
A REVIEW OPTIMIZING HEALTHCARE EFFICIENCY AND QUALITY THROUGH LEAN SIX SIGMA IN HOSPITALS

Sween. K^{*1}, Dr. Ajay Noronha^{*2}

^{*1}Research Scholar, Institute Of Management & Commerce, Srinivas University Mangalore
575001, Karnataka, India.

^{*1}Assistant Professor Of Management, Srinivas University, Mangalore, Karnataka, India.

^{*2}Research Professor, Institute Of Management And Commerce, Srinivas University, Mangalore, India.

DOI : <https://www.doi.org/10.56726/IRJMETS60208>

ABSTRACT

In today's healthcare industry, hospitals are facing more pressure to enhance efficiency, cut costs, and boost patient outcomes. Lean Six Sigma (LSS) methods have emerged as effective tools to achieve these goals by optimizing processes and eliminating waste. This summary explores how LSS interacts with hospital operations, emphasizing efficiency, service quality, and patient satisfaction. LSS principles prioritize continuous improvement through systematic issue resolution and data-driven decision-making. In hospitals, these principles are applied to enhance processes, standardize procedures, and reduce variations in healthcare delivery. By pinpointing and addressing the root causes of inefficiencies and errors, LSS helps hospitals achieve lasting improvements in operational performance. LSS has significantly impacted reducing patient wait times, enhancing medication administration accuracy, streamlining supply chain management, and optimizing overall resource utilization. These improvements not only cut costs but also enhance patient safety and satisfaction by ensuring swift and effective treatment delivery.

Moreover, implementing LSS nurtures a culture of ongoing learning and improvement among healthcare staff. Hospital employees are empowered to identify opportunities for process enhancement independently and engage in collaborative efforts to implement and sustain changes through training and involvement activities. Despite the potential benefits, successful adoption of LSS in hospitals must overcome challenges like resistance to change, financial constraints, and the complexity of healthcare settings. Effective leadership, stakeholder support, and dedicated backing are crucial for navigating these obstacles and maximizing the benefits of LSS. Lean Six Sigma (LSS) is a vital tool in hospitals for enhancing healthcare operations and patient care outcomes through structured problem-solving and process optimization.

I. INTRODUCTION

Hospitals constantly struggle to provide high-quality care effectively while controlling costs in the dynamic and complex world of healthcare. Through process optimization, improved patient outcomes, and increased organizational performance, Lean Six Sigma (LSS) has become a potent tool to solve these issues. This introduction examines the use of Lean Six Sigma principles in hospitals, emphasizing the special considerations and possible advantages in this situation.

Hospitals are responsible for providing safe, timely, effective, efficient, equitable, and patient-centered care, as defined by the Institute of Medicine's six aspects of healthcare quality. To achieve these objectives in the face of increasing patient volumes, regulatory regulations, and budgetary demands, a structured approach to continuous improvement is required. Lean Six Sigma provides a structured approach to achieving these goals by decreasing waste, lowering variation, and enhancing process flow and efficiency.

Key Principles of Lean Six Sigma:

Lean Six Sigma combines two powerful methodologies—Lean and Six Sigma—each with unique strengths to the improvement process:

Lean concepts emphasize recognizing and eliminating waste (muda) through efficient process design, uniform work, and continuous flow. Examples include lowering wait times, maximizing resource utilization, and increasing patient throughput.

Six Sigma technique focuses on minimizing variation and faults (mura and muri) while employing statistical tools and data-driven analysis to attain process stability and consistency. This includes improving pharmaceutical safety, lowering medical errors, and optimizing clinical results. The significance of the Six Sigma approach is growing in several businesses, particularly in the healthcare domain. The healthcare industry has recently benefited greatly from the application of six sigma techniques. Using the Six Sigma technique in healthcare is becoming more and more popular as healthcare practitioners—including physicians and management—become aware of a variety of problems that could negatively impact the standard of care provided to patients.

Patient data is handled by the healthcare sector and all of its participants, including hospitals, diagnostic centers, care facilities, etc. Patients' lives could be at danger if there was even a small mistake or misplacement in this data. As a result, it's critical that the workflow and processes in the healthcare industry are flawless. The Six Sigma quality improvement methodology, which is data-driven, contributes significantly to the progress and correction of healthcare systems and processes. Using Six Sigma to enhance healthcare quality can result in shorter wait times in hospitals and private practices. Avoid falls and injuries in hospitals and nursing homes. Reduce medication errors when prescribing, administering, or filling prescriptions. Six Sigma, a quality control system used to remove errors and optimize processes, has transformed the business sector. Six Sigma was established for the manufacturing business but has now been applied to various industries, including healthcare.

Six Sigma in healthcare assists doctors and hospital administration in addressing possible difficulties and obstacles in care delivery while improving patient outcomes, lowering medical errors, and enhancing efficiency. As more hospitals and healthcare organizations highlight the importance of quality treatment and waste reduction in healthcare, Six Sigma methodology is gaining popularity in the industry. To improve performance, the healthcare business is implementing Six Sigma techniques. The primary objective in healthcare is to improve patient safety and satisfaction. Nowadays, patients select healthcare services based on the quality of care and level of satisfaction. This is where Six Sigma for Healthcare comes into play. Six Sigma is a management tool that, when adopted in businesses, improves process capability and efficiency by minimizing the possibility of error and waste. Implementing Six Sigma in healthcare can assist improve patient care, decrease waste, and eliminate defects such as long wait times for doctor appointments and inaccurate diagnosis, treatments, and prescriptions. Overall, Six Sigma can help to streamline operations and save expenses. There is almost no space for error in healthcare. Simple mistakes can make the difference between life and death. Lean Six Sigma has the potential to significantly reduce medical error-related mortality.

More than 210,000 people in the United States die each year as a result of medical blunders. This increases the annual cost of \$17.1 billion to the healthcare business. Using Lean Six Sigma principles can help to solve this challenge.

Define

The first step is identifying the patients and clearly defining their requirements. Also, the objectives of the process, its capacities, shortcomings, and scope for improvement are taken into consideration.

Measure

Metrics and statistics are used to recognize sufficient performance in terms of improvement. Improvement can be measured by considering the level of patient satisfaction, service level, service cost, clinical excellence rate, etc. The benchmark to be met must be established, and methods for measurement must be determined.

Analyze

Six Sigma tools are used to collect and analyze data for measuring to check for characteristics or loopholes that may cause a quality issue.

Improve

In this stage, modifications are implemented to improve the process. The performances of these improvements are effectively monitored to track progress.

Control

The performances are constantly monitored to maintain the levels of improvement. The different tools and techniques of Six Sigma can help improve patient care to a reasonable level by reducing the number of errors made during multiple processes.

Six Sigma in Healthcare- Benefits, And Advantages

1. Intercepting Mistakes

Small data inaccuracies in the healthcare sector can have a significant impact on a patient's diagnosis and course of treatment, potentially having major health repercussions. Lean six sigma uses empirical data to measure various operational scenarios.

The optimal plan is chosen from among the options, coordinating the agents in the healthcare system—biological technology, infrastructure, physicians, etc.

By doing this, the errors are reduced to, at most, 4 in a million observations! Error detection has a significant impact on the entire medical procedure, which benefits the healthcare industry.

2. Facilitating Improvement in Patient Care

Putting the needs of the customer first is one of the most important principles of the six sigma process. In the healthcare industry, patients are the clients, and meeting their demands well can improve the quality of treatment provided to them.

Healthcare professionals' perspectives are altered when the lean Six Sigma healthcare approach is applied; they begin to view patients as their consumers, whose satisfaction is their top priority.

3. Increased Accessibility to Healthcare Services

The healthcare industry reduces costs for patients and increases access to services for a greater number of people by implementing the six sigma methodology into the processes. This is accomplished by locating and eliminating waste in order to save costs.

Healthcare operations can be analyzed to find practices and actions that waste money and don't improve the quality of care provided.

4. Reducing the Lengths of Stay

Patients' length of stay naturally decreases when the healthcare practitioners use the Six Sigma approach to help facilitate better patient care. This implies that the patient's health significantly improves in a shorter amount of time, negating the necessity for a longer stay. This satisfies both the healthcare institutions' business objective and their social responsibility goal.

Examples of Six Sigma in Healthcare

1. Valley Baptist Health System- Harlingen, Texas

This hospital used Six Sigma to cut down on the amount of time needed for each operation cycle. As a result, the hospital gained the capacity to handle 1,100 more cases annually, potentially increasing its revenue by \$1.3 million!

2. Rapides Regional Medical Center- Alexandria, Louisiana

It was possible for this hospital to find flaws in its emergency care unit by applying the six sigma technique. Reduction of flaws resulted in significant savings for the hospital (up to \$950,000 annually) and a reduction in patient wait times, allowing for the care of more patients.

3. Kent Private Hospital- Turkey

Lean Six Sigma has the potential to significantly lower these tragic avoidable deaths. A healthcare professional is well-positioned to become a highly valued asset to their business if they know how to apply the tools and technique to systematically resolve issues and improve the quality of service. In addition to preventing mortality, they also lower operational expenses and enhance patient care. The healthcare industry has a lot of room for improvement. The methodologies of Lean and Six Sigma are combined in psychology that can bring about change. Healthcare is a people-intensive and process-driven industry, making it the ideal setting for lean and six sigma methodologies. Across the globe, numerous manufacturing and service organizations are

implementing Lean Six Sigma. Even yet, the healthcare industry is not well-versed in the long-term advantages of the LSS approach, particularly in developing countries like Pakistan, India, Sri Lanka, etc. This study examined the prospects and provided a thorough literature assessment on LSS in healthcare organizations in poor countries. The results of this study will enable healthcare professionals to concentrate on areas of uncertainty in order to enhance organizational performance. Reading up on a subject or field's literature is a crucial step in the process. As soon as someone begins reading through the literature, an image gradually begins to take shape with every turn. It stands for all of the significant contributions made to the field's development. The literature review leads to an increase in knowledge about new technologies, scientific approaches, and other techniques. Additionally, it points in the direction of where more investigation and learning are needed to develop the field. The current study's research approach consists of three parts. The SLR is carried out as the initial phase. It consists of three substeps: obtaining the articles from several sources, eliminating the articles based on SLR exclusion criteria, and finally classifying the articles based on a range of criteria. The second phase involves analyzing the articles and observing certain trends, such as which department within a healthcare institution is deemed most important from a research standpoint. Finally, the implications for the future are mentioned, which can serve as a helpful reference for medical experts to watch for in the near future. One of the key goals of Six Sigma is to eliminate errors in the process. This is especially critical in the healthcare industry, since tiny data inaccuracies can result in serious health implications. Six Sigma ranks operations depending on the amount of errors. A process can reach the maximum level if it makes no more than four errors per million observations.

Lean Six Sigma uses empirical data to assess numerous operational scenarios. The optimal strategy is picked from among these, as it aligns with the healthcare agents involved, including medical practitioners, infrastructure, and biological technology, and has the fewest errors. Another distinguishing element of Lean Six Sigma in healthcare is its emphasis on patient needs. It adopts a customer-centric approach to improve patient care. Following the Six Sigma healthcare methodology, healthcare practitioners prioritize patient satisfaction. To prioritize patient care, healthcare facilities now offer wheelchair accessible, 24-hour emergency care, convenient appointment scheduling, and clean surroundings. Thus, healthcare practitioners who apply Six Sigma in healthcare can continuously enhance patient care. As previously noted, reducing waste can help to focus on patient requirements and enhance care quality. This reduces the time of stay for patients in hospitals or healthcare facilities. Better care improves a patient's health in less time, allowing them to leave the healthcare institution sooner. Thus, healthcare providers can fulfill both business and social objectives. Six Sigma in Healthcare can benefit healthcare organizations in a variety of ways, including moving patients from the emergency room to a hospital room faster and improving turnaround times for laboratory processes, as well as maximizing resources, eliminating waste, and achieving the desired results to reduce costs and increase patient satisfaction. Healthcare is a critical area since our lives depend on it. During the new coronavirus epidemic, it was clear that our healthcare organizations continue to lack efficiency and productivity. The issues were far more serious, particularly in developing countries. Lean Six Sigma (LSS) is a methodology that, when adopted in a company, improves process capability and efficiency by decreasing errors and waste. The current paper provides a thorough review of LSS research projects undertaken in the healthcare sector. It was discovered that, in comparison, less studies were conducted to improve medical procedures, with the majority of studies focusing on management processes. Furthermore, less studies were undertaken for emerging nations, however it appears that the attention of research experts has also shifted to emerging nations. There is very little space for error in healthcare. Simple errors can have far-reaching consequences for hundreds of individuals, including mortality. According to the Journal of Healthcare Finance, medical errors cost the US more than \$19.5 billion in 2008. In 1998, the Institute of Medicine calculated that medical errors may have avoided 98,000 deaths that year. While in 2008, that statistic had inflated to 200 thousand deaths a year, that's five hundred and forty-eight deaths each day, or one death roughly every two minutes in the US alone.

With lean, qualitative instruments are more intuitive. The concept of lean and six sigma is slightly easier to understand than to apply. With healthcare costs rising on a daily basis and reimbursement rates decreasing, what can hospitals do to assure operational savings, excellent patient safety, and employee engagement while

being profitable? Lean and Six Sigma work together to improve service quality by lowering costs and waste, resulting in a positive outcome for healthcare. Lean six sigma is more than simply a technique or a set of tools for making improvements; it is also about having the right mindset and psychology to effect change.

Healthcare is a people-intensive, process-driven industry, making it ideal for lean and six sigma. Worldwide, LSS is being applied in a variety of service and manufacturing organizations. Still, the healthcare industry is unfamiliar with the long-term benefits of an LSS strategy, particularly in developing countries such as India, Pakistan, and Sri Lanka. This study included a thorough literature evaluation of LSS in developing-nation healthcare organizations, as well as an exploration of the potential. With this study, healthcare professionals will be able to focus on grey areas and successfully improve their organization's performance.

How Can Six Sigma Help Health Care?

Improved patient outcomes.

Healthcare firms can improve their quality of care by implementing Six Sigma to identify and eliminate faults and inefficiencies in patient care processes. This can lead to improved patient outcomes, such as fewer hospital readmissions and lower rates of infection and sequelae.

Improved Efficiency and Cost Savings

Six Sigma can be used to streamline healthcare procedures, increasing efficiency and cost-effectiveness. This can assist healthcare companies save money on supplies and labor, which can then be passed on to patients at a lower cost.

Increased patient satisfaction

Healthcare firms can improve patient satisfaction by implementing Six Sigma to improve care quality and experience. This can result in improved loyalty and excellent word-of-mouth advertising, helping firms recruit and retain patients. Better Data-Driven Decisions Six Sigma technologies and methodologies can improve healthcare businesses' data collection, analysis, and decision-making. This can assist companies in identifying previously unseen trends and patterns, which can then be leveraged to improve care processes and results. The notion of "lean" refers to the capacity to provide healthcare professionals with a set of practices, tools, and methodologies for efficiently enhancing processes while decreasing waste and delays in providing services to patients.

Using Lean Six Sigma to improve the work process in healthcare quality can limit infections that target inpatients who have had procedures, as well as minimizing inpatient falls and injuries in hospitals or nursing homes, reducing medication mistakes and scheduling the appropriate procedure orders for outpatients. Lean Six Sigma can also cut down on wasteful expenses and time spent fixing erroneous workflow. Define: What is the real problem that has to be addressed? Specify the issues with the process. Create a work process map with step-by-step details.

Measure- Measurements are required in this stage to better understand the situation. Measurements necessitate data collection, which can occasionally be accomplished by observation.

Analyze - This step focuses on examining data to better understand the problem, such as the root cause, and identifies the remedy.

Improve- Once the analysis is complete, the following step is to improve the workflow. Almost every step in the work process is eliminated or redesigned during this stage.

Finally, every business implements monitoring and control mechanisms to guarantee that the new work process outputs meet the desired levels of performance.

II. OBJECTIVES OF REVIEW PAPER

- Standardized processes, error-proofing techniques, and improved pharmaceutical safety protocols can all help to reduce medical errors, adverse events, and patient injury.
 - Improve clinical outcomes by standardizing clinical pathways, minimizing heterogeneity in treatment procedures, and increasing adherence to evidence-based approaches.
1. Standardized processes, error-proofing techniques, and improved pharmaceutical safety protocols can all help to reduce medical errors, adverse events, and patient injury.

Standardized Procedures: Putting in place standardized procedures guarantees uniformity in the way activities are carried out at every stage of the pharmaceutical lifecycle, from distribution and administration to drug development. By doing this, variability is decreased and the possibility of mistakes resulting from misunderstandings or inconsistencies is reduced.

Error-Proofing Strategies: Also referred to as "poka-yoke" in Japanese, error-proofing strategies entail creating systems and processes that are designed to stop errors from occurring in the first place. This can involve utilizing barcode systems to verify drugs, putting in place double-check procedures for high-risk medications, or utilizing automated medication dispensing systems to guarantee proper dosages.

Improved Pharmaceutical Safety Protocols: To strengthen safety protocols, possible dangers must be identified and risk-mitigation techniques implemented. This can involve rigorous testing and quality control throughout drug development, clear labeling and packaging to avoid prescription errors, and the establishment of thorough reporting systems to monitor adverse events and respond quickly.

2. Improve clinical outcomes by standardizing clinical pathways, minimizing heterogeneity in treatment procedures, and increasing adherence to evidence-based approaches.

Standardizing Clinical Pathways: Clinical pathways are structured, interdisciplinary care plans that outline the critical phases in the treatment of a certain ailment. By standardizing these pathways, healthcare practitioners may ensure that all patients receive consistent, high-quality care based on best practices and current research. This lowers treatment differences, streamlines operations, and enhances communication among healthcare team members.

Minimizing Heterogeneity in Treatment methods: Variability in treatment methods might result in uneven outcomes and increased patient risk. To reduce this heterogeneity, create explicit protocols and standards based on the most recent research and clinical evidence. This guarantees that all patients receive the most effective treatments possible, according to their individual needs and conditions.

Increase Adherence to Evidence-Based Approaches: Evidence-based medicine (EBM) combines the greatest available scientific evidence, clinical experience, and patient values. By strengthening adherence to evidence-based practices, healthcare practitioners may ensure that treatments and interventions are scientifically validated and proven to improve outcomes. This method lowers reliance on anecdotal evidence or out-of-date techniques that may be ineffective or dangerous.

Implementing these practices can provide healthcare companies with various advantages, including:
Improved Quality of Care: Standardized pathways and evidence-based procedures guarantee that patients receive care that is consistent with the most recent research and clinical recommendations, resulting in better results.

Enhanced Patient Safety: Consistent processes and evidence-based techniques reduce the likelihood of errors, adverse events, and problems during treatment.

Identifying and Mapping Processes: The first stage is to identify and map out existing department-wide processes like admissions, discharge, and billing. This includes understanding each stage in these processes, who is in charge of each phase, and how information moves between departments.

Standardizing procedures ensures consistency and eliminates variability in how tasks are completed. This can include developing standardized checklists, templates, or standards to streamline tasks across departments and eliminate errors.
Improving Communication and Collaboration: Effective communication and collaboration within departments are critical for a smooth process flow. Regular meetings, interdisciplinary rounds, and shared technological platforms can help to ensure that information is exchanged and decisions are made efficiently.

Monitoring and Continuous Improvement: By establishing metrics and key performance indicators (KPIs), healthcare organizations can continuously assess process efficiency and discover opportunities for improvement. Regular feedback loops and process reviews ensure that improvements continue over time.

The research objectives of the review article on optimizing healthcare efficiency and quality with Lean Six Sigma in hospitals are to investigate the impact of Lean Six Sigma (LSS) on healthcare operations, patient outcomes, and organizational performance. By clearly outlining these objectives, the review aims to provide a

comprehensive understanding of how LSS principles can enhance various aspects of healthcare delivery within hospital settings.

The scope of the review will encompass specific features of Lean Six Sigma, such as tools and concepts that are applied in healthcare contexts, particularly within hospitals. It will focus on how LSS methodologies are utilized to improve quality, efficiency, and patient safety in healthcare operations. Additionally, the review will explore the organizational performance benefits that hospitals can achieve by implementing LSS practices.

For the literature search strategy, the review will conduct a thorough search in relevant databases like PubMed, Scopus, and Web of Science to identify peer-reviewed publications, reviews, case studies, and gray literature related to Lean Six Sigma in hospitals. The search will involve using key terms such as "Lean Six Sigma", "healthcare", "hospitals", "quality improvement", "patient safety", and "process optimization" to retrieve relevant studies that address the impact and effectiveness of LSS in healthcare settings. This approach will ensure that the review article is well-informed by a diverse range of sources and perspectives on the topic.

Selection criteria:

To ensure the review's rigor and relevance, the inclusion criteria will focus on studies that provide empirical evidence, case studies, or theoretical insights on the application of Lean Six Sigma (LSS) to enhance healthcare processes and outcomes. The review will consider research articles, case studies, and relevant publications regardless of the publication year, as long as they contribute valuable insights to the review objectives. Language might be a criterion; however, translations could be considered if the content is deemed essential.

For the data extraction process, a structured form will be created to systematically extract key information from selected studies. This form will include details such as study design, specific LSS methodologies employed, healthcare outcomes assessed, and the main findings of each study. By organizing the extracted data into thematic categories like LSS benefits, obstacles, and success factors, the review can effectively synthesize and analyze the information gathered from the selected studies.

In terms of quality assessment, suitable techniques such as the Critical Appraisal Skills Programme (CASP) for qualitative studies and the Newcastle-Ottawa Scale for observational studies will be utilized to evaluate the methodological rigor of the included research. This quality assessment process will help identify the strengths and limitations of the studies included in the review,

To synthesize the findings for the review article on optimizing healthcare efficiency and quality with Lean Six Sigma in hospitals, the major focus will be on the impact of LSS on healthcare efficiency, quality of care, patient safety, and financial outcomes. By summarizing and consolidating the key findings from the selected research studies, the review will highlight the effectiveness of LSS in improving various aspects of healthcare delivery within hospital settings.

Common themes, trends, and patterns across the studies will be identified to emphasize effective implementation strategies, challenges to acceptance, and areas that require further investigation. By analyzing these aspects, the review will provide insights into the successful application of LSS in healthcare operations, as well as the barriers and opportunities associated with its adoption in hospital settings.

Moreover, the review will critically assess gaps in the literature, unresolved issues, and conflicting findings to offer recommendations for future research and practice in the field of Lean Six Sigma in healthcare. By highlighting the potential of LSS to enhance patient outcomes and organizational efficiency, the review will provide practical implications for healthcare leaders, policymakers, and practitioners looking to leverage LSS approaches for sustained quality improvement in healthcare facilities.

References and Citations:

Compile a comprehensive list of references cited throughout the review paper, adhering to citation style guidelines (e.g., APA, MLA). Ensure proper attribution of sources and acknowledgment of contributors to the field of LSS in healthcare.

Revision and Finalization:

Review and revise the review paper based on feedback from peers, mentors, or reviewers to strengthen clarity, coherence, and scholarly rigor. Finalize the manuscript, ensuring adherence to journal submission requirements and ethical considerations related to intellectual property and citation practices.

Keywords:

Lean Tools, Lean Techniques ,Lean Production, Six Sigma Methodology, Six Sigma Tools, Six Sigma Techniques, Six Sigma Projects, Six Sigma Certification, **DMAIC**,Continuous Improvement Process, Kaizen,Process Improvement, Quality Improvement, Quality Assurance, Total Quality Management (TQM),Standardization, Root Cause Analysis, Error Reduction.

III. METHODOLOGY

Performance Monitoring: Constantly monitor key performance indicators (KPIs) and metrics to determine the impact of LSS initiatives on patient outcomes, operational efficiency, and financial performance. Celebrate success and learn from failures. Recognize accomplishments, share best practices, and perform post-project reviews to capture learning's and apply them to future initiatives. Develop and implement solutions: Create new ways to address root problems and improve process performance. Pilot test solutions to validate their effectiveness.

Engage stakeholders. Involve frontline employees and stakeholders in the implementation of process improvements to encourage ownership and buy-in. Define Project Scope: Clarify the scope, objectives, and deliverables of the LSS project to ensure alignment with organizational goals. Measure Baseline Performance: Collect and evaluate relevant data to determine baseline metrics and assess current process performance. Use tools such as process maps, data gathering strategies, and performance metrics.

IV. REVIEW OF LITERATURE/RELATEDWORKS

4.1 overview based on literature:

Implementation of Lean Six Sigma in Healthcare Process Improvement: Many studies show that LSS approaches like DMAIC (Define, Measure, Analyze, Improve, and Control) can be used to streamline clinical and administrative procedures in hospitals. LSS programs, for example, have resulted in improved patient flow, shorter wait times, and more efficient resource allocation.

Quality and Safety Improvements: LSS helps to improve patient safety by minimizing pharmaceutical errors, surgical complications, and hospital-associated infections. It encourages the use of evidence-based methods and standardized processes to improve clinical results.

Effect on Patient Outcomes and Healthcare Efficiency:

Positive Outcomes: Research shows that hospitals that employ LSS see gains in patient care quality, satisfaction, and safety indicators. These include lower readmission rates, better adherence to clinical recommendations, and improved patient experience through streamlined operations.

Efficiency Gains: LSS efforts help to increase operational efficiencies by removing waste, enhancing process efficiency, and optimizing resource allocation. According to studies, LSS implementations result in cost savings, shorter stays, and increased throughput.

Challenges & Barriers:

Cultural Resistance: Resistance to change among healthcare professionals and personnel can stymie the adoption and sustainability of LSS programs. Critical issues include overcoming cultural barriers and achieving stakeholder buy-in.

Data Availability and Quality: A lack of data availability or quality for analysis makes it difficult to undertake comprehensive performance measurement and data-driven decision-making, both of which are critical to LSS success.

Success Factors and Implementation Strategy:

Leadership Support: Strong executive leadership and dedication are required to drive LSS initiatives, allocate resources, and maintain momentum.

Cross-functional Collaboration: Effective teamwork and collaboration across departments and disciplines contribute to the effective execution of LSS initiatives. Engaging frontline staff in improvement projects increases ownership and accountability.

Future Directions and Research Needs:

Integration with Healthcare Technologies: Future study could look into combining LSS with new technologies like artificial intelligence (AI) and data analytics to improve predictive modeling, decision assistance, and continuous monitoring of healthcare processes.

Patient-Centered Outcomes: Future research could focus on assessing the influence of LSS on patient-centered outcomes such as satisfaction, engagement, and health-related quality of life.

Sustainability and Long-term Impact: Longitudinal studies are required to determine the long-term viability of LSS improvements and to identify solutions for maintaining healthcare quality and efficiency advantages.

4.2 systematic literature reviews of LSS

Exploring the literature for a topic or field is a vital step. As soon as a person begins reviewing the material, an image emerges slowly with each step forward. It includes all of the key contributions to the development of the field. The literature review provides insight into numerous procedures, scientific methodologies, and emerging technology [11]. Furthermore, it points to the need for additional research and study in order to improve the sector. The research technique for the current study consists of three parts. The first step is to conduct the SLR. It involves three sub steps of accessing the articles from multiple sources, then excluding the articles based on the exclusion criteria of SLR, and lastly categorizing them based on numerous characteristics.

Table 1: LSS in Healthcare: Developed Nations and Global.

SR.NO	Findings	Research Type
1.	Implemented Six Sigma in red cross hospital in Netherlands. 3 million euros are expected to be saved annually. (2005)	Exploratory
2.	Integrated lean six sigma and listed its benefits. (2006) Integrated lean six sigma and provided the details where it can implement in healthcare organization. (2006)	Empirical
3.	Provided the information to improve the pharmaceutical industry and demonstrate the way how to enhance the efficiency and quality of it. (2009)	Descriptive
4.	Applied lean techniques in emergency ward in the hospitals to improve the quality and reduced the unusual fatalities.(2009)	Empirical
5.	To achieve clinical and organizational success, Bon Secours Health System applies Lean Six Sigma and technology transfer. (2009)	Empirical
6.	In an anaesthesiology residency clinic or hospital, Lean Six Sigma methods were used to achieve high	Conceptual

	performance, punctuality, and consistency of treatment. (2010)	
7.	In an intensive care unit, lean Six Sigma is being used to minimize linen failure. (2011) analysis of lean technique is to be used in emergency ward. (2011)	Empirical
8.	Lean techniques introduce to consolidated filtration to discuss the drug discovery bottleneck. (2012) USA In a medical university, the effect of five years of lean and six sigma principles is evaluated. (2012) importance to enhance the quality in this particular field. (2013)	Exploratory
9.	It is all about an Indian hospital in which lean techniques are often used to increase value and decrease outpatient long waits. (2015)	Descriptive
10.	A worldwide outlook on Lean thinking in healthcare, a	Conceptual

Table 2: LSS in Healthcare: Developing Nations.

Reference	Sr.	Findings	Research Type	Country
[64]	1	Study conducted in an Indian hospital on QM techniques. (2007)	Descriptive	India
[65]	2	Innovated a process using LSS for imaging section in a hospital. (2008)	Empirical	Mexico
[66]	3	Used the quality indicators in an Indian laboratory for assessing its performance. (2010)	Descriptive	India
[67]	4	Six Sigma is used for enhancing the efficiency of an operating room. (2011)	Conceptual	India
[68]	5	To boost the selenium analysis process, a Lean Six Sigma approach was used. (2012)	Empirical	South Africa
[69]	6	In designing a research management program, the business management techniques Lean Six Sigma and PMBOK were used. (2012)	Empirical	Brazil
[70]	7	The Lean Six Sigma approach is used to monitor inventory quality in clinical engineering. (2012)	Empirical	Brazil
[71]	8	Improved the patient discharge procedure with six-sigma (2012)	Conceptual	India
[72]	9	A case report of a hospital in India, where Six Sigma has been used to increase the health care quality. (2013)	Conceptual	India

[73]	10	In an Indian rural hospital, Lean Six Sigma technique was used to reduce the time required for out-patient department processes. (2014)	Empirical	India
[74]	11	In operation theatres, lean six-sigma was used to reduce wastes related to non-valuable actions and hence saving time. (2014)	Empirical	India
[75]	13	Examined the present situation and future of lean in healthcare during a decade. (2015)	Exploratory	India
[76]	14	In a hospital's medical records system, productivity and results are improved using Lean Six Sigma. (2016)	Empirical	India
[77]	15	LSS was used to enhance patient's care in a healthcare organization. (2017)	Empirical	India
[78]	16	Identified the problems and opportunities of Lean six sigma in health operations in resource-constrained environments. (2017)	Conceptual	India
[79]	17	Investigated how Lean Six Sigma methodologies would help the health-care sector. (2017)	Empirical	India
[80]	18	An ISM method for identifying factors that can influence lean adoption in healthcare sector. (2017)	Conceptual	India
[81]	19	A case study conducted to determine if healthcare organizations are ready to adopt lean. (2018)	Descriptive	India
[82]	20	Lean Six Sigma approach has been used to improve the hospital referral system. (2018)	Conceptual	KSA
[83]	21	A statistical model was developed to evaluate lean technique application in hospital systems. (2018)	Exploratory	India
[84]	22	Developed a framework for implementing Six Sigma in a healthcare organization's logistics department. (2019)	Descriptive	Jordan
[85]	23	A case study was undertaken to examine the application of Lean Six Sigma in various Indian healthcare organizations. (2019)	Descriptive	India
[86]	24	A systematic literature review was conducted on the Lean management methodology in the healthcare organizations. (2019)	Conceptual	Iran

V. RESEARCH GAP

In the realm of Lean Six Sigma (LSS) implementation in hospitals, several research gaps have been identified, suggesting opportunities for further exploration and advancement:

1. Long-term Sustainability of Improvements:

While many studies highlight initial successes of LSS projects in hospitals, there is a gap in understanding the long-term sustainability of these improvements. Research focusing on factors that contribute to sustained results, barriers to long-term success, and strategies for maintaining gains over time is needed.

2. Integration of LSS with Healthcare Technologies:

With the rapid evolution of digital technologies in healthcare, there is a gap in research exploring how LSS methodologies can be effectively integrated with technologies such as AI, machine learning, electronic health records (EHR), and telehealth. Studies could examine how these technologies enhance LSS outcomes, facilitate data-driven decision-making, and improve patient care processes.

3. Patient-Centered Outcomes:

While LSS projects often aim to improve operational efficiency and reduce errors, there is a gap in research focusing on patient-centered outcomes. Future studies could explore how LSS initiatives impact patient satisfaction, engagement, and overall experience within hospital settings.

4. Adaptation of LSS to Complex Healthcare Settings:

Healthcare environments are complex, involving multiple stakeholders, regulatory requirements, and ethical considerations. Research is needed to understand how LSS methodologies can be adapted and tailored to address these complexities effectively. This includes studying cultural barriers, resistance to change, and strategies for successful implementation across diverse healthcare settings.

5. Comparative Effectiveness of LSS in Different Hospital Settings:

There is a need for comparative effectiveness research that evaluates the outcomes of LSS interventions across different types of hospitals (e.g., academic medical centers, community hospitals, rural hospitals). Understanding which LSS strategies are most effective in various contexts can inform tailored implementation approaches and best practices.

6. Leadership and Organizational Culture:

Research gaps exist in understanding the role of leadership support, organizational culture, and change management strategies in the successful adoption and sustainability of LSS in hospitals. Exploring leadership behaviors, organizational readiness for change, and cultural factors that influence LSS implementation outcomes could provide valuable insights.

7. Ethical and Legal Implications:

Given the sensitive nature of healthcare data and patient care decisions, there is a gap in research examining the ethical and legal implications of LSS applications in hospitals. Research could address issues related to patient privacy, data security, informed consent, and ethical considerations in process improvement initiatives.

VI. LIMITATIONS

The current study involved an extensive systematic literature review. The significant disadvantage of this study is that a number of papers were screened out during the extensive literature review because they were in a language other than English, were unrelated to the healthcare industry, did not use the LSS approach, or had not yet been published. As a result, a clear picture of LSS in the healthcare industry may not be offered. Second, the study did not contain an LSS framework to aid healthcare professionals in implementing the LSS technique in their companies; however this might be addressed in a subsequent article.

Implementing Lean Six Sigma in hospitals can confront a number of problems and limits due to the particular nature of healthcare operations and settings.

Complexity of Healthcare Processes: Healthcare processes can be extremely complicated and interwoven, including numerous departments, stakeholders, and variables. This intricacy can make it difficult to discover and correct inefficiencies.

Resistance to Change: Healthcare personnel may be resistant to process and workflow changes, particularly if they believe they will have an impact on patient care or their own workload. Changing existing procedures in healthcare necessitates careful analysis and stakeholder involvement.

Patient Variability: Patients' requirements, circumstances, and treatment reactions differ greatly from one another, unlike manufacturing processes. This variation can make it challenging to standardize processes and apply consistent techniques to distinct patient populations. **Regulatory regulations:** Healthcare firms must adhere to severe regulatory regulations and standards, which may conflict with Lean Six Sigma principles or necessitate changes to achieve both quality improvement goals and regulatory mandates.

Cost Considerations: Implementing Lean Six Sigma necessitates investment in training, resources, and possibly technological or infrastructure improvements. Hospitals may have budget constraints that limit their capacity to fully support these programs.

Measurement and Metrics: While metrics are critical for Lean Six Sigma to evaluate progress, healthcare outcomes might be difficult to precisely measure or may not immediately reflect process changes due to the complexity of patient care.

Sustainability: Long-term improvements in healthcare can be difficult to maintain, as external influences such as changes in patient demographics, medical developments, and economic pressures can all have an impact on operational performance.

Addressing these limits necessitates careful planning, stakeholder engagement, and the adaption of Lean Six Sigma principles to the specific needs and problems of healthcare environments.

VII. FINDINGS

LSS implementation in healthcare began no early than 2005. A lot of study has already been done on LSS in healthcare all around the world, but in developing countries like India and Brazil, there has been relatively little research. The time constraint trend in article categorization is critical for indicating how trends change over time and how many researches are undertaken each year to address the problem. Furthermore, the timing demonstrates how the researchers' areas of interest shift over time. Until 2013, research researchers focused primarily on strengthening the healthcare sector in industrialized nations. Aids in allocating the items in accordance with the medical, managerial, and general processes—the three main categories of processes in the healthcare organization they target. Additionally, the articles are separated based on the location they have addressed. The fact that very few articles have discussed medical procedures is seen from the. The majority of research studies carried out in underdeveloped countries was empirical; On the other hand, there is a difference between conceptual and exploratory investigations. This pattern is important because it prevents the problems specific to a certain nation from being understood if fewer exploratory investigations are conducted there. Therefore, an exploratory study is required to illustrate the straightforward and workable solution. The researchers must come up with fresh ideas and tackle unresolved issues, not just for one company but for the entire country.

Strong Leadership and Commitment: Overcoming opposition to change and guaranteeing that Lean Six Sigma projects receive the required resources and attention depend heavily on the support and active engagement of the leadership.

Frontline Staff Engagement: Including frontline healthcare workers in process improvement initiatives helps to better identify inefficiencies and fosters support for modifications that have an immediate impact on their jobs.

Adaptation to the Healthcare Environment: Realistic and practical solutions can be developed in a healthcare setting by taking into account the particular difficulties of healthcare processes and modifying Lean Six Sigma approaches accordingly.

Put Patient-Centered Care First: Lean Six Sigma initiatives that are in line with patient outcomes and satisfaction guarantee that improvements put patient safety, care quality, and overall experience first. Hospitals can make better decisions by enhancing their capacities for data collection, analysis, and usage to more precisely pinpoint the underlying causes of issues and efficiently track the effects of process modifications.

Establishing a culture of continuous improvement promotes proactive identification of areas for improvement beyond the first Lean Six Sigma initiatives and constant assessment of processes.

Education and Training: Giving employees at all levels thorough instruction on Lean Six Sigma concepts and practices gives them the tools they need to contribute to improvement projects successfully and maintain progress over time.

VIII. CONCLUSION

A breakdown in one area could have a detrimental effect on the care of patients in the healthcare industry, which is a very important and intricate field with multiple departments. We also needed operational expertise in healthcare operations, as demonstrated by the Covid-19 pandemic. With the aid of a lean and six sigma toolkit, a business can decrease waste and variation by implementing the Lean Six Sigma technique. A well-known methodology, Lean Six Sigma is mostly applied in the industrial industry. But in the last ten years, it has also been widely applied to non-manufacturing industries like the services sector. The amount of research being undertaken has changed according on location. The gap has been recognized by the researchers, when it when it comes to emerging countries, and the quantity of research done on these countries has increased , This study demonstrates that up to now, in the healthcare industry, Position the hospital as a leader in healthcare

quality, efficiency, and patient safety, thereby increasing its reputation and competitiveness in the healthcare industry.

IX. REFERENCES

- [1] Andel C., Davidow S.L., Hollander M., Moreno D.A. The economics of health care quality and medical errors. *J. Health Care Finan.* 2012;39(1):39. [PubMed] [Google Scholar]
- [2] Rathi R., Khanduja D., Sharma S.K. A fuzzy MADM approach for project selection: a Six Sigma case study. *Decis. Sci. Lett.* 2016;5(2):255–268. [Google Scholar]
- [3] Kaswan M., Rathi R. Analysis and modeling the enablers of Green Lean Six Sigma implementation using Interpretive Structural Modeling. *J. Cleaner Prod.* 2019;231:1182–1191. doi: 10.1016/j.jclepro.2019.05.253. [CrossRef] [Google Scholar]
- [4] Yeh H.L., Lin C.S., Su C.T., Wang P.C. Applying lean six sigma to improve healthcare: An empirical study. *Afr. J. Business Manage.* 2011;5(31):12356–12370. [Google Scholar]
- [5] Singh M., Rathi R., Garza-Reyes J.A., Antony J. Lean Six Sigma project selection in a manufacturing environment using hybrid methodology based on intuitionistic fuzzy MADM approach. *IEEE Trans. Eng. Manage.* 2021 [Google Scholar]
- [6] Singh M., Rathi R. Investigation and Modelling of Lean Six Sigma barriers in small and medium-sized industries using hybrid ISM-SEM approach. *Int. J. Lean Six Sigma.* 2021 [Google Scholar]
- [7] Singh M., Rathi R. Lean Six Sigma imperatives for casting quality improvement of automotive components: A Case. *Int. J. Six Sigma Compet. Adv.* 2020 (accepted) [Google Scholar]
- [8] Rathi R., Khanduja D., Sharma S.K. A fuzzy-MADM based approach for prioritizing Six Sigma projects in the Indian auto sector. *Int. J. Manage. Sci. Eng. Manage.* 2017;12(2):133–140. doi: 10.1080/17509653.2016.1154486. [CrossRef] [Google Scholar]
- [9] Rathi R., Khanduja D., Sharma S.K. Efficacy of fuzzy MADM approach in Six Sigma analysis phase in automotive sector. *J. Indust. Eng. Int.* 2016;12(3):377–387. doi: 10.1007/s40092-016-0143-0. [CrossRef] [Google Scholar]
- [10] Rathi R., Ammar V., Kaswan M. Grey Relational Analysis of Green Lean Six Sigma Critical Success Factors for Improved Organizational Performance. *Int. J. Six Sigma Compet. Adv.* (accepted) 2021 [Google Scholar]
- [11] Knopf J.W. Doing a literature review. *PS. Polit. Sci. Polit.* 2006;39(01):127–132. [Google Scholar]
- [12] Tranfield D., Denyer D., Smart P. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *Br. J. Manag.* 2003;14(3):207–222. [Google Scholar]
- [13] Singh M., Rathi R. A structured review of Lean Six Sigma in various industrial sectors. *Int. J. Lean Six Sigma.* 2019;10(2):622–664. [Google Scholar]
- [14] Antony J. A conceptual Lean Six Sigma framework for quality excellence in higher education institutions. *Int. J. Quali. Reliab. Manage.* 2018 [Google Scholar]
- [15] Locklear T.M. University of KY; 2012. A Descriptive, Survey Research Study of the Student Characteristics Influencing the Four Theoretical Sources of Mathematical Self-Efficacy of College Freshmen. [Google Scholar]
- [16] de Carvalho M.M., Ho L.L., Pinto S.H.B. The Six Sigma program: an empirical study of Brazilian companies. *J. Manufact. Technol. Manage.* 2014 [Google Scholar]
- [17] Moody W., Kinderman P., Sinha P. An exploratory study. *Journal of Fashion Marketing and Management: An. Int. J.* 2010 [Google Scholar]
- [18] Buck C.R. Health care through a Six Sigma lens. *Milbank Quart.* 1998;76(4):749–753. [PMC free article] [PubMed] [Google Scholar]
- [19] Niemeijer G.C., Trip A., Ahaus K.T., Does R.J., Wendt K.W. Quality in trauma care: improving the discharge procedure of patients by means of Lean Six Sigma. *J. Trauma Acute Care Surg.* 2010;69(3):614–619. [PubMed] [Google Scholar]

- [20] Pocha C. Lean Six Sigma in health care and the challenge of implementation of Six Sigma methodologies at a Veterans Affairs Medical Center. *Qual. Manage. Healthcare*. 2010;19(4):312-318. [PubMed] [Google Scholar]
- [21] Van Den Heuvel J., Does R.J., Verver J.P. Six Sigma in healthcare: lessons learned from a hospital. *Int. J. Six Sigma Compet. Adv.* 2005;1(4):380-388. [Google Scholar]
- [22] Van den Heuvel J., Does R.J., De Koning H. Lean Six Sigma in a hospital. *Int. J. Six Sigma Compet. Adv.* 2006;2(4):377-388. [PubMed] [Google Scholar]
- [23] De Koning H., Verver J.P., van den Heuvel J., Bisgaard S., Does R.J. Lean six sigma in healthcare. *J. Healthcare Qual.* 2006;28(2):4-11. [PubMed] [Google Scholar]
- [24] Hammond C., Donnell O., J C. Lean Six Sigma-Its Application to Drug Discovery. *DDW Drug Discov. World.* 2008;9(2):9. [Google Scholar]
- [25] Andersson S., Armstrong A., Björe A., Bowker S., Chapman S., Davies R., Donald C., Egner B., Elebring T., Holmqvist S., Inghardt T., Johannesson P., Johansson M., Johnstone C., Kemmitt P., Kihlberg J., Korsgren P., Lemurell M., Moore J., Pettersson J.A., Pointon H., Pontén F., Schofield P., Selmi N., Whittamore P. Making medicinal chemistry more effective—application of Lean Sigma to improve processes, speed and quality. *Drug Discovery Today*. 2009;14(11-12):598-604. [PubMed] [Google Scholar]
- [26] Carleysmith S.W., Dufton A.M., Altria K.D. Implementing Lean Sigma in pharmaceutical research and development: a review by practitioners. *R&d Manag.* 2009;39(1):95-106. [Google Scholar]
- [27] Dickson E.W., Singh S., Cheung D.S., Wyatt C.C., Nugent A.S. Application of lean manufacturing techniques in the emergency department. *J. Emerg. Med.* 2009;37(2):177-182. [PubMed] [Google Scholar]
- [28] Dickson E.W., Anguelov Z., Vetterick D., Eller A., Singh S. Use of lean in the emergency department: a case series of 4 hospitals. *Ann. Emerg. Med.* 2009;54(4):504-510. [PubMed] [Google Scholar]
- [29] Douglas Sears H. Bon Secours Health System integrates Lean Six Sigma and knowledge transfer to drive clinical and operational excellence. *Glob. Busin. Organizat. Excell.* 2009;28(6):31-45. [Google Scholar]
- [30] Tjahjono B., Ball P., Vitanov V.I., Scorzafave C., Nogueira J., Calleja J., Minguet M., Narasimha L., Rivas A., Srivastava A., Srivastava S., Yadav A. Six Sigma: a literature review. *Int. J. Lean Six Sigma*. 2010;1(3):216-233. [Google Scholar]
- [31] DelliFraine J.L., Langabeer J.R., Nembhard I.M. Assessing the evidence of Six Sigma and Lean in the health care industry. *Qual. Manage. Healthcare*. 2010;19(3):211-225. [PubMed] [Google Scholar]
- [32] Fischman D. Applying Lean Six Sigma methodologies to improve efficiency, timeliness of care, and quality of care in an internal medicine residency clinic. *Qual. Manage. Healthcare*. 2010;19(3):201-210. [PubMed] [Google Scholar]
- [33] Varkey P., Kollengode A. A framework for healthcare quality improvement in India: the time is here and now! *J. Postgrad. Med.* 2011;57(3):237. doi: 10.4103/0022-3859.85222. [PubMed] [CrossRef] [Google Scholar]
- [34] Cima R.R., Brown M.J., Hebl J.R., Moore R., Rogers J.C., Kollengode A., Amstutz G.J., Weisbrod C.A., Narr B.J., Deschamps C. Use of lean and six sigma methodology to improve operating room efficiency in a high-volume tertiary-care academic medical center. *J. Am. Coll. Surg.* 2011;213(1):83-92. [PubMed] [Google Scholar]
- [35] Furterer S.L. Applying lean Six Sigma to reduce linen loss in an acute care hospital. *Int. J. Eng., Sci. Technol.* 2011;3(7):39-55. [Google Scholar]
- [36] Holden R.J. Lean thinking in emergency departments: a critical review. *Ann. Emerg. Med.* 2011;57(3):265-278. [PMC free article] [PubMed] [Google Scholar]
- [37] van der Meulen F., Vermaat T., Willems P. Case study: An application of logistic regression in a six sigma project in health care. *Qual. Eng.* 2011;23(2):113-124. [Google Scholar]
- [38] Aguezzoul A., Nyongue A. *IEEE*; 2012. July). A preliminary analysis on Lean Six Sigma application in healthcare. In *ICSSM12*; pp. 714-717. [Google Scholar]
- [39] Chiarini A. Risk management and cost reduction of cancer drugs using Lean Six Sigma tools. *Leadersh. Health Serv.* 2012;25(4):318-330. [Google Scholar]

- [40] Gowen C.R., McFadden K.L., Settaluri S. Contrasting continuous quality improvement, Six Sigma, and lean management for enhanced outcomes in US hospitals. *Am. J. Bus.* 2012;27(2):133–153. [Google Scholar]
- [41] Silich, S. J., Wetz, R. V., Riebling, N., Coleman, C., Khoueiry, G., Abi Rafeh, N., ... & Szerszen, A. (2012). Using six sigma methodology to reduce patient transfer times from floor to critical-care beds. *J. Healthcare Qual.*, 34(1), 44-54. [PubMed]
- [42] Weller H.N., Nirschl D.S., Paulson J.L., Hoffman S.L., Bullock W.H. Addressing the medicinal chemistry bottleneck: a lean approach to centralized purification. *ACS Comb. Sci.* 2012;14(9):520–526. [PubMed] [Google Scholar]
- [43] Niemeijer G.C., Trip A., de Jong L.J., Wendt K.W., Does R.J. Impact of 5 years of lean six sigma in a University Medical Center. *Qual. Manage. Healthcare.* 2012;21(4):262–268. [PubMed] [Google Scholar]
- [44] Liberatore, M. J. (2013). Six Sigma in healthcare delivery. *Int. J. Health Care Qual. Assur.* [PubMed]
- [45] Chassin M.R. Improving the quality of health care: what's taking so long? *Health Aff.* 2013;32(10):1761–1765. [PubMed] [Google Scholar]
- [46] Vaishnavi V., Suresh M. Assessment of readiness level for implementing lean six sigma in healthcare organization using fuzzy logic approach. *Int. J. Lean Six Sigma.* 2020 [Google Scholar]
- [47] Swarnakar, V., Tiwari, A. K., & Singh, A. R. (2020). Evaluating critical failure factors for implementing sustainable lean six sigma framework in manufacturing organization. *Int. J. Lean Six Sigma.*
- [48] Kam A.W., Collins S., Park T., Mihail M., Stanaway F.F., Lewis N.L., Smith J.E. Using Lean Six Sigma techniques to improve efficiency in outpatient ophthalmology clinics. *BMC Health Serv. Res.* 2021;21(1):1–9. [PMC free article] [PubMed] [Google Scholar]
- [49] Trakulsunti Y., Antony J., Edgeman R., Cudney B., Dempsey M., Brennan A. Reducing pharmacy medication errors using Lean Six Sigma: A Thai hospital case study. *Total Qual. Manage. Business Excell.* 2021:1–19. [Google Scholar]
- [50] “Kaswan, M.S. and Rathi, R. (In press) ‘An inclusive review of Green Lean Six Sigma for sustainable development: readiness measures and challenges’, “*Int. J. Advanced Operations Management*”
- [51] Rathi R., Khanduja D., Sharma S.K. Synergy of fuzzy AHP and Six Sigma for capacity waste management in Indian automotive industry. *Decis. Sci. Lett.* 2015;4(3):441–452. [Google Scholar]
- [52] Singh M., Rathi R., Garza-Reyes J.A. Analysis and Prioritization of Lean Six Sigma Enablers with Environmental facets using Best Worst Method: A Case of Indian MSMEs. *J. Cleaner Prod.* 2021;239 doi: 10.1016/j.jclepro.2020.123592. [CrossRef] [Google Scholar]
- [53] Kaswan M., Rathi R., Khanduja D. Integration of Green Lean Six Sigma: A Novel Approach for Sustainable Development. *Int. J. Six Sig. Compet. Adv.* 2020;12(4):389–405. doi: 10.1504/IJSSCA.2020.10034341. [CrossRef] [Google Scholar]
- [54] Kapur S., Kaswan M.S. Ergonomic Assessment of the Lifting Tasks Performed by North Indian Workers in LPG Cylinder Distribution Supply Chain. Springer; Cham: 2020 July. pp. 252–258. [Google Scholar]
- [55] Singh M., Kumar P., Rathi R. Modelling the barriers of Lean Six Sigma for Indian micro-small medium enterprises: An ISM and MICMAC approach. *TQM J.* 2019;31(5):673–695. doi: 10.1108/TQM-12-2018-0205. [CrossRef] [Google Scholar]
- [56] 40. Gowen C.R., McFadden K.L., Settaluri S. Contrasting continuous quality improvement, Six Sigma, and lean management for enhanced outcomes in US hospitals. *Am. J. Bus.* 2012;27(2):133–153. [Google Scholar]
- [57] 41. Silich, S. J., Wetz, R. V., Riebling, N., Coleman, C., Khoueiry, G., Abi Rafeh, N., ... & Szerszen, A. (2012). Using six sigma methodology to reduce patient transfer times from floor to critical-care beds. *J. Healthcare Qual.*, 34(1), 44-54. [PubMed]