Indonesian Journal of Global Health Research
Volume 7 Number 5, October 2025
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

ANALYZING WASTE IN EMERGENCY RADIOLOGY SERVICES THROUGH A LEAN MANAGEMENT APPROACH: A LITERATURE REVIEW

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ABSTRACT
Hospitals play a strategic role in supporting promotive, preventive, curative, and rehabilitative health efforts. The Emergency Department (ED) and Radiology Unit are critical services that directly affect the speed and accuracy of diagnosis, especially in emergency cases. This study aims to evaluate the efficiency of these two units using a Lean Management approach. A systematic literature review was conducted through databases including Scopus, PubMed, and Google Scholar using the keywords "emergency department," "radiology," and "lean management." Inclusion criteria consisted of English- and Indonesian-language articles published between 2015 and 2024. Article selection followed the PRISMA guidelines. A total of 250 records were initially identified, with 10 high-quality articles ultimately meeting all inclusion and quality appraisal criteria for analysis. Findings indicate that Lean Management effectively identifies process waste, particularly prolonged patient waiting times and delays in radiology reporting. Techniques such as Value Stream Mapping and Root Cause Analysis were found to streamline workflows and reduce non-productive time. The implementation of Lean Management significantly enhances the efficiency of radiology services in emergency settings by optimizing processes and minimizing waste. Continuous outcome monitoring, regular training, multidisciplinary collaboration, and information technology integration are essential to ensure sustainable and system-wide improvements.

Keywords: emergency department; lean management; radiology; value stream mapping; waste

How to cite (in APA style)
Indriani, C. R., Arso, S. P., & Jati, S. P. (2025). Analyzing Waste in Emergency Radiology Services through A Lean Management Approach: A Literature Review. Indonesian Journal of Global Health Research, 7(5), 1037-1044. https://doi.org/10.37287/ijghr.v7i5.7016.

INTRODUCTION

Hospitals are advanced healthcare institutions that play a strategic role in the national health system (Mariawati et al., 2023). Beyond serving as centers for treatment, they also function as facilities for rehabilitation and improving patients' quality of life (Dano, 2023). To fulfill these roles, hospitals must provide timely, safe, accurate, and high-quality services through efficient, integrated, and patient-centered healthcare systems (Ayuningtyas & Wibowo, 2024). These responsibilities are in accordance with the 1945 Constitution of the Republic of Indonesia, specifically Article 28H Paragraph (1), which guarantees every citizen's right to health, and Article 34 Paragraph (3), which mandates the state's duty in providing healthcare services. Furthermore, these mandates are reinforced by the Law of the Republic of Indonesia No. 44 of 2009 on Hospitals, and further regulated under Government Regulation No. 38 of 2023 concerning the Administration of Hospitals, which emphasizes patient safety, service quality, and good governance. Strengthening hospital governance is thus essential to ensuring inclusive and sustainable healthcare services (Megawati Hutajulu et al., 2024)

In response to growing public expectations, improving hospital service delivery has become essential. The public demands healthcare services that are not only fast and accurate but also affordable and user-friendly (Akbar & Rizky, 2020). However, hospitals continue to face challenges such as suboptimal service quality, long patient waiting times, shortages of medical personnel, and operational difficulties with advanced medical technologies (Pawah et al., 2022). Moreover, Indonesia's commitment to Universal Health Coverage (UHC) through the National Health Insurance (Jaminan Kesehatan Nasional/JKN) requires hospitals to enhance capacity across infrastructure, human resources, and clinical governance (Suyanti et al., 2024).

Among the key indicators of improved healthcare quality is the availability of diagnostic support services, particularly radiology. Radiological examinations are essential in clinical decision-making, especially in emergency care (Wulandari et al., 2023). Radiology is a medical discipline that uses imaging technologies such as X-rays, ultrasound, CT scans, and MRI to detect, diagnose, and manage diseases. Despite its important role and revenue potential, radiology is also a cost-intensive unit due to the high operational and maintenance demands of advanced imaging technology (Udyanto, 2021).

The Emergency Department (ED) is one of the most complex and dynamic hospital units. It requires a high level of efficiency, particularly in interdepartmental coordination involving emergency medicine, nursing, radiology, laboratory, and admission services (Novita et al., 2023). Inefficient workflows and poor communication between these units can compromise patient safety and diminish service quality (Adriansyah et al., 2021). In many hospitals, radiology services still face systemic barriers, such as the physical distance between the ED and radiology unit, limited Picture Archiving and Communication System (PACS) infrastructure, and the lack of integration between radiology reports and Hospital Information Systems (SIMRS). These limitations lead to delays in diagnosis and increase the risk of adverse outcomes for emergency patients.

To address these inefficiencies, the adoption of performance-based management strategies such as Lean Management has become increasingly relevant (Sari, 2023) Lean is a continuous improvement methodology that aims to eliminate non-value-added activities from the patient's perspective. Its application in healthcare has shown effectiveness in reducing waiting times, streamlining processes, and enhancing productivity and service quality (Diana Safitri et al., 2025) The Lean framework is built on five core principles: defining value from the patient's viewpoint, mapping the value stream, establishing smooth process flow, implementing pull-based systems, and fostering continuous improvement.

Various tools such as Value Stream Mapping (VSM), 5 Why's, and Root Cause Analysis (RCA) are commonly used to evaluate and refine clinical workflows. For instance, Zyl et al. (2020) identified major delays in the radiology examination process within the ED, particularly during the transition from scanning to reporting (averaging 72.21 minutes), as well as in patient transport. VSM helps to pinpoint specific bottlenecks such as delays in annotation requests, porter authorizations, and report finalization.

Additional studies support the efficacy of the Lean approach. Hitti et al. (2017a) documented a reduction in radiology patient transport time from 22.8 minutes to 9.8 minutes, while Rachh et al. (2021) demonstrated significant gains in operational efficiency through workflow redesign. Nevertheless, research focused on Lean Management implementation in emergency radiology services in Indonesian hospitals remains limited. This review seeks to explore the application of Lean methods in optimizing radiology services within the ED, focusing on identifying dominant sources of waste, analyzing the Lean tools employed, and evaluating their impact on service efficiency. The findings are expected to inform strategies for improving the quality and responsiveness of emergency radiology services in hospitals across Indonesia. This literature review aims to examine existing evidence on waste reduction in emergency radiology services through a Lean Management approach and to generate actionable insights that can assist hospitals in Indonesia in enhancing efficiency, quality, and responsiveness.

METHOD

This study adopted a Systematic Literature Review (SLR) approach guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a transparent, structured, and replicable review process. The search for relevant literature was conducted across four major electronic databases: PubMed, ScienceDirect, Scopus, and Google

Scholar, covering publications from 2015 to 2024. The keywords used included combinations of "lean management," "waste," "radiology service," "emergency department," and "healthcare," connected using Boolean operators (AND/OR), and searches were limited to titles and abstracts. A total of 250 records were initially identified. After screening, 31 articles were retained for full-text assessment, with 166 excluded due to irrelevance or failure to meet the inclusion criteria. Of the 31 full-text articles reviewed, 25 met the research objectives and were further evaluated using the Critical Appraisal Skills Programme (CASP) checklist. Following quality appraisal, 15 studies with low scores were excluded, resulting in 10 high-quality articles included in the final synthesis.

The inclusion criteria consisted of (1) articles written in English, (2) empirical studies (quantitative, qualitative, or mixed methods), (3) research focusing on the implementation of lean management in radiology or emergency department services, (4) studies reporting the types of waste identified, and (5) availability of full-text. The exclusion criteria were (1) non-empirical articles such as reviews, editorials, or opinion papers, (2) studies unrelated to the healthcare sector, (3) inaccessible full-texts, and (4) duplicate publications.

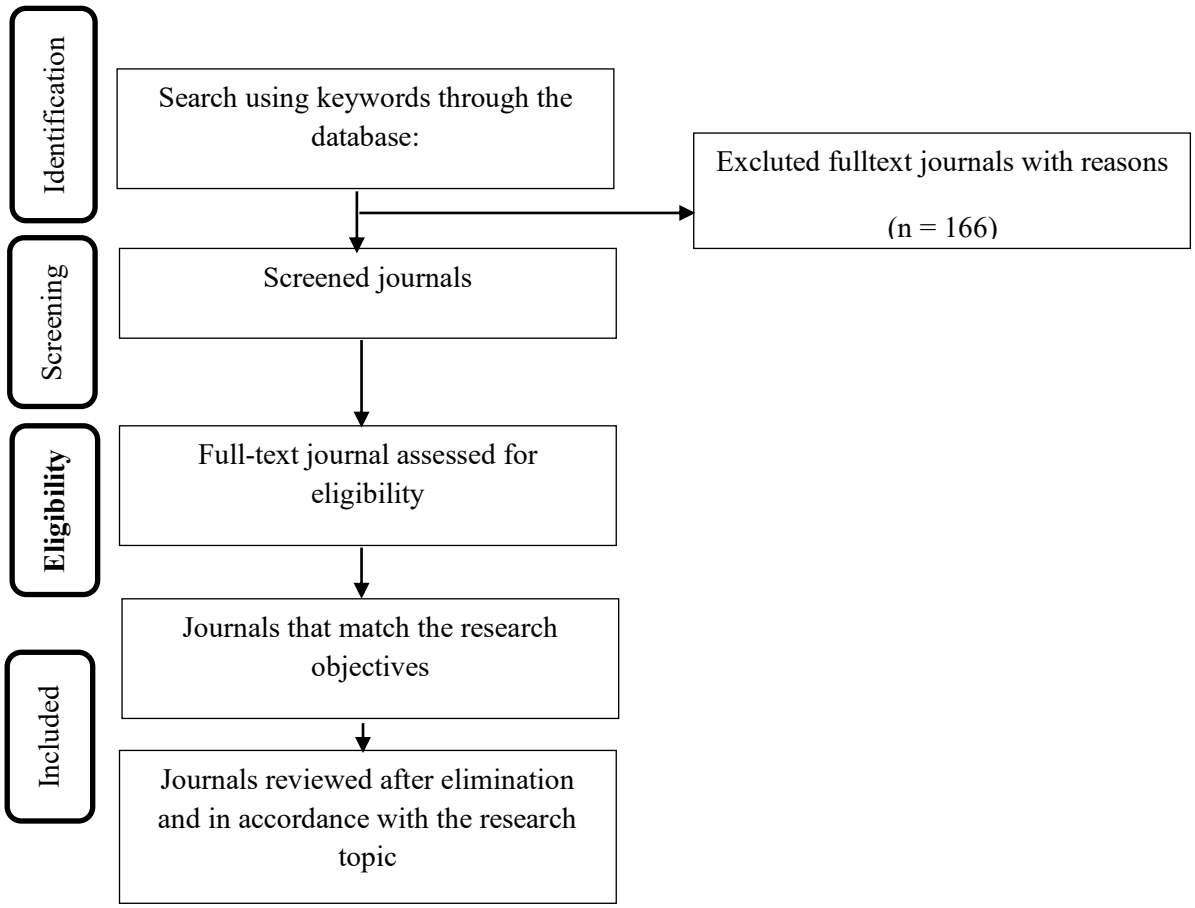

Figure 1. Systematic Literature Review Process

A thematic analysis was used to synthesize the findings, categorizing them into three main themes: (1) types of waste identified in emergency radiology services, (2) lean tools and strategies applied (e.g., 5S, Kaizen, Value Stream Mapping), and (3) the impacts of lean management on service efficiency, waiting times, and patient satisfaction. Although most of the reviewed studies were conducted in high-income countries, the findings were interpreted in the context of radiology services in Indonesia, where emergency departments often experience inefficiencies, procedural redundancies, and prolonged patient wait times. Therefore, the application of lean management in the Indonesian healthcare context holds significant potential to improve service delivery and patient outcomes.

RESULT

The implementation of lean management in radiology services within emergency departments (EDs) demonstrates considerable potential in minimizing waste and enhancing the efficiency of healthcare workflows. Lean management is a strategic approach focused on eliminating non-value-added activities from the patient care process. In the context of emergency radiology services, this approach involves analyzing workflows, identifying critical bottlenecks, and applying systemic changes often without the need for additional resources. The findings from a review of ten scientific articles on lean management application are summarized in the following table as a foundation for comparative analysis.

Table 1. Summary of Reviewed Research Articles

No	Title & Authors	Research result
1	Implementation of Lean Hospital in Emergency Unit Services at RSUD Bayu Asih (Wati & Nu, 2021)	This study demonstrates that Lean Hospital implementation effectively identifies and reduces waste, particularly non-productive patient waiting time. The value-added activity ratio was only 23.68%, indicating that most processes do not directly benefit patients. Through lean analysis, the study proposed workflow improvements that significantly enhance patient waiting time and minimize non-value-added activities.
2	Utilizing Lean Hospital to Analyze Inpatient Boarding Time Inpatient care services of RS UNHAS (Wirawan, 2022)	This study addresses the prolonged inpatient boarding time in the ED, which exceeded the national standard of <6 hours. By applying Lean principles, the main bottleneck was found in the patient transfer process. Using Value Stream Mapping, the study identified inefficiencies and proposed workflow restructuring to optimize patient transfer.
3	Applying Lean Management to Reduce Radiology Turnaround Times for Emergency Departments (Verbano & Crema, 2019)	This Italian case study applied lean principles to reduce radiology turnaround time in the ED. The process from request to result was significantly shortened without additional staff or equipment. The project also improved staff engagement, internal communication, and established a culture of operational efficiency.
4	Improving Emergency Department Radiology Transportation Time: A Successful Implementation of Lean Methodology (Hitti et al., 2017b)	Post-intervention, average radiology transport time significantly decreased (from 22.89 ± 22.05 minutes to 9.87 ± 15.05 minutes, $p < 0.0001$). Additionally, 71.6% of post-intervention patients had transport times ≤10 minutes, compared to 32.3% pre-intervention. Further improvements were noted in report processing time and length of stay.
5	A Systematic Review on Lean Applications in Emergency Departments (Souza et al., 2021)	This systematic review identified six critical ED issues that can be addressed using Lean, such as long waits, inefficient patient flows, and high costs. Lean tools like Value Stream Mapping, Kaizen, DMAIC, and teamwork were found effective in improving efficiency and lowering operational costs.
6	Implementation of the Lean Healthcare System in the Emergency Room of the Clinical Hospital of the Federal University of Uberlândia: A Case Study (Freitas et al., 2023)	Conducted in three phases (pre, during, and post-implementation), this Brazilian study found improvements in staff motivation and service indicators. However, patient length of stay remained high, suggesting incomplete lean implementation. The study highlights the need for strong coordination between hospital management and local government.
7	Applying Lean Production Philosophy to Reduce Patient Waiting Time in Healthcare Services: Simulation-Based Optimization and Validation (Hassan et al., 2024)	Using Arena software simulations, the study found that adding one technician and one radiologist could reduce patient waiting time by up to 80% and lead time by 75%. Work-in-process (WIP) levels also decreased. The results emphasize the potential of data-driven lean strategies without infrastructure expansion.
8	Decreasing CT Acquisition Time in the Emergency Department through Lean Management Principles (Rachh et al., 2021)	After six months of lean implementation, the proportion of CT scans completed within 120 minutes rose from 61% to 71%, though sustained improvement lasted only six weeks. Monthly median TAT reduced from 90–109 minutes to 82–106 minutes, saving approximately 268 hours of full-time technologist labor.
9	Identifying Non-Value-Added Waste that Delays Emergency CT Brain Workflow Using Lean Management Principles (Zyl et al., 2020)	Lean analysis revealed that the longest process was from scan completion to report generation (mean 72.21 minutes, $p < 0.01$). In contrast, the shortest was the interval between scan request and radiologist annotation (mean 5.84 minutes), identifying critical areas for workflow optimization.

No	Title & Authors	Research result
10	Applying Systems Engineering to Reduce Radiology Transport Cycle Times in the Emergency Department (White et al., 2017)	Lean intervention significantly reduced average radiology transport time from 28.7 ± 4.2 minutes to 21.3 ± 3.1 minutes over one year (26% reduction, p = 0.0001). These results were achieved without additional resources, highlighting the value of systems engineering in ED radiology process efficiency.

DISCUSSION

Similarities in Study Findings

A review of ten articles on the application of Lean Management in emergency radiology services reveals consistent findings supporting its effectiveness. All studies concluded that Lean enhances service process efficiency without requiring additional human or technological resources. This suggests that operational gains can be achieved primarily through workflow optimization rather than capacity expansion. Waiting time emerged as the most frequently reported form of waste. Wati & Nu (2021) found that only 23.68% of radiology service activities were value-added, while the remainder comprised non-value-adding tasks. This aligns with studies reporting significant reductions in patient transport time to the radiology unit following Lean implementation Hitti et al. (2017a) highlighting Lean's ability to eliminate time-based inefficiencies across service stages.

A consistent feature across studies is the use of Value Stream Mapping (VSM) as the principal tool for process analysis. VSM enabled identification of bottlenecks and wasteful steps, serving as a data-driven foundation for targeted intervention planning ((Souza et al., 2021; White et al., 2017; Wirawan, 2022). Beyond efficiency gains, several studies reported positive shifts in organizational culture. Lean implementation contributed to improved interprofessional communication, enhanced staff motivation, and greater involvement in decision-making, ultimately strengthening team collaboration within healthcare environments (Freitas et al., 2023; Verbano & Crema, 2019).

Differences in Study Outcomes

Despite a shared foundation in Lean principles, studies varied in focus, methodology, and outcomes. While some investigated system-wide improvements in emergency care processes (Zyl et al., 2020; Wati & Nu, 2021), others concentrated on specific components such as patient transport (Hitti et al., 2017a), CT-scan reporting (Zyl et al., 2020), or radiology turnaround time (Rachh et al., 2021). Methodological diversity was also evident. Most studies employed case-based implementations (Freitas et al., 2023; Verbano & Crema, 2019), while others utilized simulation software such as Arena to assess Lean's impact under various scenarios before implementation (Hassan et al., 2024). Additionally, systematic reviews were used to identify existing inefficiencies and improvement opportunities (Souza et al., 2021).

Differences also emerged in the sustainability of outcomes. For example, Rachh et al. (2021) reported that efficiency improvements lasted only six weeks in the absence of continuous monitoring, while (White et al., 2017) observed sustained efficiency gains one year after implementation. These contrasting results underscore the importance of ongoing performance tracking to maintain Lean benefits. Structural challenges also contributed to divergent outcomes. Freitas et al. (2023) emphasized the impact of weak coordination between hospitals and local governments as a barrier to sustaining internal improvements. This illustrates that successful Lean adoption depends not only on internal organizational change but also on supportive policy and system-level structures. Geographically, studies conducted in low- and middle-income countries (e.g., Indonesia, Brazil, South Africa) faced limitations in resources and systemic support, whereas those from high-income countries demonstrated more stable and sustainable implementations. These contextual contrasts highlight the need for adaptive Lean strategies tailored to specific resource environments.

Strategies to Improve Emergency Radiology Efficiency

The literature identifies several strategic approaches for enhancing emergency radiology efficiency through Lean:

1. **Process Mapping via VSM**: Effectively identifies bottlenecks and wasteful activities, serving as a diagnostic baseline for data-driven interventions.
2. **Interdepartmental Communication**: Strengthening coordination between emergency departments, radiology units, and transport teams using standardized protocols and daily briefings can reduce waiting times significantly.
3. **Staff Training and Engagement**: Applying Kaizen principles and involving frontline staff in problem-solving fosters ownership and supports sustained improvement.
4. **Simulation-Based Decision-Making**: Simulation tools such as Arena allow for testing multiple improvement scenarios, reducing implementation risk in real settings.
5. **Information System Integration**: Adopting Picture Archiving and Communication Systems (PACS) and integrated hospital information systems accelerates imaging interpretation, reporting, and data flow.
6. **Managerial Commitment and Continuous Monitoring**: Leadership support and regular performance evaluations are essential to maintaining long-term efficiency gains. Without institutionalized monitoring, improvements may not persist beyond pilot phases.

Critical Discussion and Contextual Reflection

Although the reviewed studies consistently highlight the potential of Lean Management to Improve process efficiency in emergency radiology services; however, the variability of outcomes across settings suggests that systemic and cultural factors heavily influence effectiveness. In low- and middle-income countries (LMICs), Lean implementation is often limited by structural challenges such as fragmented healthcare delivery, inconsistent funding streams, limited health IT infrastructure, and overstretched human resources (Ramla et al., 2021) Unlike high-income countries where Lean initiatives are supported by strong leadership, stable data systems, and a culture of continuous improvement LMICs often lack the institutional readiness needed for sustained operational transformation.

Beyond structural barriers, organizational culture plays a pivotal role in determining the adoption and durability of Lean practices. As noted by Freitas et al. (2023), Lean requires not only changes in workflow but also a transformation in mindset from hierarchical, reactive problem-solving toward collaborative and proactive improvement. In resource-constrained settings, where healthcare workers are frequently overburdened and under-supported, resistance to change, limited psychological safety, and diminished motivation for engaging in non-clinical quality initiatives are common. These cultural and behavioral obstacles can undermine the long-term sustainability of Lean interventions. The divergent findings of Rachh et al. (2021)) and White et al. (2017) further illustrate the importance of institutionalization. Rachh et al. reported that initial efficiency gains dissipated within six weeks due to the absence of ongoing monitoring mechanisms. Conversely, White et al. documented sustained improvements over one year, enabled by regular performance tracking and leadership accountability. This contrast underscores that the mere presence of Lean tools is insufficient; what matters is the governance structure in which those tools are embedded. A nuanced understanding of contextual enablers is thus essential for translating Lean principles into lasting impact.

In the Indonesian context, Lean Management holds considerable relevance. Emergency departments (EDs) across the country face persistent challenges, including high patient volumes, limited radiology staffing, and administrative inefficiencies all of which contribute to prolonged diagnostic delays. However, systematic Lean adoption remains rare. Given Indonesia's decentralized healthcare governance and unequal distribution of hospital capacity, a contextually adapted Lean framework one that aligns with local digital readiness, workforce competencies, and service

demands may offer a feasible pathway to measurable improvements in emergency radiology quality.

Moreover, this review reveals a gap in cross-study synthesis. While many studies utilize similar tools (e.g., Value Stream Mapping) and report comparable outcomes (e.g., reduced turnaround time), such findings are often presented in isolation. A more integrative approach is needed to assess under which conditions Lean tools are most effective, and which combinations of interventions yield the most resilient outcomes. Bridging these insights could inform a more actionable roadmap for Lean implementation in resource-limited settings. This review contributes to a more nuanced academic understanding of Lean implementation in complex healthcare systems, particularly in under-resourced environments. From a scholarly perspective, it advances the discourse by framing Lean not merely as a technical intervention but as a form of organizational change shaped by institutional capability and policy alignment. From a policy standpoint, the findings emphasize the need for investments in health information systems, workforce capacity-building, and institutionalization of continuous improvement cultures at both hospital and regional levels. In the Indonesian context, Lean offers a strategic framework to mitigate structural inefficiencies and elevate the quality of emergency radiology care in a sustainable and measurable manner.

CONCLUSION

Based on the literature review, the implementation of Lean Management has proven effective in identifying and reducing waste, particularly within emergency radiology services. Core Lean principles such as Value Stream Mapping (VSM), interdepartmental collaboration, and a culture of continuous improvement play a critical role in enhancing service efficiency without requiring substantial investments. However, the effectiveness of Lean is highly dependent on organizational readiness, leadership support, and the external policy framework. Therefore, Lean implementation must be contextually adapted and accompanied by a consistent monitoring system to ensure long-term sustainability.

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