



The Evolution of Lean Six Sigma Research in Hospitals: Trends, Themes, and Future Directions

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Track Record Article	Abstract
Revised: 24 July 2026 Accepted: 26 September 2026 Published: 29 September 2026 How to cite : Fadhilah, N. R., & Arini, M. (2026). The Evolution of Lean Six Sigma Research in Hospitals: Trends, Themes, and Future Directions. <i>Contagion: Scientific Periodical Journal of Public Health and Coastal Health</i>, 8(3), 602–618.	<i>In response to the increasing complexity of healthcare services, hospitals have adopted systemized approaches to enhance operational performance while ensuring safe, high-quality patient care. Lean Six Sigma (LSS) has been widely applied in healthcare settings to improve processes, such as patient flow, discharge procedures, and hospital length of stay. However, the overall development of LSS research in hospitals, including the evolution and interrelationships of key research themes, has not been comprehensively examined. This study aimed to explore the current landscape of hospital-based LSS research with respect to publication trends, major research themes, collaboration characteristics, and research gaps. A total of 70 publications indexed in the Scopus database between 2016 and 2025 were analysed using the keywords “Lean Six Sigma” AND “Hospital”. Bibliographic data were analysed using Bibliometrix in R and VOSviewer to examine publication trends, keyword co-occurrence networks, collaboration networks, and thematic evolution. The results showed that publications increased at an annual growth rate of 18.19% indicating growing interest in hospital-based LSS research. Research efforts were primarily focused on operational efficiency, particularly patient flow, discharge processes, and length of stay. Three interconnected research domains emerged: operational efficiency, clinical quality, and organisational performance. Identified research gaps included the limited integration of digital technologies, the underrepresentation of low- and middle-income countries, limited international collaboration, and relatively less attention to patient safety and patient-centred outcomes. Although hospital-based LSS research continues to expand, it remains predominantly oriented toward operational improvement. Future research should focus on integrating digital technologies, broadening the range of healthcare contexts studied, strengthening international collaboration, and addressing clinical, safety, and patient-centred outcomes.</i> Keywords: <i>Lean Six Sigma, Healthcare Quality Improvement, Operational Efficiency, Patient Safety, Hospital Process Management, Bibliometric Analysis, VOSviewer.</i>

INTRODUCTION

In recent years, healthcare systems have faced increasing pressure to improve operational efficiency without compromising patient safety and quality of care. Patient harm remains a major concern in healthcare delivery. The World Health Organization estimates that approximately one in ten patients experiences harm during healthcare, while many of these incidents are potentially preventable through stronger healthcare systems and better-designed service processes. The situation is particularly concerning in low- and middle-income countries, where hospitals are estimated to experience around 134 million adverse events

annually. These events are associated with around 2.6 million deaths and impose substantial economic and social burdens on healthcare systems and communities (Organization, 2021;Slawomirski et al., 2017). Such conditions have heightened the need for management approaches that improve healthcare processes while maintaining the quality and safety of patient care. One approach that has gained increasing attention is Lean Six Sigma (LSS), which was originally developed in industrial settings and has since been adapted for healthcare quality improvement (Komaling et al., 2025).

Lean Six Sigma (LSS) integrates two complementary principles: Lean, which emphasises the elimination of non-valuable-added activities, and Six Sigma, which focuses on reducing process variation and defects (Komaling et al., 2025). These principles have been applied in hospitals to address a range of operational challenges, including patient flow, waiting times, length of stay, discharge processes, and procedural or administrative errors (Sonali & Shenoy, 2025). Healthcare is particularly well suited to the application of LSS because it involves complex interactions among clinical staff, administrative personnel, patients, technology, and available resources in the delivery of care. Consequently, variations in demand, resources constraints, and interdependencies among processes can contribute to delays, unnecessary activities, and other inefficiencies.

Previous research has primarily focused on the operational aspects of Lean Six Sigma (LSS). Commonly investigated areas include patient waiting times, patient flow, discharge processes, resource utilisation, and process variation (Al-Zain et al., 2019;Zhafarin et al., 2023). More recently, the application of LSS has extended to patient safety initiatives, including error reduction and process standardization (Niñerola et al., 2020). Despite these developments, the literature remains largely centered on process improvement and patient safety, whereas clinical outcomes and patient-centred care are less frequently examined as primary outcomes of LSS interventions. This pattern suggests that research on LSS in hospital settings is gradually expanding beyond operational efficiency, highlighting the need for more holistic approach that considers quality of care, patient safety, clinical outcomes, and overall organisational performance.

The field of LSS continues to grow, making it important to understand its historical development and evolution. However, merely counting publications is insufficient. It is also necessary to identify the research themes that have been explored over time, emerging areas of interests, and the relationships among researchers and research communities. Several issues remain relevant in the current literature. First, LSS the integration of LSS with digital and data-driven technologies has not been fully explored. Second, research from low- and middle-

income countries remains underrepresented. Third, international collaboration among researchers is still limited. Fourth, comparatively little attention has been given to patient safety and clinical outcomes relative to operational performance. These gaps present opportunities for further investigation through a bibliometric approach. Therefore, this study tried to systematically map the publication patterns, research topics, and cooperation in the hospital-based LSS literature.

In this light, the present study aimed to provide a bibliometric analysis of Lean Six Sigma (LSS) research conducted in hospital settings and published between 2016 and 2025. The analysis examines publication trends, keyword co-occurrence patterns, thematic development, temporal evolution, and collaborative relationships among authors to provide a comprehensive understanding of the field development. The study also explored the emergence of research related to digital technologies, the geographical distribution of publications, the extent of international collaboration, and the degree to which patient safety and outcome-oriented perspectives have been incorporated into the literature. By integrating these dimensions, the study offers a focused overview of the current state of LSS research in hospitals and identifies areas that warrant greater attention in future investigations, including the role of digital technologies, the expansion of international research collaboration, and the integration of operational improvement initiatives with patient safety, clinical outcomes, and patient-centred care.

METHOD

Research Design

A descriptive bibliometric design using a science mapping approach was applied in this study. This approach was used to explore the evolution of Lean Six Sigma (LSS) research in hospitals and to identify the relationships among key research components. The study employed network analysis to examine the connections among central concepts, authors, and research institutions. The analysis also facilitated the investigation of the evolution of key themes, concepts, and collaboration patterns within the contemporary LSS literature on hospitals.

Data Source and Search Strategy

In this study, the literature was sourced from the Scopus database. Scopus was selected because it provides extensive coverage of peer-reviewed international publications, along with structured bibliographic and citation data. The use of a single database also ensured consistency across records and minimised potential differences in metadata among databases. Although

other databases, such as Web of Science, PubMed, and Dimensions, may have yielded additional publications, the aim of this study was to describe and map the development of Lean Six Sigma (LSS) research in hospitals rather than to conduct a comprehensive clinical evidence review. Therefore, Scopus was considered an appropriate database for conducting the bibliometric analysis (Mongeon & Paul-Hus, 2016; Donthu et al., 2021).

The search was carried out on Scopus on 18 January 2026. The search strategy used publications containing the words "Lean Six Sigma" and "hospital" in the title, abstract, or keywords. The following search strings were used:

Lean Six Sigma AND hospital AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "arv") OR LIMIT-TO(DOCTYPE, "a")) AND (LIMIT-TO(EXACTKEYWORD, "Human") OR LIMIT-TO(EXACTKEYWORD, "Humans")) AND LIMIT-TO(LANGUAGE, "English") AND LIMIT-TO(SRCTYPE, "j") AND LIMIT-TO(OA, "all") AND PUBYEAR > 2015 AND PUBYEAR < 2026.

The observation period for this study was 2016-2025, and the literature search was therefore restricted to publications within this timeframe. The year 2016 was selected as the starting point because studies applying Lean Six Sigma (LSS) in hospital settings had already been published by that time. The year 2025 was chosen as the final year because it represented the most recent complete publication year available at the time of the search. Publications from 2026 were not excluded because the search was conducted in January, when publication records for that year were still incomplete. This ten-year period provided a suitable basis for examining trends in publication output, thematic developments, research collaboration, and emerging topics in hospital-based LSS research.

Screening and Data Cleaning

Prior to screening, the following inclusion criteria were established to ensure the relevance and quality of the data. Only English-language, open-access journal articles indexed in Scopus were included in the analysis. Furthermore, only studies involving human subjects were considered, as defined by the Human/Humans filter in Scopus. Publications that did not meet these criteria were excluded. These included conference papers, review articles, book chapters, editorials, and other document types. Studies that were not conducted within the hospital healthcare context were also excluded, and records with incomplete bibliographic information were removed.

The initial search on Scopus yielded 346 records. The retrieved records were then manually screened to assess their relevance to the research topic and their compliance with the predefined inclusion criteria. During this stage, duplicate records and inconsistencies in the

bibliographic metadata were identified and removed. Following the screening, deduplication, and data-cleaning processes, 70 articles remained for analysis. The overall selection procedure was guided by the principles of PRISMA, ensuring a clear and transparent account of the identification and screening process. The final dataset of 70 articles was subsequently analysed using Bibliometrix (in RStudio) and VOSviewer to generate insights into the evolution and structure of the research field.

Data Analysis

The bibliometric analysis was conducted through several sequential stages, as illustrated in Figure 1. First, bibliographic records were retrieved from Scopus and exported in CSV format. The dataset contained relevant publication information, including article titles, authors, keywords, publication years, source titles, and citation data. The retrieved records were then processed and analysed using Bibliometrix in RStudio and VOSviewer. Bibliometrix was used to examine the general characteristics of the publications, while VOSviewer facilitated the mapping of research relationships through keyword co-occurrence and co-authorship analyses. The resulting maps were presented using network, overlay, and density visualisations, enabling the exploration of the development of research themes and the relationships among authors, institutions, and key research topics.

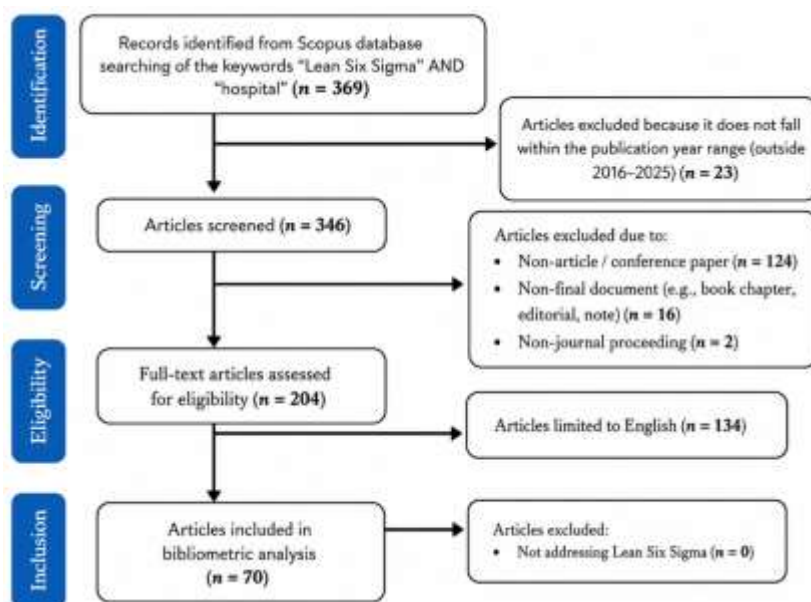


Figure 1. Research Flow

RESULTS

A comprehensive review of Lean Six Sigma (LSS) publications in the hospital sector from 2016 to 2025 was conducted to examine the characteristics of the existing literature, patterns of scientific growth, collaboration among researchers, and changes in the field's

conceptual and thematic structure. Using a science mapping approach, this study explores how the body of knowledge has evolved over time and the extent to which the field has become conceptually established. The findings indicate a gradual shift in research emphasis, from a primary focus on operational efficiency toward broader concerns related to process integration, quality improvement, and the overall hospital service performance. This evolution reflects an increasing orientation toward a value-based approach that integrates clinical quality, patient safety, and organisational performance.

Table 1. Characteristics of the Bibliometric Dataset

Indicator	Result
Publication period	2016–2025
Sources	37
Documents	70
Annual growth rate	18.19%
Average document age	5.04 years
Average citations per document	16.63
Total references	552
Keywords Plus	751
Authors' keywords	214
Number of authors	404
Authors of single-authored documents	1
Single-authored documents	1
Average number of co-authors per document	6.6
International co-authorship	17.14%
Document type – Article	70

The results demonstrate an increase in research on the implementation of LSS in hospitals, as evidenced by the growing number of publications and citations. These findings suggest that this field of study is interdisciplinary, highly dependent on existing literature, and characterized by collaboration among authors. Nevertheless, the relatively low level of international collaboration indicates a degree of geographical fragmentation within the research landscape.

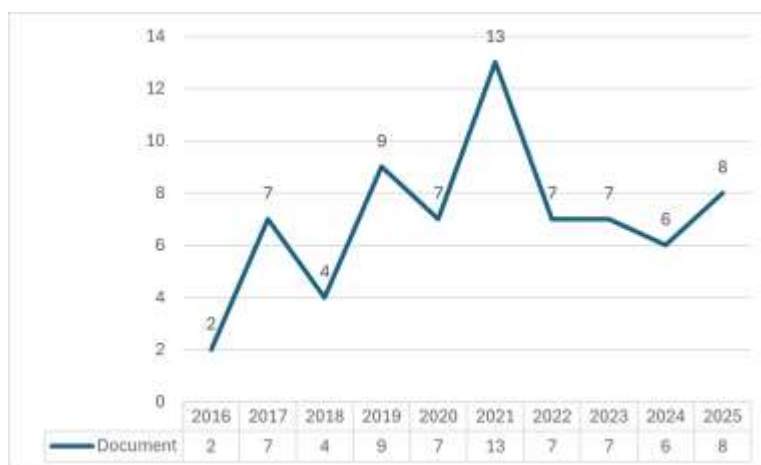


Figure 2. Publications by Year

As shown in Figure 2, publication output during the period from 2016 to 2025 was not stable but exhibited an overall upward trend. Beginning with only two publications in 2016 and reaching a peak of 13 publications in 2021, this growth indicates a substantial increase in interest in the application of Lean Six Sigma (LSS) within hospital settings. This trend was particularly evident in studies focusing on improving patient flow, reducing waiting times, and managing length of stay. Although the number of publications reached its highest level in 2021, publication output remained relatively consistent from 2022 to 2025. This pattern may suggest that research on hospital-based LSS has entered a more mature stage of development, characterized by sustained scholarly interest and continued contributions to the field.



Figure 3. Geographical distribution of publications on Lean Six Sigma in healthcare

Figure 3 illustrates a clear geographical concentration of LSS research in healthcare. Ireland and the United States account for the highest number of publications, with 16 publications each, whereas countries such as Brazil have produced substantially fewer studies. This pattern suggests that research on LSS in healthcare remains largely concentrated within a relatively small group of countries. In contrast, developing countries, including Indonesia, are less represented in the literature. Nevertheless, differences in publication output should not be interpreted solely as an indicators of the level of LSS implementation. Research capacity, access to funding, institutional priorities, and the extent of international collaboration may also influence the volume of research produced in a given country. Therefore, expanding international collaboration and conducting more context-specific studies could help broaden the understanding of LSS implementation across different healthcare systems.

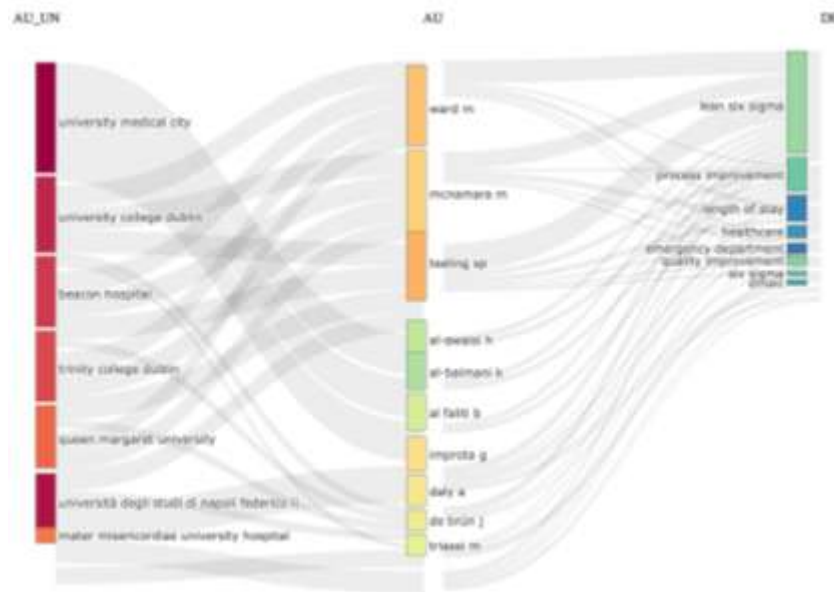


Figure 4. Three-field plot analysis

Figure 4 illustrates the relationships among institutions, authors, and keywords in the three-field plot (AU_UN-AU-DE). The institutions represented in the diagram are University Medical City, University College Dublin, Beacon Hospital, and Trinity College Dublin. Prominent authors identified in the network are Ward M, McNamara M, and Teeling SP. The analysis also highlights several key themes in the literature, including Lean six sigma, process improvement, length of stay, health care, and emergency department.

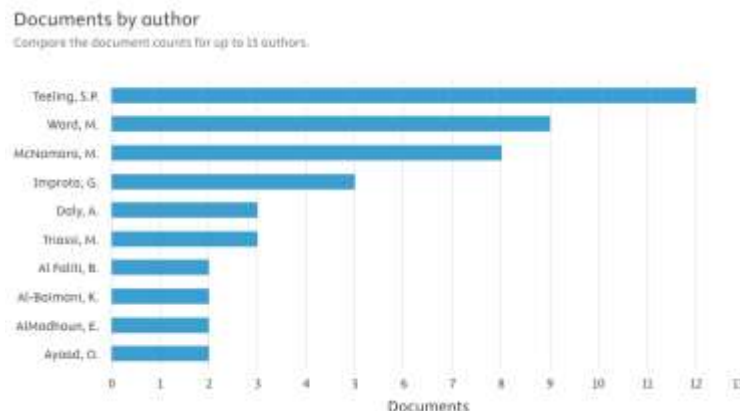


Figure 5. Author with the most contributions

Figure 5 indicates a high concentration of Lean Six Sigma (LSS) research in hospitals among the publications of a small number of highly active authors. These include Teeling, S.P. with 13 publications, followed by Voronov, M. (9), McNamara, M. (6), and Improta, G. (5). Authors with fewer than four publications occupy the peripheral areas of the network. This

pattern suggests that the field is largely driven by a small number of research clusters and leading contributors.

Table 2. Most Global Cited Documents

Author&Year	Title	Journal	Total Citattions	Total Citattions Per Year
(Scala et al., 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	102	17.00
(Improta et al., 2022)	Machine Learning and Lean Six Sigma to Assess How COVID-19 Has Changed the Patient Management of the Complex Operative Unit of Neurology and Stroke Unit: A Single Center Study	International Journal of Environmental Research and Public Health	81	16.20
(Antony et al., 2019)	An exploratory study into the use of Lean Six Sigma to reduce medication errors in the Norwegian public healthcare context	Leadership in Health Services	42	5.25
(Kam et al., 2021)	Using Lean Six Sigma techniques to improve efficiency in outpatient ophthalmology clinics	BMC Health Services Research	40	6.67
(Molla et al., 2018)	A Lean Six Sigma Quality Improvement Project Improves Timeliness of Discharge from the Hospital	The Joint Commission Journal on Quality and Patient Safety	40	4.44

Source: Rstudio

The following table highlights the most cited articles published in the field of Lean Six Sigma (LSS) in healthcare.

As shown in Table 2, most of these publications focus on the implementation of LSS in healthcare, particularly in relation to process improvement and patient safety. Key areas of investigation include patient management, the reduction of medication errors, ambulatory care, and hospital discharge processes. The high citation counts of these studies suggest that LSS remains an important area of research due to its potential to enhance operational efficiency and improve the quality and safety of healthcare services.

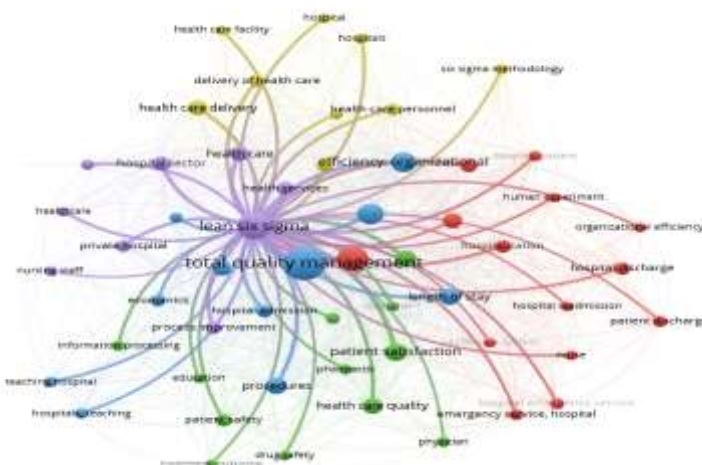


Figure 6. Network Mapping by Keyword

As illustrated in Figure 6, the keyword co-occurrence network reveals that Lean Six Sigma (LSS) and the total quality management are the two dominant themes in healthcare-related LSS research. These themes are closely associated with topics such as patient flow, hospital discharge, and length of stay, reflecting the strong emphasis on operational and process improvement within healthcare settings. Peripheral themes, including clinical safety, treatment outcomes, and interdisciplinary roles, suggest that LSS remains less integrated into clinical decision-making, partly because clinical outcomes are influenced by a wide range of factors beyond process design and management interventions. Overall, the thematic evolution indicates a shift from a primary focus on technical process optimisation toward broader organisational performance, quality improvement, and patient-centred care.

Table 3. Keyword Clusters and Thematic Grouping

Research Theme	Cluster Colour	Keywords
Quality Management and Lean Six Sigma in Hospital Performance Improvement	Blue	lean six sigma, total quality management, organizational efficiency, length of stay
Healthcare Quality and Patient Safety	Purple	health care, hospital sector, private hospital, nursing staff
Operational Efficiency and Hospital Patient Flow Management	Green	patient satisfaction, health care quality, patient safety, treatment outcome, drug safety, physician, pharmacist
	Red	organizational efficiency, hospitalization, hospital discharge, patient discharge, hospital readmission, emergency service hospital, nurse, human experiment
	Cyan (Light Blue)	hospital admission, procedures, process improvement, information processing, education, teaching hospital, hospital teaching
	Yellow	hospital, hospitals, health care personnel, delivery of health care, health care facility, six sigma methodology

Table 3 presented keyword network analysis reveals that LSS research in healthcare is structured around three main thematic domains. The first theme focuses on quality management and LSS as a framework for improving hospital performance. The second theme focuses on healthcare quality and patient safety, particularly in relation to clinical outcomes and indicators

used to assess service quality. Thirdly, the third theme relates to operation efficiencies and flow of patients, where researches include the issues of admission, discharging of patients, and improvement of work flow process within the health sector.

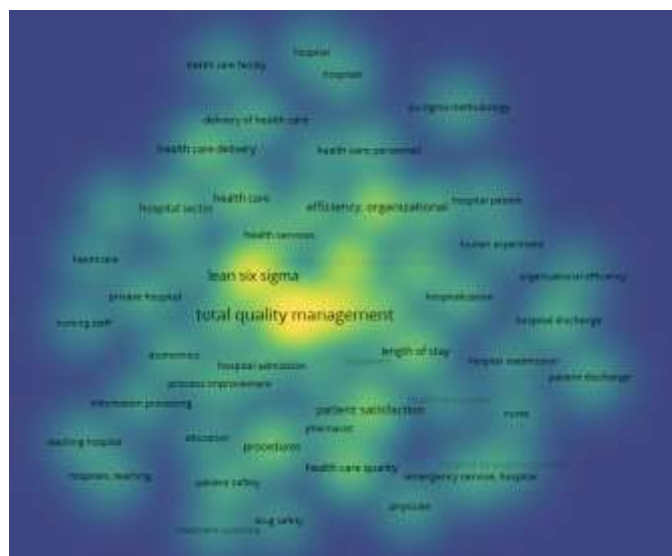


Figure 7. Lean six sigma overlay visualization (2016-2025)

As illustrated in Figure 7, there is a high density of research work associated with Lean Six Sigma (LSS) and total quality management regarding efficiency, operations within the hospital, and length of stay. On the other hand, patient safety and outcomes of treatment seem to be less emphasized while professional-specific aspects seem to be even less relevant. It seems that LSS-related research has mainly emphasized performance rather than patient safety and outcomes.

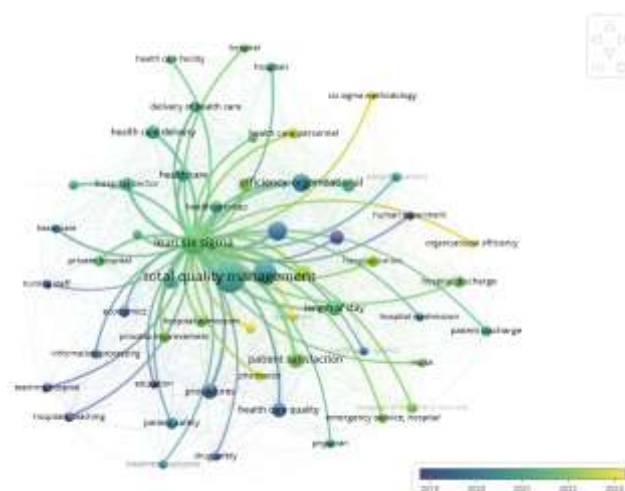


Figure 8. Development of Lean six sigma studies

The temporal evolution of themes in Lean Six Sigma (LSS) research in healthcare is depicted in Figure 8. LSS and total quality management remain central themes and are closely aligned with key healthcare objectives. Early studies primarily focused on quality management

and hospital processes, whereas more recent research has shifted toward topics such as patient admission, workflow optimization, information processing, length of stay, hospital discharge, organisational efficiency, and patient satisfaction. The limited emergence of digital and data-driven themes highlights opportunities for future research to integrate LSS with digital transformation initiatives in healthcare.

DISCUSSION

This study demonstrated that Lean Six Sigma (LSS) research in hospital settings has evolved from a primary focus on process improvement toward broader perspectives encompassing quality of care and organisational performance. Research has predominantly concentrated on patient flow, discharge management, length of stay, and process optimisation, reflecting the complexity of hospital operations and the need to address resource constraints and variability in service demand (Antony et al., 2021 ; Henrique & Godinho Filho, 2020).

The thematic evolution of the field also indicates a shift toward outcome-oriented quality management. Whereas earlier studies emphasised DMAIC, standardisation, waste reduction, and patient flow, more recent research increasingly links operational performance with patient safety, clinical quality, and organisational outcomes (Improta et al., 2021; Tanna et al., 2023; Antony et al., 2021; Steenbergen et al., 2025). This trend supports a socio-technical perspective of LSS, in which workflows, technology, organisational culture, leadership, and healthcare professionals collectively influence performance (Garvanovic et al., 2021; Buestan et al., 2025; Kemp et al., 2024).

Lean Six Sigma (LSS) can also be viewed through the lens of Value-Based Healthcare (VBHC), in which value is defined as the patient outcomes achieved relative to the resources utilised. From this perspective, research on patient flow, discharge processes, and length of stay is directly relevant to timeliness, resource utilisation, continuity of care, and patient experience (Brown et al., 2019; Molla et al., 2018; Rahul et al., 2020). However, because the present study employs a bibliometric approach, these patterns should be interpreted as indicators of research priorities and trends rather than as causal evidence of improvements in patient outcomes.

The findings are broadly aligned with the World Health Organization's dimensions of quality of care, particularly safety, effectiveness, people-centredness, timeliness, integration, equity, and efficiency. Research themes such as patient flow, discharge processes, and length of stay primarily reflect the dimensions of timeliness and efficiency, whereas standardisation is closely associated with effectiveness and safety. The growing attention to patient satisfaction further suggests an increasing emphasis on people-centred care. Nevertheless, clinical

outcomes, equity, and patient-centred care remain relatively underexplored within the LSS literature, highlighting the need for future research to adopt a more comprehensive approach to healthcare quality.

The integration of Lean Six Sigma (LSS) with artificial intelligence (AI), Big Data Analytics, and digital health technologies is emerging as a promising direction, particularly for process monitoring, demand forecasting, bottleneck identification, and deviation detection across the Measure, Analyse, and Control phases of DMAIC framework (Sonali & Shenoy, 2025; Tlapa et al., 2020). The concept of industry 5.0 further emphasizes human-centredness, resilience, and sustainability. Thus, future LSS research should seek to balance technological innovation with workforce wellbeing, patient-centred care, and the sustainable use of resources.

From a managerial perspective, LSS should be viewed as an approach to enhancing quality and value rather than solely as a cost-reduction strategy. Key processes such as patient flow, discharge management, emergency department operations, and length of stay should be evaluated using balanced set of indicators encompassing efficiency, safety, clinical outcomes, patient experience, and staff-related outcomes. In addition, the use of cross-functional teams and the integration of hospital information systems, process analytics, and AI technologies may further strengthen quality improvement initiatives.

Geographically, hospital-based Lean Six Sigma (LSS) research remains concentrated in a limited number of countries and institutional networks. Therefore, research influence should be evaluated not only in terms of publication output but also through citation impact and the extent of international collaboration, both of which are essential for facilitating knowledge transfer and contextual adaptation. Overall, LSS research in hospital settings is evolving from a primary focus on process optimization toward broader considerations of value, quality, technology, and organizational resilience. Integrating LSS with the World Health Organization (WHO) quality-of-care framework, Value-Based Healthcare (VBHC), artificial intelligence (AI), Big Data Analytics, and Industry 5.0 may provide valuable directions for future research. However, these conclusions reflect patterns in the development of the literature and should not be interpreted as evidence of the effectiveness of LSS interventions.

Limitations and Cautions

This study is subject to several limitations. First, the use of Scopus database and the specific search terms like “Lean Six Sigma” and “hospital” may have resulted in the exclusion of relevant studies indexed in other databases or identified using alternative terminology. Second, the restriction to English-language and open access publications may have introduced

selection bias and limited the comprehensiveness of the review. In addition, the relatively small number of included articles ($n = 70$) may affect the stability and generalisability of the identified trends. Finally, bibliometric analysis provides insights into the evolution of research themes, publication patterns, and collaborative networks but does not assess the methodological quality of individual studies or establish causal relationships between LSS implementation and healthcare outcomes.

Recommendations for Future Research

Future research on LSS should adopt a broader scope by incorporating multiple databases and more comprehensive search strategies. Longitudinal, quasi-experimental, and comparative studies are needed to examine the role of LSS in facilitating the integration of digital health technologies, artificial intelligence (AI), process mining, and advanced analytics into healthcare practice. In addition, future investigations should consider a wider range of outcomes, including operational performance, patient safety, clinical effectiveness, patient experience, equity, and continuity of care. Such efforts would contribute to a more comprehensive understanding of the impact of LSS on healthcare quality and organizational performance.

CONCLUSION

In summary, Lean Six Sigma (LSS) research in hospital settings is increasingly focusing on issues related to efficiency, quality, organisational performance, patient safety, and patient-centred care. The annual growth rate of 18.19% in publications, together with the peak in publication output observed in 2021, indicates sustained interest in LSS research. However, these findings should be interpreted with caution because of the limitations of the dataset and the potential influence of the COVID-19 pandemic on research activity and healthcare priorities. Furthermore, the results reflect patterns and trends in the literature rather than causal evidence of the effectiveness of LSS interventions. Future research should place greater emphasis on the empirical evaluation of LSS implementation., particularly its effects on patient-centred outcomes, digital transformation, clinical effectiveness, and sustainable healthcare performance. In addition, further studies are needed in underrepresented healthcare settings and should incorporate broader, multidimensional measures of healthcare quality, and organisational performance.

REFERENCES

Al-Zain, Y., Al-Fandi, L., Arafeh, M., Salim, S., Al-Quraini, S., Al-Yaseen, A., & Abu Taleb, D. (2019). Implementing lean six sigma in a Kuwaiti private hospital. *International*

- Journal of Health Care Quality Assurance*, 32(2), 431–446. <https://doi.org/10.1108/IJHCQA-04-2018-0099>
- Antony, J., Forthun, S. C., Trakulsunti, Y., Farrington, T., McFarlane, J., Brennan, A., & Dempsey, M. (2019). An exploratory study into the use of Lean Six Sigma to reduce medication errors in the Norwegian public healthcare context. *Leadership in Health Services*, 32(4), 509–524. <https://doi.org/10.1108/LHS-12-2018-0065>.
- Antony, J., Kaul, A., Sony, M., Singh, N., Vij, B., Bhat, Y., & Laureani, A. (2021). A study into the themes of quality management: Early findings from a global research project and agenda for future research. *The TQM Journal*, 33(6), 1464–1480. <https://doi.org/10.1108/TQM-08-2020-0182>. <https://doi.org/10.1108/TQM-08-2024-0271>.
- Brown, R., Grehan, P., Brennan, M., Carter, D., Brady, A., Moore, E., Teeling, S. P., Ward, M., & Eaton, D. (2019). Using Lean Six Sigma to improve rates of day of surgery admission in a national thoracic surgery department. *International Journal for Quality in Health Care*, 31(Supplement_1), 14–21. <https://doi.org/10.1093/intqhc/mzz083>.
- Buestan, M., Perez, C. C., & Rodríguez-Zurita, D. (2025). Lean six sigma for health care: multiple case studies in Latin America. *International Journal of Lean Six Sigma*, 16(1), 172–196. <https://doi.org/10.1108/IJLSS-10-2023-0169>.
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133(April), 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Garvanovic, S. H., Gatling, J. W., Wang, A. T., Wong, C. M., Stevens, W. T., Lauer, R. E., & Ramsingh, D. (2021). Using Lean Six Sigma to decrease delivery time of blood products to the operating room. *A&A Practice*, 15(5), e01463. <https://doi.org/10.1213/XAA.0000000000001463>.
- Henrique, D. B., & Godinho Filho, M. (2020a). A systematic literature review of empirical research in Lean and Six Sigma in healthcare. *Total Quality Management & Business Excellence*, 31(3–4), 429–449. <https://doi.org/10.1080/14783363.2018.1429259>
- Improta, G., Balato, G., Ricciardi, C., & Russo, M. A. (2021). Lean Six Sigma in healthcare: Fast track surgery for patients undergoing prosthetic hip replacement surgery. *The TQM Journal*, 33(4), 911–927. <https://doi.org/10.1108/TQM-10-2019-0250>
- Improta, G., Borrelli, A., & Triassi, M. (2022). Machine learning and lean six sigma to assess how COVID-19 has changed the patient management of the complex operative unit of neurology and stroke unit: a single center study. *International Journal of Environmental Research and Public Health*, 19(9), 5215. <https://doi.org/10.3390/ijerph19095215>.
- Kam, A. W., Collins, S., Park, T., Mihail, M., Stanaway, F. F., Lewis, N. L., Polya, D., Fraser-Bell, S., Roberts, T. V., & Smith, J. E. H. (2021). Using Lean Six Sigma techniques to improve efficiency in outpatient ophthalmology clinics. *BMC Health Services Research*, 21(1), 38. <https://doi.org/10.1186/s12913-020-06034-3>.
- Kemp, T., Ayton, J., Butler-Henderson, K., & Lam, M. (2024). Using socio-technical systems theory to study the health information management workforce in Australian acute hospitals. *Social Theory & Health*, 22(4), 285–300. <https://doi.org/10.1057/s41285-024-00214-5>.
- Komaling, J., Arie, F. V., & Tumiwa, J. R. (2025). *Transforming Systematic Literature Synthesis into Meta-Data Analysis : The Impact of Lean Six Sigma in the Healthcare Sector*. 39(39). <https://doi.org/10.70147/s39144158>.
- Laureani, A., & Antony, J. (2020). Lean Six Sigma in healthcare: a systematic literature review. *Total Quality Management & Business Excellence*, 31(3–4), 429–449. <https://doi.org/10.1080/14783363.2018.1429259>
- Molla, M., Warren, D. S., Stewart, S. L., Stocking, J., Johl, H., & Sinigayan, V. (2018). A lean

- six sigma quality improvement project improves timeliness of discharge from the hospital. *The Joint Commission Journal on Quality and Patient Safety*, 44(7), 401–412. <https://doi.org/10.1016/j.jcjq.2018.02.006>.
- Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, 106(1), 213–228. <https://doi.org/10.1007/s11192-015-1765-5>
- Niñerola, A., Sánchez-Rebull, M.-V., & Hernández-Lara, A.-B. (2020). Quality improvement in healthcare: Six Sigma systematic review. *Health Policy*, 124(4), 438–445. <https://doi.org/https://doi.org/10.1016/j.healthpol.2020.01.002>
- Organization, W. H. (2021). *Global patient safety action plan 2021-2030: towards eliminating avoidable harm in health care*. World Health Organization. [https://books.google.co.id/books?hl=en&lr=&id=csZqEAAQBAJ&oi=fnd&pg=PR7&dq=Organization,+W.+H.+\(2021\).+Global+patient+safety+action+plan+2021-2030:+towards+eliminating+avoidable+harm+in+health+care.+World+Health+Organization.&ots=xKY0aZhiwp&sig=m6iblPljaOE2s0nye3lgoLwS-0M&redir_esc=y#v=onepage&q&f=false](https://books.google.co.id/books?hl=en&lr=&id=csZqEAAQBAJ&oi=fnd&pg=PR7&dq=Organization,+W.+H.+(2021).+Global+patient+safety+action+plan+2021-2030:+towards+eliminating+avoidable+harm+in+health+care.+World+Health+Organization.&ots=xKY0aZhiwp&sig=m6iblPljaOE2s0nye3lgoLwS-0M&redir_esc=y#v=onepage&q&f=false).
- Rahul, G., Samanta, A. K., & Varaprasad, G. (2020). A Lean Six Sigma approach to reduce overcrowding of patients and improving the discharge process in a super-specialty hospital. *2020 International Conference on System, Computation, Automation and Networking (ICSCAN)*, 1–6. <https://doi.org/10.1109/ICSCAN49426.2020.9262393>.
- 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), 2843. <https://doi.org/10.3390/ijerph18062843>.
- Slawomirski, L., Auraaen, A., & Klazinga, N. (2017). The economics of patient safety. *Paris: Organisation for Economic Co-Operation and Development*. https://www.oecd.org/en/publications/the-economics-of-patient-safety_5a9858cd-en.html.
- Sonali, S., & Shenoy, S. (2025). Mapping Lean Six Sigma in Healthcare: A Bibliometric Analysis Revealing Research Gaps in Developing Countries. *Cureus*, 17(7). <https://doi.org/10.7759/cureus.88692>.
- Steenbergen, G. J. van, van de Kar, M. R. D., Schulz, D. N., Dekker, L. R. C., & van Veghel, D. (2025). Advancing patient-centred innovation: data-driven approaches to value-based health care. *International Journal of Healthcare Management*, 1–10. <https://doi.org/10.1080/20479700.2025.2547953>.
- Tanna, N., Clappier, M., Barnett, S. L., Talamini, M. A., Coppa, G. F., Cifu, K., Bianculli, A. R., Drummond, D., Bello, S., & Smith, M. L. (2023). Streamlining and consistency in surgery: lean six sigma to improve operating room efficiency. *Plastic and Reconstructive Surgery*, 152(3), 682–690. <https://doi.org/10.1097/PRS.00000000000010240>.
- Teeling, S. P., Moffatt, S., Garry, C., McCann, H., 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), 1588. <https://doi.org/10.3390/ijerph19031588>.
- Tlapa, D., Zepeda-Lugo, C. A., Tortorella, G. L., Baez-Lopez, Y. A., Limon-Romero, J., Alvarado-Iniesta, A., & Rodriguez-Borbon, M. I. (2020). Effects of Lean Healthcare on Patient Flow: A Systematic Review. *Value in Health*, 23(2), 260–273. <https://doi.org/10.1016/j.jval.2019.11.002>

- Widiwati, I. T. B., Liman, S. D., & Nurprihatin, F. (2025). The implementation of Lean Six Sigma approach to minimize waste at a food manufacturing industry. *Journal of Engineering Research*, 13(2), 611–626. <https://doi.org/10.1016/j.jer.2024.01.022>.
- Zhafarin, B. S., Ghifary, H., Novianti, P. A., & Iswanto, A. H. (2023). Penerapan Lean Six Sigma Dalam Meningkatkan Aliran Pasien. *Jurnal Rumpun Ilmu Kesehatan*, 3(2), 136–145. <https://doi.org/10.55606/jrik.v3i2.1918>.