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IMPLEMENTATION OF LEAN SIX SIGMA IN PHARMACEUTICAL INVENTORY CONTROL AT HOSPITALS: A LITERATURE REVIEW

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ABSTRACT
Controlling drug inventory in hospitals plays an important role in ensuring the continuation of safe, timely, and efficient health services. However, problems such as overstock, out-of-stock, and inefficiency of the distribution process are often the main obstacles that still occur frequently. Lean Six Sigma in drug inventory control in hospitals is an approach that combines Lean and Six Sigma principles to improve efficiency, reduce waste, and decrease variation in the drug management process. The implementation of Lean Six Sigma aims to overcome problems such as stock out, overstock, and inefficient drug purchases, thereby improving the quality of pharmaceutical services in hospitals. Methods: This literature study used a combination of keywords "six", "sigma", lean", "inventory", "pharmacy", "hospital" and "Indonesia" in three databases ProQuest, ScienceDirect and Google Scholar. With the guidance of PRISMA, the selection of research articles that meet the inclusion and exclusion requirements is carried out. Results: Using the PRISMA guide, 6703 articles were found from the combined keywords. After screening for conformity with the inclusion and exclusion criteria, only 5 research articles were found that explained the implementation of lean six sigma in the pharmaceutical inventory supervision area in hospitals. From the five research articles, there are several implementations of lean six sigma such as DMAIC, 5 R's, Pareto Chart, Turnover Ratio, and waste analysis. Conclusion: Several methods of implementing lean management can be applied in pharmaceutical logistics to improve inventory oversight in pharmaceutical logistics.
Keywords: Six Sigma, Lean Management, Inventory, Hospital Pharmacy, Controlling

INTRODUCTION

The budget for drug spending in hospitals is the largest component of hospital spending. In many developing countries, drug spending in hospitals can absorb about 40 to 50% of the overall hospital costs (Jakovljevic & Getzen, 2016). These large costs must of course be managed effectively and efficiently, considering that funds for the purchase of drugs in hospitals are not always in accordance with needs. Efficiency in drug use can be achieved through good drug planning and control. Inventory control of pharmaceutical supplies is carried out to ensure that inventory is effective and efficient or there are no excess and shortages/voids, damage, expiration, and loss and return of orders for Pharmaceutical Preparations, Medical Devices, and Medical Consumables (Direktorat Jenderal Kefarmasian dan Alat Kesehatan, 2019).

Inefficient drug management will have a negative impact on hospitals and patients medically and economically. From several studies, it was found that there are still many hospitals that do not carry out a good drug planning and control process, causing problems such as empty drugs, excess stock, found damaged drugs and expired drugs at the service site.

Stockout causes hampered hospital services, loss of hospital revenue, and results in emergency purchases at higher costs. On the other hand, overstock causes the depletion of most of the pharmaceutical budget, resulting in insufficient funds for other essential medicines, drugs that are stored in excess often expire, and excess stock can increase storage costs and decrease storage conditions so that it can cause stock to be damaged and lost (Quick et al., 2012).

Lean six sigma is a combination of the concepts of Lean Process and Six Sigma. The combination of these two methods is by integrating the concept of Lean Process in Six Sigma tools. Lean is about speed, flow and elimination while Six Sigma is about understanding and decreasing the amount of variety. Lean Six Sigma is a multi-pronged effort to eliminate waste and variety, improving speed and flow in the supply chain (Goldsby & Martichenko, 2005). The principle of Lean Six Sigma is to improve and improve the quality of all activities that cause delays in the process (Gaspersz & Fontana, 2011). This approach also serves as a means to make continuous improvements. Lean Six Sigma is based on the concept of DMAIC, namely Determining, Measuring, Analyzing, Improving, and Controlling. These concepts allow us to clarify the problem thoroughly, identify weak points, analyze the root cause of the problem, and provide innovative proposals to address it.

Previous studies have explored various Lean Six Sigma implementations in hospital settings. For example, Ananda et al. (2024) applied the DMAIC framework to improve outpatient pharmacy operations, while Shamsan et al. (2024) used Pareto analysis and turnover ratios to address medicine expiration issues. Other studies, such as those by Supatmanto (2023) and Harahap (2023), demonstrated the utility of Lean principles in procurement and service quality enhancement. However, Sallam's systematic review (2024) revealed that only 2.74% of reviewed journals applied Lean Six Sigma in the context of hospital inventory, exposing a significant research gap in this specific application area. This study, therefore, aims to bridge that gap by reviewing Lean Six Sigma interventions explicitly targeting pharmaceutical inventory control in hospitals, particularly in Indonesia, a context that remains underexplored.

The novelty of this research lies in its focused synthesis of Lean Six Sigma implementation for pharmaceutical inventory management within Indonesian hospitals, guided by the PRISMA framework and confined to recent literature (2023–2025). By concentrating on this niche, the study offers fresh insights into context-specific challenges and practices, paving the way for more tailored interventions. The objective of this review is to identify key Lean Six Sigma tools and methods applied in hospital pharmacy inventory management and evaluate their effectiveness in addressing stock-related issues. The benefits of this study include providing healthcare administrators, pharmacists, and policymakers with a clearer understanding of evidence-based strategies to enhance pharmaceutical service efficiency, reduce waste, and improve patient satisfaction.

RESEARCH METHOD

This study employs a systematic literature review approach based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The aim of the study is to explore the implementation of Lean Six Sigma in pharmaceutical inventory control in hospitals, focusing on its efficiency and effectiveness in inventory management.

For data collection, this study gathered data from three major academic databases: ProQuest, ScienceDirect, and Google Scholar, using the search keywords "Six", "Sigma", "Lean", "Inventory", "Pharmacy", "Hospital", and "Indonesia". The search was limited to articles published between 2023 and 2025 to ensure the inclusion of the most recent studies. The initial search resulted in 6,703 articles, which were then screened for relevance to the research topic. Inclusion criteria were set to select primary research articles focusing on pharmaceutical inventory control in hospital settings, published in peer-reviewed journals or conference proceedings. Articles were excluded if they were systematic reviews, outside the pharmaceutical or hospital domain, or non-peer-reviewed such as posters or books. After the screening process, only 5 articles met the inclusion criteria and were selected for further analysis.

The population for this review consists of academic articles related to Lean Six Sigma applications in pharmaceutical inventory management. The sample includes 5 primary research studies specifically focusing on Lean Six Sigma methods such as DMAIC (Define, Measure, Analyze, Improve, Control), 5S (Sort, Set in Order, Shine, Standardize, Sustain), and Pareto Analysis within hospital pharmacy settings.

Data analysis in this review was conducted through a qualitative synthesis of the selected studies. Key themes and approaches identified in the articles were categorized and summarized. The analysis focused on identifying common Lean Six Sigma methods, their effectiveness in addressing inventory issues such as stockouts and overstocking, and the tools used for process improvements like the Pareto chart, Turnover Ratio, and DMAIC. The findings were presented with a detailed comparison of the methodologies used in different studies.

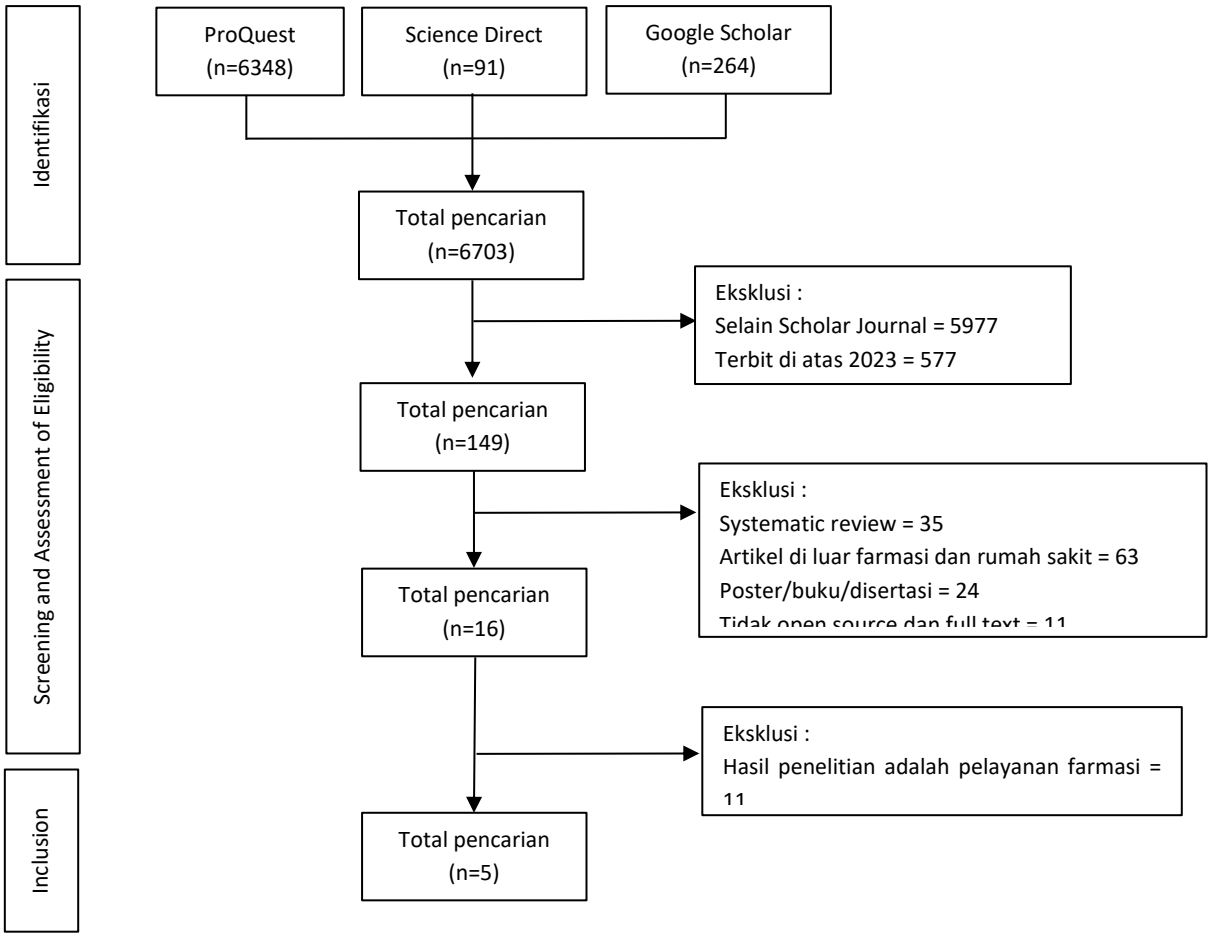

Figure 1. PRISMA flow
Source : Researcher

RESULTH AND DISCUSSION

From the results of article search from 3 databases, 16 primary research articles were obtained that met the inclusion criteria. Further searches found only 5 studies that discussed the effectiveness of lean six sigma in inventory management in hospital pharmacy. Details of the article can be seen in table 2. Several lean six sigma approaches are applied in improving inventory supervision in Hospitals. Some of the approaches include using the 5 S (Sort, Set in Order, Shine, Standardize, and Sustain), ABC VEN Approach, DMIC, Waste Analysis, Pareto Chart, and Turn Over Ratio Calculation.

Table 1. Article search results

Author (year)	Title	Publisher	Intervention	Result
Ananda, Susan Oktiwidya, et al (2024)	Prescription Coverage Improvement Strategy for	Jurnal Penelitian Ilmu Manajemen	Menggunakan pendekatan DMAIC (Define, Measure, Analyze, Improve,	Analisis internal menunjukkan ada beberapa isu seperti kekosongan

	Pharmacy Outpatient Installation at Premier Jatinegara Hospital		and Control) untuk menentukan kunci masalah dan rencana perbaikan. Perbaikan diusulkan dan dievaluasi dengan Siklus PDCA (Plan Do Check Action)	stok,monitor inventori secara real time tidak adekuat, alur kerja yang tidak efisien, dan kekurangan petugas saat peak hour. Analisis eksternal menunjukkan ketidakpuasan pasien dikarenakan lamanya waktu tunggu dan kekacauan rantai pasok karena faktor distributor.
Shamsan, Shamsan, et al (2024)	Identification of Causes of Medicine Expiration in the Warehouse-A Case of Saudi Medical Company	Proceedings of the Conferences on Industrial Engineering and Operations Management	Mengidentifikasi akar masalah dengan Pareto Chart, Turnover Ratio (TOV), dan Wawancara	Dengan Teknik TOV Ratio, diambil dalam ratio 1-3 sebagai produk yang terkontrol sebanyak 49 (40,2%), dan 73 (59,80%)di luar rentang 1-3. Dengan Pareto, akar masalah paling banyak dalam area forecasting (65%) dan production (15%)
Supatmanto, Ulfia, et al (2023)	Optimization of the Procurement Process of Pharmaceutical Supplies at Dr. M Goenawan Partowidigdo Pulmonary Hospital with a Lean Six Sigma Approach	BIO Web of Conferences	Implementasi Proposal ABC VEN, Observasi dan Analisis Dokumen, Interview dan Focused Group Discussion	Dalam sistem RS, ada modul untuk menentukan buffer stock (stock warning system). Perhitungan buffer stock berdasarkan penggunaan 2 bulan. Dari data wawancara, terkait ABC VEN, petugas

				non medis cenderung belum dipahami oleh petugas walaupun memiliki latar belakang medis dan non medis. Kurang adanya prosedur yang resmi berkontribusi terhadap panjangnya waktu pengadaan.
Harahap, Anton, et al (2023)	The Effect of Lean Approach on Hospital Service Quality and Inpatient Satisfaction	Unnes Journal of Public Health	Mengukur efektivitas pendekatan lean dari kepuasan inpatient melalui waste variable seperti: overproduction, waktu tunggu, transportasi, kelebihan proses, invention, motion, dan defect	Seluruh variabel waste memiliki efek yang signifikan terhadap kepuasan pasien rawat inap. Berdasarkan analisis multivariate, servis rumah sakit yang mempengaruhi kepuasan pasien antara lain inventori dan yang kurang mempengaruhi adalah transportation.
Wen-Jing Huang, et al (2024)	5S management improves the service quality in the outpatient-emergency pharmacy: from management process optimisation to staff capacity enhancement	European Association Hospital Pharmacists	Memberlakukan standar 5S secara bertahap di area farmasi rawat jalan-IGD : *Sort* (Ringkas) pada bulan Maret dan April *Set in Order* (Rapi) pada akhir April *Shine* (Resik)	Penggunaan alat dan ruang distribusi: Area alat yang sangat dibutuhkan meningkat 4,8%, sedangkan area alat yang kurang dibutuhkan turun 42,24%, adanya peningkatan area kerja 16,8% dan penambahan ruang

			pada awal bulan Mei *Standardize* (Rawat) pada akhir bulan Mei *Sustain* (Rajin) pada bulan Juni sampai Agustus	penyimpanan. Akurasi dan efisiensi penyiapan obat Tingkat kesalahan penyiapan obat turun 45,6 %, dan waktu tunggu pasien dan waktu penyiapan obat turun 36-38%. Penyimpanan Obat dan Turnover Adanya penurunan waktu drug stocking selama program 5S dari rata-rata 100 menit di awal menjadi rata-rata 50 menit. Kepuasan Pasien dan Petugas Kepuasan Pasien dan Petugas meningkat 41,8 % pada akhir program.

Source : Researcher

Controlling drug inventory in hospitals is a management process that aims to maintain the availability of drugs so that there is no shortage or excess stock, so that services to patients can run optimally at an efficient cost. Lean Six Sigma is a method that can be used in drug inventory control efforts in Hospital Pharmacy Logistics. The lack of lean six sigma research in inventory management was also found in the literature study conducted by Sallam. Sallam in a published journal in 2023, shows that a very small number of published journals implement six sigma, namely only 2 out of 73 journals (2.74%). From the study, the most evaluation of lean six sigma implementation was carried out for improvements in the areas of Quality Improvement Initiatives (30.13%), Workflow Optimizations (30.13%) and Technical Integration (20.55%) (Sallam, 2024). This shows the lack of six sigma research in the inventory area.

The DMAIC cycle also serves to make the service process more efficient continuously,

and stands for Define, Measure, Analyze, Improve, and Controln (Boersma et al., 2019). Ananda in 2024 will conduct research using a lean six sigma approach with the DMAIC method. The purpose of this research is to determine the key problems and improvement plans, then provide improvement proposals and evaluate them with the PDCA (Plan Do Check Action) Cycle5. The results of the Define phase reveal various operational inefficiencies, such as poor workflows, frequent medication dispensing errors and long wait times. The Measure phase within the DMAIC framework focuses on identifying the most impactful actions and processes that need improvement. The Measure Phase within the DMAIC framework successfully identified key areas in the workflow that need to be improved to improve operational efficiency. In the analysis phase, it was found that Environment, Human Resources (People), Process, and Technology are the main contributors to the decrease in prescription coverage. Long waiting times, out of stock, shortage of staff during peak hours, lack of training and inadequate skills. The Improve phase focuses on implementing targeted strategies based on the root of the problem that has been identified in the Analysis phase. These proposed improvements directly respond to key issues such as frequent out-of-stock and long patient wait times by implementing the implementation of the PDCA cycle in the control phase effectively monitoring and maintaining improvements that have been implemented in the Improve phase.

Shamsan in 2024 conducted research using the Pareto Chart, Turnover Ratio (TOV), and Interviews to identify the root cause of the problem of expired drugs in Saudi medical service warehouses. In the turnover ratio analysis, it was found that 73 (59.8%) products with a turnover ratio of less than 1 were identified as uncontrollable products and became the main focus of the analysis. The Pareto chart shows that forecasting is the main cause of drug expiration (65%) in the warehouse and production is the second most common cause of drug expiration (15%). This diagram also shows sales fluctuations, raw material shortages, untraceable products, and operational quality combined account for 20% of the cause of expiration, and therefore are not given the same emphasis as the previous two main factors.

In the research conducted by Supatmanto in 2023, the researcher used a Lean Six Sigma approach in optimizing the procurement process of pharmaceutical supplies at Dr. M. Goenawan Partowidigdo Lung Hospital. In the study, waste was found in the planning process and procurement process. Waste at the planning point occurs due to re-evaluation using different methods in calculating pharmaceutical inventory needs. Waste in the board of directors arises because the process is carried out manually so that if the directors are not in the place, the length of time is waiting for procurement approval. This waste is caused by the absence of planning and procurement indicators in the procurement process of pharmaceutical supplies. In this study, it was also found that the application of ABC VEN and stock buffers has not been understood by all parties involved in procurement activities. The proposed ABC VEN as a method of grouping pharmaceutical stocks becomes more relevant when used not only by the planning department, but also by the budget or finance departments. Opening up access to the pharmacy module for decision-makers, developing standard operational procedures that include procurement indicators and the development of hospital information systems based on research results, by including the grouping of ABC VEN and buffer stocks as part of the online procurement system are proposals for improvement from researchers.

Hopefully, in 2023, research will be conducted using a lean approach to hospital service quality and inpatient satisfaction. This study is a quantitative research with a data collection method using a closed questionnaire that contains a number of questions related to seven types of waste or inefficiency in hospital management. The results of the study on overproduction waste showed that 59.1% of respondents responded well with a 95% confidence interval (1,253–8,547) and a p-value of 0.019, indicating statistical significance. The study showed that the average service time from arrival to medication collection was 199.4 minutes for general patients and 408.4 minutes for BPJS patients. On wastage waiting time, 96.3% of respondents with a 95% confidence interval (1,353–13,875) and a p-value of 0.012 showed statistical significance. On transportation waste, the results showed that 71.8% of respondents responded well with a 95% confidence interval (1,353–13,875) and a p value of 0.011, indicating statistical significance. The over-processing waste results showed that 50.9% of respondents responded well with a 95% confidence interval (1,353–13,875) and a p value of 0.017. On wasting inventory, the results showed that 67.3% of respondents responded well with a confidence interval of 95% (1,353–13,875) and a p value of 0.010. On the waste of movements, the results showed that 83.6% of respondents responded well with a 95% confidence interval (1.353–13.875) and a p-value of 0.015. On waste defects The results showed that 71.8% of respondents responded well to the service defect variable, with a confidence interval of 95% (1.353–13.875) and a p-value of 0.010, which shows statistical significance. Based on a lean approach, management at the research site has shown the best performance in avoiding wastage of waiting time compared to other waste variables.

Waste analysis is also applied in the lean six sigma approach in hospitals, not only in the industry in general. There are 8 types of waste introduced by the Toyota Production System (TPS) in developing lean management in the company such as: overproduction, inventory, motion, transportation, over-processing, defect, waiting, and under-utilizing staff (Teich & Faddoul, 2013). Harahap in his analysis stated that the inventory obtained a good satisfaction value from 67.3% of inpatients (CI 95% 1.253-8.547, p value 0.019). Inventory in the Waste perspective is an overview of capital and storage costs. Things like excess medication inventory, excessive equipment, irrelevant data, or stacks of form printouts can result in inventory waste. Excess inventory can increase the risk of loss due to theft or obsolescence (Society, 2023). Several things were also found in a case study by Margaretha in 2024 related to inventory. From the cashier's side, it is necessary to procure the queue number, so that there are no patients who scramble and feel blocked in the queue. Meanwhile, from the pharmaceutical side, it is necessary to separate the queue of insurance and non-insurance patients so that there are no patient complaints, the number of filling forms in pharmaceutical warehouses that cause waste in inventory (Margaretha et al., 2024).

The 5S method, is one of the simpler lean methods for organizing and standardizing work areas. Each S represents each stage, including: seiri, seiton, seiso, seiketsu, and shitsuke in Japanese, then adopted in English into: sort, set to order, shine, standardize, and sustain. This method results in the actions needed to create a better work environment where employees can easily see the differences, and can reduce defects and costs and maintain a safe work environment (Venkateswaran et al., 2013). This is reflected in research conducted by Wen-Jing

Huang, in 2022 which used the 5S approach to improve the quality of services at the IGD9 Outpatient Pharmaceutical Installation. From the results of the implementation of 5S for 6 months, there was an increase in the work area by 16.8% with the addition of storage space. The increase in work area reflects the effectiveness of the 5S program, especially at the series stage, namely eliminating unused items.

CONCLUSSION

The implementation of Lean Six Sigma in pharmaceutical inventory control at hospitals plays a significant role in improving efficiency and reducing waste. The research highlights that methods such as DMAIC, 5S, and ABC VEN can be effectively applied to streamline inventory management, minimizing the issues of stockouts, overstock, and inefficiencies in the distribution process. By integrating Lean Six Sigma principles, hospitals can enhance their pharmaceutical logistics and ensure more effective drug management, leading to better healthcare outcomes and cost savings. The study also shows that these techniques, although applied in various hospital settings, remain under-researched, indicating a significant gap in the literature regarding their comprehensive implementation in hospital pharmacies.

Future research could focus on conducting case studies to evaluate the long-term impact of Lean Six Sigma implementation on pharmaceutical inventory management across a variety of hospitals with different operational scales and geographical locations. Additionally, exploring the integration of advanced technologies, such as artificial intelligence and machine learning, with Lean Six Sigma practices could offer further insights into enhancing drug inventory control. It would also be beneficial to investigate the role of employee training and engagement in the successful application of these methodologies, as human factors are crucial to the overall effectiveness of Lean Six Sigma processes.

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