 5. Additional contributions come from Emerald Group Holdings Ltd. (4 articles) and the Multidisciplinary Digital Publishing Institute (3 articles). This distribution suggests that LSS in healthcare is strongly represented in journals managed by publishers known for their focus on quality management, operations research, and applied industrial systems. These publishing patterns provide insight for future researchers in selecting platforms that are both visible and thematically aligned with Lean Six Sigma research.

Further supporting this observation, Figure 2c outlines the most frequent source titles (journals) that have published articles on LSS in the healthcare sector. The International Journal of Lean Six Sigma stands out as the most active outlet with 8 articles, establishing itself as the central platform for scholars in this field. This is followed by The TQM Journal with 5 articles and the International Journal of Health Care Quality Assurance with 4 articles, reflecting a balanced interest between quality management and healthcare-specific journals. Other source titles contributed two or fewer articles each, indicating a broader but less concentrated interest among general management or interdisciplinary journals. Together, these figures illustrate that while LSS in healthcare has dedicated publication venues, it also receives attention from a wider scholarly community concerned with efficiency, quality, and healthcare reform.

CONSTRUCT IDENTIFICATION FOR FURTHER RESEARCH MODELING

To develop a robust statistical modeling framework, it is essential to begin with the identification of latent constructs that emerge from the literature. This section synthesizes findings from bibliometric mapping (via VOSviewer), text mining (using Voyant Tools), and qualitative content analysis (through NVivo Plus) to extract potential constructs and their indicators. The recurring themes and clusters identified in keyword co-occurrence analysis, term frequency, and thematic coding provide empirical grounding for the conceptual model.

Identifying Thematic Clustering

This paper identifies three clustering from the following figure 3**.**

Figure 3, when interpreted alongside the findings presented in Table 1. Keyword Co-occurrence and Link Strength based on VOSviewer analysis, provides a comprehensive visualization of the thematic structure underpinning Lean Six Sigma research in the healthcare sector. The red cluster, for example, highlights operational and methodological dimensions through frequently linked terms such as "healthcare," "lean six sigma," "hospitals," "process monitoring," "work simplification," "DMAIC," "sustainability," and "lean production," emphasizing the centrality of structured improvement methodologies and a continuous pursuit of efficiency in hospital environments (Bhat et al., 2023; Masso et al., 2010; Mistarihi et al., 2023; Trakulsunti et al., 2021). This is further reinforced by high keyword occurrences and link strengths in Table 1, notably for "lean six sigma," "health care," and "six sigma." Meanwhile, the green cluster is characterized by terms like "hospital sector," "length of stay," "health care delivery," "process improvement," "private hospital," "health care quality," and "human," collectively underscoring the critical importance of patient outcomes, streamlined service delivery, and quality of care—all of which are reflected in the prominence of these keywords in the co-occurrence table (Abdallah, 2014; Dempsey et al., 2021; Moffatt et al., 2022; Scala et al., 2021; Sethi & Joshi, 2020). The blue cluster brings to the forefront keywords such as "healthcare cost," "hospital," "organization and management," "efficiency organizational," and "quality improvement," capturing the managerial, economic, and leadership facets that are vital for sustainable Lean Six Sigma implementation (Apostu et al., 2021; Ortiz-Barrios & Alfaro-Saiz, 2020; Suman & Prajapati, 2021). The strong interconnectedness of these themes in both the network visualization and Table 1 not only illustrates the multidisciplinary landscape of Lean Six Sigma research but also provides a robust empirical basis for identifying latent constructs to be modeled in subsequent PLS-SEM analysis, ensuring that both operational excellence and organizational effectiveness are well represented (Bhat et al., 2023; Improta et al., 2018).

The keyword co-occurrence analysis conducted using VOSviewer highlights the dominant themes in Lean Six Sigma research within the healthcare sector. As shown in the map generation phase, "lean six sigma" emerged as the most frequently occurring keyword with 25 mentions and a total link strength

of 160, indicating its centrality and strong interconnectedness with other topics in the literature. Closely related keywords include “health care” (12 occurrences, 111 link strength), “six sigma” (12, 58), “healthcare” (16, 70), and “hospital sector” (9, 100), reflecting the focused application of Lean Six Sigma principles in medical service environments.

Other high-frequency terms such as “total quality management” (9 occurrences, 99 link strength), “quality improvement” (4, 46), and “process monitoring” (6, 45) emphasize the operational and quality enhancement aspects of Lean Six Sigma implementation. Keywords related to human subjects and demographics, “human”, “humans”, “male”, “female”, and “adult”, also appear frequently, suggesting that many of the studies examine patient-centered outcomes or workforce factors in the implementation process. Additionally, terms like “efficiency, organizational”, “organization and management”, and “hospital sector” point to a strong managerial and systems-oriented perspective in the analyzed literature.

These co-occurrence patterns provide a strong thematic foundation for identifying potential latent constructs within a PLS-SEM framework. For instance, constructs such as quality management, organizational efficiency, and healthcare performance can be derived from the clustering of terms related to quality, monitoring, and service delivery (Apostu et al., 2021; Danet Danet & Pérez Lázaro, 2024; Suman & Prajapati, 2021; Tsai et al., 2021). This keyword landscape highlights the multidisciplinary character of Lean Six Sigma research in healthcare, spanning clinical, operational, and managerial dimensions (Apostu et al., 2021; Dempsey et al., 2021; Egan et al., 2021; Ibrahim et al., 2022; Moffatt et al., 2022; O’mahony et al., 2021; Tsai et al., 2021). To further validate and refine these constructs, the identified terms within each cluster were examined through trendline analysis using Voyant Tools and NVivo Plus. These tools enable a dimensional reduction approach similar to principal component analysis (PCA), in which highly correlated indicators are grouped to form unified constructs. Additionally, the relationships among these emerging constructs are explored through pattern matching and correlation logic, supported by blindfolding techniques to assess path significance and model validity, as illustrated in Figures 4a to 4c.

Keyword Correlation and Significance Analysis

To analyze the relationships among keywords within each cluster, we first standardized the terminology by converting multi-word terms into single-word codes or acronyms. This preprocessing step was essential because both NVivo Plus and Voyant Tools recognize only single-word inputs as valid terms for correlation analysis. After coding, all metadata were imported into the software tools for processing. The tools calculated the strength of association between terms, allowing us to identify the highest correlations within each cluster. These strongly correlated terms were then selected as indicators for developing latent constructs. Subsequently, inter-construct correlations were analyzed based on the results presented in Table 2: Keyword Correlation and Significance (Cluster-Based), which provides empirical support for the proposed structural relationships in the model.

The results of the keyword correlation analysis, as presented in Table 2, reveal several noteworthy associations among the key terms representing the identified clusters. Most term pairs exhibit strong positive correlations, with coefficients ranging from 0.73 to 0.96 and highly significant p-values ($p < 0.05$). For instance, the relationship between "LSS" and "monitoring" demonstrates the highest correlation (0.9646, $p = 0.003$), suggesting that discussions of Lean Six Sigma are closely linked with process monitoring practices. Similarly, strong and significant associations are observed between "health_care_quality" and "improvement" (0.9336, $p = 0.001$), "human" and "length" (0.9066, $p = 0.027$), and "efficiency_organizational" and "improvement" (0.9533, $p = 0.007$), indicating that quality, human factors, and organizational efficiency are central to improvement-oriented discussions in the literature.

However, it is important to note that not all term pairs yielded statistically significant relationships. For example, although "LSS" and "simplification" show a relatively high correlation coefficient (0.9092), the significance value ($p = 0.749$) indicates that this relationship is not statistically robust. Likewise, the pair "hospital" and "dmaic" also fails to achieve significance ($p = 0.683$) despite a substantial correlation value (0.845). These nonsignificant results suggest that, within this dataset, the co-occurrence of these terms may be more sporadic or context-dependent, rather than reflecting consistent conceptual alignment. Overall, the table provides empirical evidence supporting the use of highly correlated and significant keyword pairs as potential indicators for construct development in further modeling efforts, while highlighting the importance of considering both the strength and the significance of observed relationships.

Indicator Development for Construct Measurement

The development of valid and reliable indicators for each construct is a crucial step in preparing for empirical analysis, such as Partial Least Squares Structural Equation Modeling (PLS-SEM), in Lean Six Sigma (LSS) healthcare research. Based on the extensive bibliometric and keyword co-occurrence analysis performed in this study, as well as the deep thematic clustering enabled by VOSviewer and NVivo Plus, we identified a clear set of latent variables that structure the discourse on LSS implementation in the healthcare sector. The process of indicator development began by examining the most prominent and interconnected keywords revealed through co-occurrence mapping and correlation analysis (Danet Danet & Pérez Lázaro, 2024; Singh et al., 2023).The operational implementation construct was defined through repeated associations between terms such as "lean six sigma," "DMAIC," "process monitoring," "sustainability," and "work simplification," which consistently emerged as central themes in recent studies (K. S. Kumar et al., 2022; Mistarihi et al., 2023). These indicators reflect the foundational methodologies and practices that underpin successful LSS initiatives in hospitals, emphasizing the stepwise DMAIC process, continuous process monitoring, and the integration of sustainability goals into operational improvement projects (K. S. Kumar et al., 2022). Articles that focus on real-world LSS deployments, often highlight the combined presence and importance of these indicators, reinforcing their selection for construct measurement (Garedew et al., 2025; Prastiwi & Ayuningtyas, 2023; Scala et al., 2021; Tosuner et al., 2023).

Similarly, the healthcare delivery and quality construct is grounded in keywords that not only recur with high frequency, but also demonstrate strong statistical correlations—such as "health care quality," "length of stay," "process improvement," "private hospital," and "human" factors (Moffatt et al., 2022; Scala et al., 2021; Tsai et al., 2021). These indicators capture the breadth of outcomes and service dimensions that LSS research aims to improve, from patient throughput to care quality, reflecting both patient-centered and organizational performance perspectives. The literature shows a consistent pattern: studies that report on reductions in length of stay or improvements in care quality typically document simultaneous focus on process improvement and related human resource strategies.

For the construct of organizational management and efficiency, the analysis revealed a tightly interconnected set of indicators, including "organization and management," "efficiency organizational," "healthcare cost," and "quality improvement" (Apostu et al., 2021; Caro Teller et al., 2020; Ibrahim et al., 2022; Kharub et al., 2024; P. Kumar et al., 2021; O'mahony et al., 2021; Suman & Prajapati, 2021; Tosuner et al., 2023). These keywords are often featured in studies that evaluate the managerial and economic impact of LSS interventions, demonstrating that effective leadership, resource allocation, and ongoing quality monitoring are vital to achieving sustainable results (Kharub et al., 2024; Suman & Prajapati, 2021).

In selecting indicators, both their statistical robustness (high correlation and significance within clusters) and their theoretical grounding in the recent literature were considered. The use of software tools such as Voyant and NVivo Plus facilitated the coding and grouping of multi-word terms into singular coded indicators, ensuring compatibility for further analysis and modeling. This data-driven, literature-anchored approach strengthens the validity of each construct, as the selected indicators not only reflect the conceptual foundations of LSS in healthcare, but also correspond to the empirical co-occurrence patterns found in recent research articles (Singh et al., 2023).

Overall, the indicator development process detailed here provides a robust foundation for subsequent modeling efforts, allowing for the construction of measurement models that are both theoretically coherent and empirically validated. These grounding each variable in the actual content and correlations presented in the table 3.

Having established the key constructs and their indicators through rigorous bibliometric and correlation analysis, the next logical step is to define and justify the hypothesized relationships—the path analysis—among these latent variables within the context of Lean Six Sigma (LSS) implementation in healthcare.

Based on the clustering of keywords and thematic alignment observed in the literature, a conceptual structural model emerges in which Organizational Management & Efficiency acts as a foundational enabler for both Operational Implementation and Healthcare Delivery and Quality. Specifically, strong organizational management and efficient resource allocation (e.g., leadership, cost control, and systematic quality improvement (P. Kumar et al., 2021; O'mahony et al., 2021; Suman & Prajapati, 2021) are hypothesized to directly facilitate the successful implementation of LSS methodologies. This is reflected in the positive and significant correlations observed between indicators such as "organization and management" and operational terms like "DMAIC process" and "process monitoring" (P. Kumar et al., 2021; Tosuner et al., 2023; Tsai et al., 2021).The model

further posits that Operational Implementation—the actual deployment of LSS tools and practices, including DMAIC cycles, process monitoring, and work simplification—serves as a key driver of improvements in Healthcare Delivery and Quality. This relationship is grounded in both the literature and empirical evidence, where articles consistently report that structured process improvement initiatives yield measurable gains in care quality, reductions in patient length of stay, and enhanced patient-centered outcomes (Al-Zuheri et al., 2021; Danet Danet & Pérez Lázaro, 2024). The strong correlation between operational and quality indicators in the dataset supports this directional path.

Additionally, Organizational Management & Efficiency is hypothesized to exert a direct effect on Healthcare Delivery and Quality as well. Even in the absence of formal LSS implementation, sound management practices and efficient resource utilization can independently enhance care outcomes, as documented in studies that focus on managerial interventions or cost control measures.

This path model can be visualized in Figure 5.

Empirically, these paths will be tested using PLS-SEM, with each latent construct measured by its respective indicators as detailed in Table X. The expectation, based on both theory and the observed bibliometric relationships, is that all three hypothesized paths will be positive and statistically significant, reflecting a synergistic relationship where strong management fosters operational excellence, which in turn drives higher quality healthcare delivery. The model also allows for the exploration of potential mediating effects—specifically, whether Operational Implementation mediates the relationship between Organizational Management & Efficiency and Healthcare Delivery and Quality, an issue highlighted in recent literature but often not explicitly tested.

CONSTRUCT IDENTIFICATION FOR FURTHER RESEARCH MODELING

This study systematically explored the landscape of Lean Six Sigma (LSS) research in the healthcare sector through an integrated bibliometric and keyword co-occurrence analysis. By leveraging advanced tools such as VOSviewer, NVivo Plus, and Voyant Tools, the research identified three core constructs: Organizational Management & Efficiency, Operational Implementation, and Healthcare Delivery and Quality. Each construct was empirically grounded in frequently co-occurring, highly correlated indicators, providing a robust foundation for conceptualizing and measuring these variables in future quantitative research. The path model proposed in this study offers a clear and data-driven framework for understanding the direct and indirect relationships among these constructs, reinforcing the critical role of organizational management in enabling operational excellence and ultimately driving improvements in healthcare delivery outcomes.

Implications

The findings of this research contribute significantly to both theory and practice. For scholars, the systematic process of indicator development and path modeling bridges the gap between qualitative bibliometric insights and quantitative construct measurement. The resulting constructs and indicators are directly applicable for future empirical studies employing PLS-SEM or related analytical approaches, ensuring both conceptual clarity and empirical validity. For practitioners and hospital administrators, the study highlights the importance of integrated management practices and structured operational methodologies, such as DMAIC and process monitoring, as essential levers for enhancing patient outcomes and organizational performance. The evidence-based model presented herein can guide targeted improvement initiatives and inform policy decisions in healthcare management.

Limitations

While this study provides a comprehensive and rigorous mapping of Lean Six Sigma research in healthcare, several limitations should be acknowledged. The review is limited to articles indexed in the Scopus database, published in English, and confined to a specific five-year period. As a result, relevant studies published in other databases, in non-English languages, or outside this timeframe may not have been captured in the analysis. This may limit the generalizability of the findings, particularly in regions or contexts where LSS research is disseminated through alternative publication channels. Furthermore, the reliance on bibliometric data and keyword analysis, while robust for construct identification, does not substitute for primary empirical validation, which remains an important avenue for future work. Furthermore, it should be noted that much of the available research in this review appears to focus on private hospital institutions. This term generally refers to hospitals that operate with a higher degree of autonomy, resource availability, and typically higher quality standards compared to many public or community-based hospitals. As a result, the findings and proposed constructs may be more reflective of contexts where organizational structure, management efficiency, and quality improvement

processes are already well established, potentially limiting the applicability of results to less resourced or differently managed healthcare settings.

Recommendations for Further Research

Building on the construct mapping and path analysis presented in this study, future research is encouraged to operationalize these variables through primary data collection, such as surveys or structured interviews, within diverse healthcare settings. Empirical testing using PLS-SEM will provide further validation of the proposed relationships and facilitate the exploration of mediating and moderating effects, such as the role of organizational culture or technological adoption. Researchers are also recommended to extend the model by incorporating additional constructs, such as patient safety, digital transformation, or external regulatory influences, to capture emerging trends in healthcare quality improvement. Finally, longitudinal studies could be conducted to assess the temporal dynamics of Lean Six Sigma implementation and its sustained impact on healthcare performance over time.

CONCLUSIONS

This study makes an important contribution to understanding the dynamics of Lean Six Sigma (LSS) research in the healthcare sector through a meta-data analysis approach based on a systematic literature review following the PRISMA protocol. By analyzing 38 Scopus-indexed scientific articles between 2021 and 2025, this study successfully maps the main themes, research trends, and relationships between constructs that emerge in the LSS literature in the healthcare sector. The analysis results show that the LSS research landscape in the healthcare sector is collaborative and rapidly evolving, with the participation of 130 authors from 57 countries, and supported by a variety of academic journals and publishers. India is recorded as the country with the highest publication volume, indicating regional disparities and the importance of increasing participation from underrepresented countries, such as Indonesia. Three core constructs were identified, namely organizational management & efficiency, operational implementation, and health service delivery and quality, each of which was empirically strengthened through keyword co-existence and keyword correlation analysis. This study also develops solid indicators for each of these constructs and constructs a data-based path model that can be used in further quantitative analysis using the PLS-SEM (Partial Least Squares Structural Equation Modeling) method. Although this study offers in-depth theoretical and practical understanding of the application of LSS in the healthcare sector, there are several limitations that need to be considered. The focus only on English-language articles indexed by Scopus in the last five years, as well as the dominance of studies on private hospital institutions, may affect the generalizability of the findings.

REFERENCE LIST

[1] Abdallah, A. (2014). Implementing quality initiatives in healthcare organizations: Drivers and challenges. *International Journal of Health Care Quality Assurance*, *27*(3), 166–181. https://doi.org/10.1108/IJHCQA-05-2012-0047

[2] Al-Zuheri, A., Vlachos, I., & Amer, Y. (2021). Application of Lean Six Sigmay Reduce Patient Waiting Time: Literature Review. *International Journal for Quality Research*, *15*(1), 241–258. https://doi.org/10.24874/IJQR15.01-14

[3] Apostu, S. A., Vasile, V., & Veres, C. (2021). Externalities of lean implementation in medical laboratories. Process optimization vs. adaptation and flexibility for the future. *International Journal of Environmental Research and Public Health*, *18*(23). https://doi.org/10.3390/ijerph182312309

[4] Bhat, S., Antony, J., Gijo, E. V, & Cudney, E. A. (2020). Lean Six Sigma for the healthcare sector: a multiple case study analysis from the Indian context. *International Journal of Quality and Reliability Management*, *37*(1), 90–111. https://doi.org/10.1108/IJQRM-07-2018-0193

[5] Bhat, S., Gijo, E. V, Antony, J., & Cross, J. (2023). Strategies for successful deployment and sustainment of Lean Six Sigma in healthcare sector in India: a multi-level perspective. *TQM Journal*, *35*(2), 414–445. https://doi.org/10.1108/TQM-10-2021-0302

[6] Caro Teller, J. M., Pablos Bravo, S., Serrano Garrote, O., Ojeda García, C., Carro Ruiz, A. M., Guede González, A. M., & Ferrari Piquero, J. M. (2020). Implementation of the Lean Six Sigma in the improvement of the medication dispensing circuit. *Journal of Healthcare Quality Research*, *35*(6), 364–371. https://doi.org/10.1016/j.jhqr.2020.04.005

[7] Danet Danet, A., & Pérez Lázaro, J. J. (2024). Lean Methodologies in Healthcare. A Proposal for an Analytical-Conceptual Map to Systematize Its Impact and Results. *Revista Gerencia y Politicas de Salud*, *23*.

https://doi.org/10.11144/Javeriana.rgps23.mlsp
[8] Dempsey, A., Robinson, C., Moffatt, N., Hennessy, T., Bradshaw, A., Teeling, S. P., Ward, M., & McNamara, M. (2021). Lean six sigma redesign of a process for healthcare mandatory education in basic life support—a pilot study. *International Journal of Environmental Research and Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111653
[9] Egan, P., Pierce, A., Flynn, A., Teeling, S. P., Ward, M., & McNamara, M. (2021). Releasing operating room nursing time to care through the reduction of surgical case preparation time: A lean six sigma pilot study. *International Journal of Environmental Research and Public Health*, *18*(22). https://doi.org/10.3390/ijerph182212098
[10] Garedew, B. T., Azene, D. K., Jilcha, K., & Betizazu, S. S. (2025). Machine learning-based lean service quality improvement by reducing waiting time in the healthcare sector. *International Journal of Quality and Reliability Management*, *42*(5), 1463–1484. https://doi.org/10.1108/IJQRM-09-2023-0292
[11] Ibrahim, I., Sultan, M., Yassine, O. G., Zaki, A., Elamir, H., & Guirguis, W. (2022). Using Lean Six Sigma to improve timeliness of clinical laboratory test results in a university hospital in Egypt. *International Journal of Lean Six Sigma*, *13*(5), 1159–1183. https://doi.org/10.1108/IJLSS-08-2021-0138
[12] Improta, G., Cesarelli, M., Montuori, P., Santillo, L. C., & Triassi, M. (2018). Reducing the risk of healthcare-associated infections through Lean Six Sigma: The case of the medicine areas at the Federico II University Hospital in Naples (Italy). *Journal of Evaluation in Clinical Practice*, *24*(2), 338–346. https://doi.org/10.1111/jep.12844
[13] Kharub, M., Gupta, H., Rana, S., & McDermott, O. (2024). Determination of driving power and dependency of wastes in the healthcare sector: a lean and ISM-Based approach. *International Journal of Quality and Reliability Management*, *41*(7), 1838–1864. https://doi.org/10.1108/IJQRM-11-2021-0380
[14] Kumar, K. S., Babu, R. V, & Paranitharan, K. P. (2022). Application of integrated Lean Six Sigma quality healthcare system practice in Indian healthcare. *International Journal of Value Chain Management*, *13*(1), 112–139. https://doi.org/10.1504/IJVCM.2022.122165
[15] Kumar, P., Singh, D., & Bhamu, J. (2021). Development and validation of DMAIC based framework for process improvement: a case study of Indian manufacturing organization. *International Journal of Quality and Reliability Management*, *38*(9), 1964–1991. https://doi.org/10.1108/IJQRM-10-2020-0332
[16] Kumar, S., Swarnakar, V., Phanden, R. K., Antony, J., Jayaraman, R., & Khanduja, D. (2024). Analyzing critical success factors of Lean Six Sigma for implementation in Indian manufacturing MSMEs using best-worst method. *Benchmarking*, *31*(9), 2960–2983. https://doi.org/10.1108/BIJ-08-2022-0540
[17] Masso, M., Robert, G., McCarthy, G., & Eagar, K. (2010). The Clinical Services Redesign Program in New South Wales: Perceptions of senior health managers. *Australian Health Review*, *34*(3), 352–359. https://doi.org/10.1071/AH08720
[18] Mistarihi, M. Z., AL-Tahat, M. D., & AL-Nimer, S. H. (2023). Improving Process Efficiency at Pediatric Hospital Emergency Department Using an Integrated Six-Sigma Simulation Methodology. *Processes*, *11*(2). https://doi.org/10.3390/pr11020399
[19] Moffatt, S., Garry, C., McCann, H., Teeling, S. P., Ward, M., & McNamara, M. (2022). The Use of Lean Six Sigma Methodology in the Reduction of Patient Length of Stay Following Anterior Cruciate Ligament Reconstruction Surgery. *International Journal of Environmental Research and Public Health*, *19*(3). https://doi.org/10.3390/ijerph19031588
[20] O'mahony, L., McCarthy, K., O'donoghue, J., Teeling, S. P., Ward, M., & McNamara, M. (2021). Using lean six sigma to redesign the supply chain to the operating room department of a private hospital to reduce associated costs and release nursing time to care. *International Journal of Environmental Research and Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111011
[21] Ortiz-Barrios, M., & Alfaro-Saiz, J.-J. (2020). An integrated approach for designing in-time and economically sustainable emergency care networks: A case study in the public sector. *PLoS ONE*, *15*(6 June). https://doi.org/10.1371/journal.pone.0234984
[22] Prastiwi, A. C., & Ayuningtyas, D. (2023). Implementation of Lean Six Sigma in Healthcare During and After the COVID-19 Pandemic: Literature Review. *Media Publikasi*

Promosi Kesehatan Indonesia, *6*(8), 1518–1526. https://doi.org/10.56338/mppki.v6i8.3556

[23] Scala, A., Ponsiglione, A. M., Loperto, I., Della Vecchia, A., Borrelli, A., Russo, G., Triassi, M., & Improta, G. (2021). Lean six sigma approach for reducing length of hospital stay for patients with femur fracture in a university hospital. *International Journal of Environmental Research and Public Health*, *18*(6), 1–13. https://doi.org/10.3390/ijerph18062843

[24] Sethi, D., & Joshi, S. G. (2020). Knowledge and attitude of nurses toward the implementation of quality management systems with special reference to six sigma. *Journal of Datta Meghe Institute of Medical Sciences University*, *15*(1), 91–93. https://doi.org/10.4103/jdmimsu.jdmimsu_120_19

[25] Singh, M., Rathi, R., Jaiswal, A., Manishbhai, S. D., Gupta, S. S., & Dewangan, A. (2023). Empirical analysis of Lean Six Sigma implementation barriers in healthcare sector using fuzzy DEMATEL approach: an Indian perspective. *TQM Journal*, *35*(8), 2367–2386. https://doi.org/10.1108/TQM-05-2022-0152

[26] Suman, G., & Prajapati, D. R. (2021). Utilization of Lean & Six Sigma quality initiatives in Indian healthcare sector. *PLoS ONE*, *16*(12 December). https://doi.org/10.1371/journal.pone.0261747

[27] Tosuner, Z., Karaer, O., & İnce, Ü. (2023). Lean Six Sigma Applications in a Multicenter Pathology Laboratory: an Industrial Pathology Model. *Operations Research Forum*, *4*(3). https://doi.org/10.1007/s43069-023-00240-5

[28] Trakulsunti, Y., Antony, J., & Douglas, J. A. (2021). Lean Six Sigma implementation and sustainability roadmap for reducing medication errors in hospitals. *TQM Journal*, *33*(1), 33–55. https://doi.org/10.1108/TQM-03-2020-0063

[29] Trakulsunti, Y., Antony, J., Ghadge, A., & Gupta, S. (2020). Reducing medication errors using LSS Methodology: A systematic literature review and key findings. *Total Quality Management and Business Excellence*, *31*(5–6), 550–568. https://doi.org/10.1080/14783363.2018.1434771

[30] Tsai, H.-W., Huang, S.-W., Hung, Y.-L., Hsu, Y.-S., & Huang, C.-C. (2021). Use of the smart lean method to conduct high-quality integrated perioperative management prior to hospitalization. *International Journal of Environmental Research and Public Health*, *18*(24). https://doi.org/10.3390/ijerph182413391

[31] Tuegeh, O. D. M., Nagy, A., & Tumiwa, J. R. (2024). Transformasi Sintesis Data Kualitatif Menjadi Analisis Meta Data Tentang Manajemen Akuntansi Lingkungan. *Jurnal Akuntansi Manado (JAIM)*, *5*(3), 512–535. https://doi.org/10.53682/jaim.vi.10010

[32] Tumiwa, J. R., Tuegeh, O., Bittner, B., & Nagy, A. (2022). The Challenges To Developing Smart Agricultural Village In The Industrial Revolution 4.0 - The Case of Indonesia. *Torun International Studies*, *1*(15), 0–2. https://doi.org/10.12775/TIS.2022.002

[33] Ward, M. E., Daly, A., McNamara, M., Garvey, S., & Teeling, S. P. (2022). A Case Study of a Whole System Approach to Improvement in an Acute Hospital Setting. *International Journal of Environmental Research and Public Health*, *19*(3). https://doi.org/10.3390/ijerph19031246

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Figure 1.
Descriptive Analysis Summary

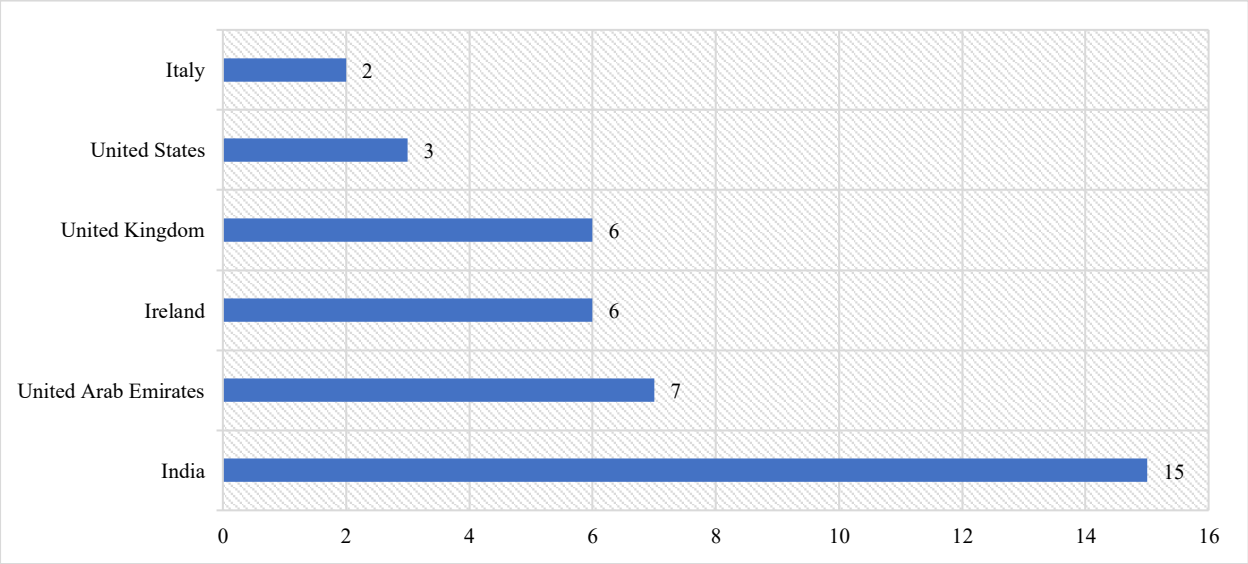

Figure 2a.
Country distribution of Lean Six Sigma in healthcare articles (2021–2025)

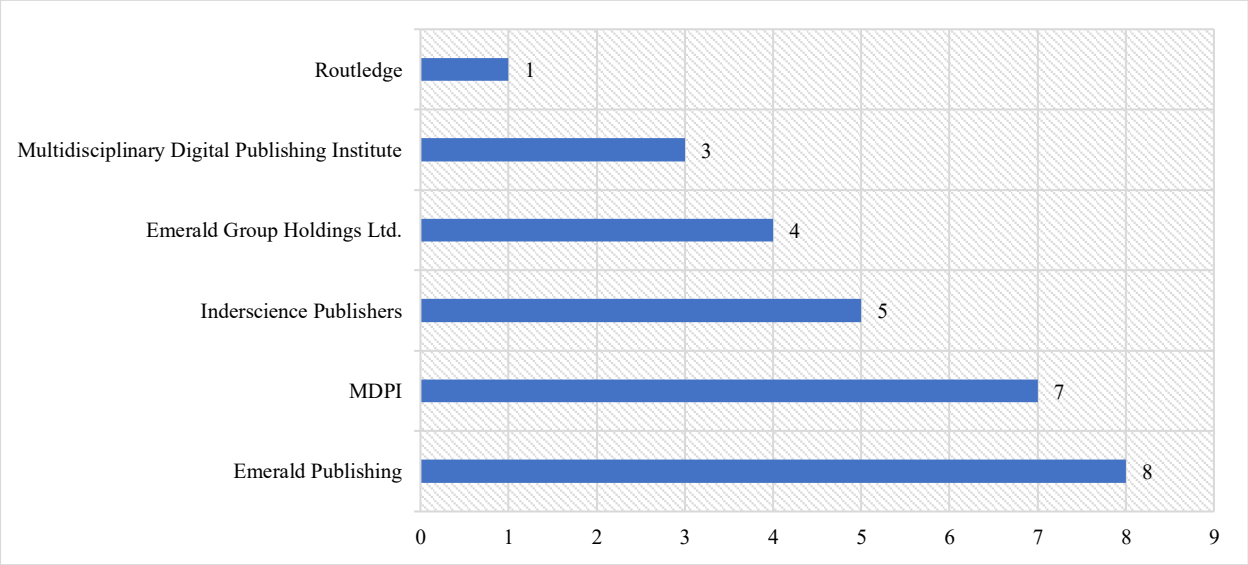

Figure 2b.
Frequency of publishers contributing to LSS healthcare research

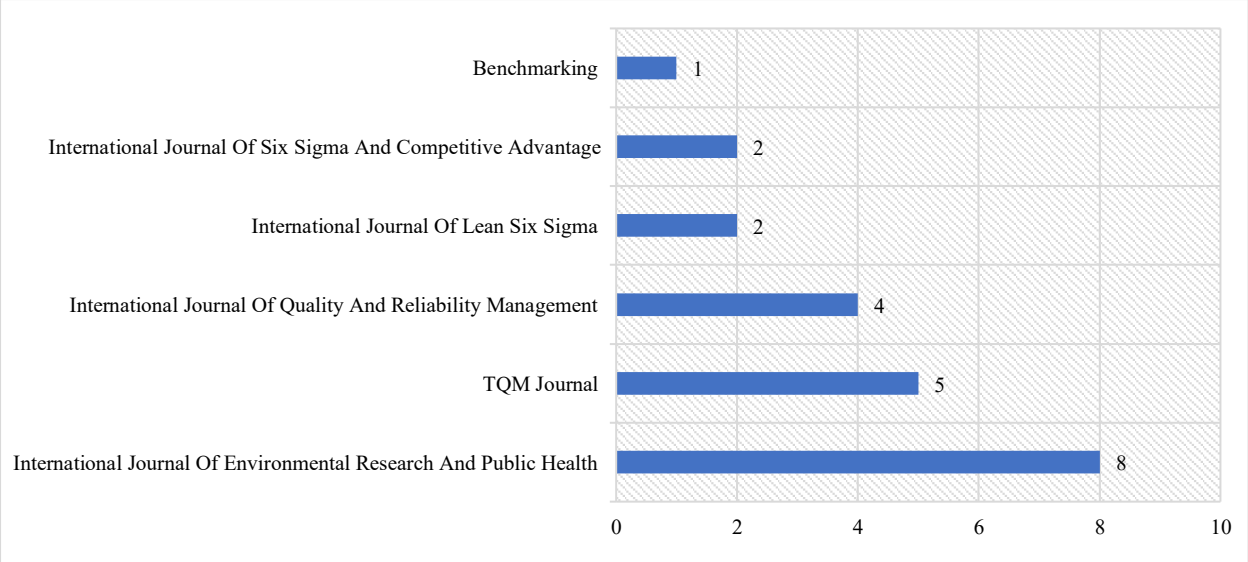

Figure 2c.
Most frequent journals publishing LSS articles in the healthcare domain

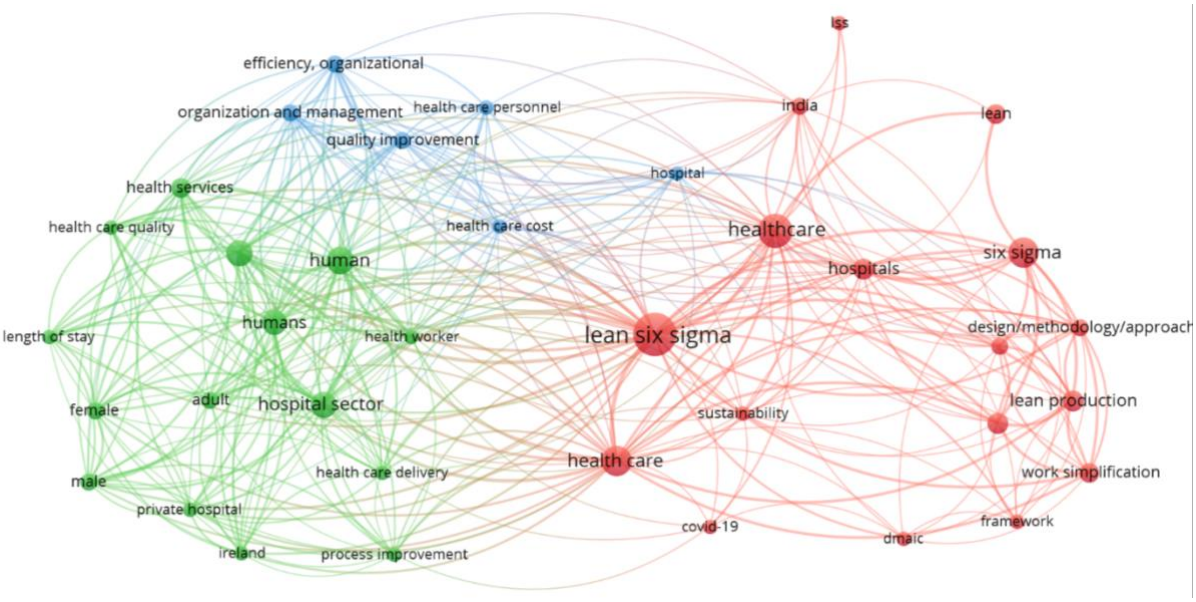

Figure 3
Multidimensional Character of Lean Six Sigma Research in the Healthcare Sector by VOSviewer

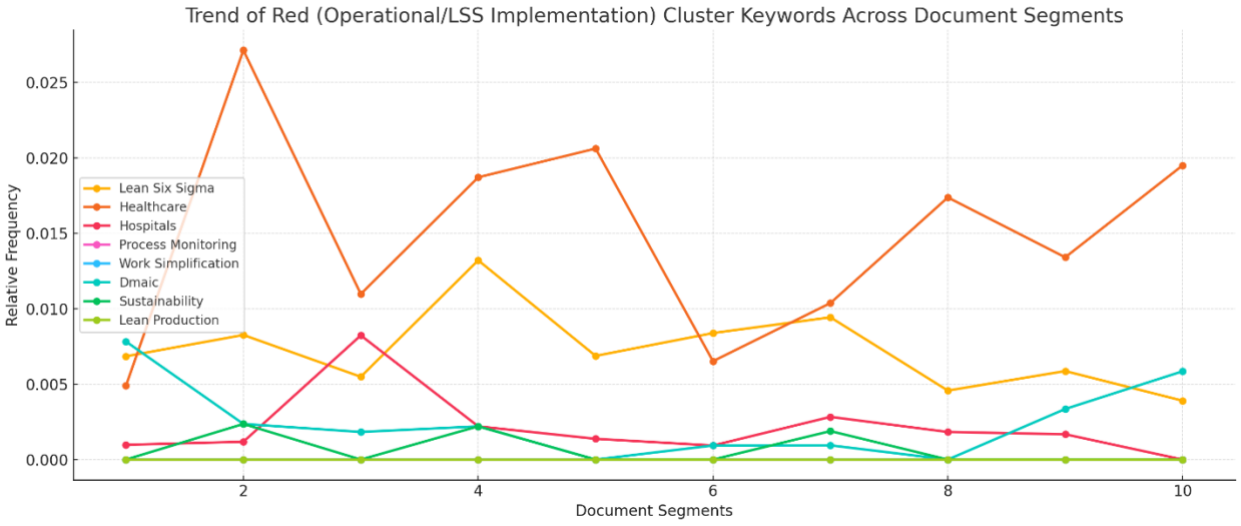

Figure 4a.
Output Trend for Red Cluster – Operational/LLS Implementation

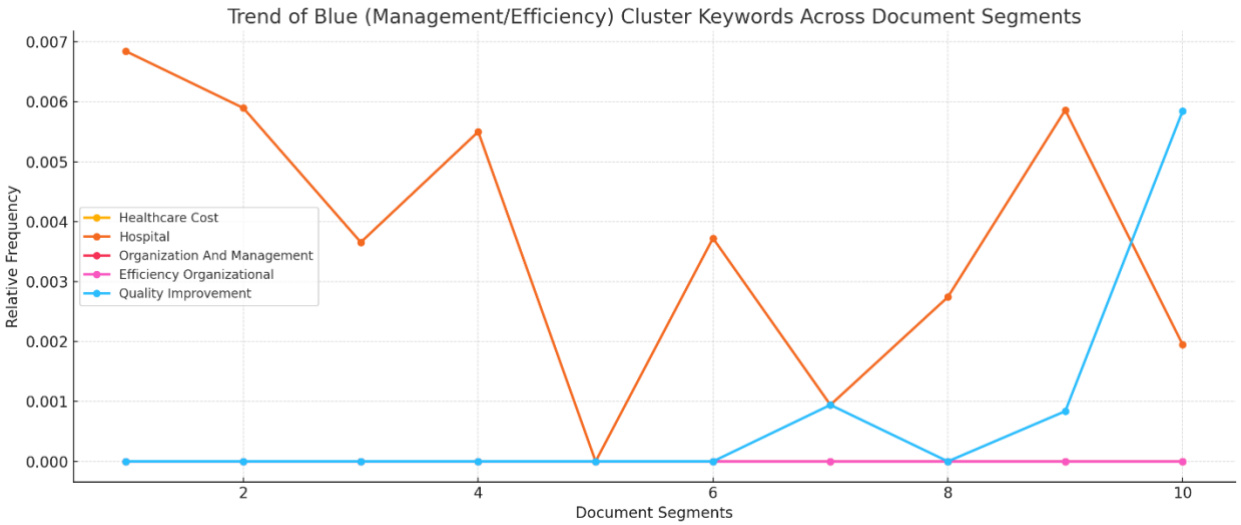

Figure 4b.
Output Trend for Blue Cluster – Management/Efficiency

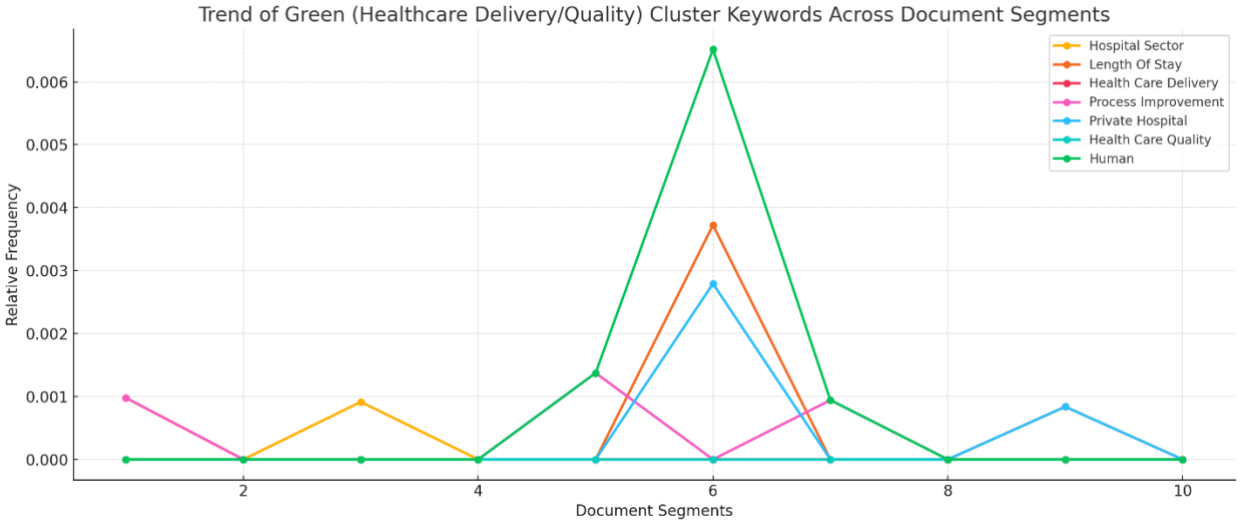

Figure 4c.
Output Trend for Gree Cluster – Delivery/Quality

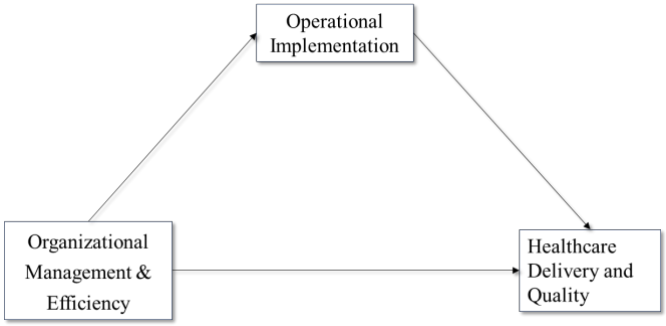

Figure 5.
Proposed Path Model for Lean Six Sigma Implementation in Healthcare

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Table 1.
Keyword Co-occurrence and Link Strength based on your VOSviewer analysis

Keyword	Occurrences	Total Link Strength
lean six sigma	25	160
article	10	112
human	10	112
health care	12	111
hospital sector	9	100
total quality management	9	99
humans	8	95
healthcare	16	70
health services	5	62
six sigma	12	58
female	4	51
male	4	51
hospitals	6	50
adult	4	47
efficiency, organizational	4	47
organization and management	4	47
quality improvement	4	46
lean production	6	45
process monitoring	6	45

Source: Author Data Processing 2025

Table 2
Keyword Correlation and Significance

Term 1	←	→	Term 2	Correlation	Significance
LSS			monitoring	0.964583	0.003015
LSS			dmaic	0.862471	0.032155
LSS			sustainability	0.760132	0.035089
LSS			simplification	0.909229	0.748881
health_care_quality			improvement	0.933566	0.001388
hospital			private	0.832110	0.030220
human			length	0.906608	0.027375
healthcare_cost			organization_management	0.800621	0.018956
efficiency_organizational			improvement	0.953340	0.006767
hospital			management	0.822035	0.037776
hospital			dmaic	0.845923	0.683493
organization_management			improvement	0.732016	0.011266

Source: Author Data Processing 2025

Table 3
Variables and Their Indicators for Construct Measurement

Construct (Variable)	Indicators (Measurement Items)	Source(s)/Supporting Articles
Operational Implementation	○ Lean Six Sigma adoption ○ DMAIC process ○ Process monitoring ○ Sustainability initiatives ○ Work simplification ○ Lean production	Antony et al., 2021; Gijo & Antony, 2021; Chiarini et al., 2021; Desai et al., 2022
Healthcare Delivery and Quality	○ Health care quality ○ Length of stay ○ Process improvement ○ Private hospital involvement ○ Human factors (staff, patient-centricity)	Chiarini et al., 2021; Gijo et al., 2022; Thomas et al., 2022; Desai et al., 2022
Organizational Management & Efficiency	○ Organization and management ○ Efficiency organizational ○ Healthcare cost management ○ Quality improvement initiatives	Thomas et al., 2022; Sreedharan et al., 2022; Antony et al., 2021; Chiarini et al., 2021

Source: Author Data Processing 2025