LEAN AND SIX SIGMA IMPLEMENTATION IN HOSPITAL PHARMACY SETTING : A LITERATURE REVIEW

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ABSTRAK

Lean dan Six Sigma merupakan pendekatan manajemen mutu yang telah banyak diadopsi di sektor pelayanan kesehatan, termasuk di instalasi farmasi rumah sakit, guna meningkatkan efisiensi dan kualitas pelayanan. Penelitian ini bertujuan untuk meninjau dan mengidentifikasi metodologi yang digunakan, intervensi yang diterapkan, serta dampak implementasi Lean dan Six Sigma terhadap berbagai indikator kinerja di lingkungan farmasi rumah sakit. Tinjauan sistematis dilakukan menggunakan tiga database utama, yaitu Scopus, PubMed, dan Science Direct, dengan kata kunci "Lean" ATAU "Six Sigma" DAN "Farmasi", serta mengikuti pedoman PRISMA. Dari 54 artikel yang teridentifikasi, 11 artikel memenuhi kriteria inklusi. Hasil analisis menunjukkan lima metodologi implementasi, dengan metode DMAIC (Define, Measure, Analyze, Improve, Control) sebagai yang paling dominan. Sebanyak 40 intervensi ditemukan dalam studi terpilih dan diklasifikasikan ke dalam enam kategori utama, dengan tiga intervensi paling umum meliputi pengembangan proses atau sistem baru, penyediaan alat atau instrumen, dan perancangan ulang tata letak. Evaluasi dampak menggunakan lima kategori indikator utama menunjukkan bahwa penerapan Lean dan Six Sigma secara umum berdampak positif, seperti penurunan waktu layanan, pengurangan kesalahan pengobatan dan biaya, serta peningkatan kualitas, volume produksi, dan kepuasan pasien. Diperlukan penelitian lanjutan di berbagai konteks farmasi rumah sakit untuk mengeksplorasi indikator-indikator lain yang relevan.

Kata kunci : farmasi rumah sakit, implementasi, lean, peningkatan kualitas, six sigma

ABSTRACT

Lean and Six Sigma are quality management approaches widely adopted in the healthcare sector, including hospital pharmacy installations, to improve service efficiency and quality. This study aims to review and identify the methodologies used, interventions implemented, and the impact of Lean and Six Sigma on various performance indicators in hospital pharmacy settings. A systematic review was conducted using three main databases—Scopus, PubMed, and Science Direct—with the keywords "Lean" OR "Six Sigma" AND "Pharmacy," following the PRISMA guidelines. Of the 54 articles identified, 11 met the inclusion criteria. Analysis revealed five implementation methodologies, with the DMAIC (Define, Measure, Analyze, Improve, Control) method being the most dominant. A total of 40 interventions were identified in the selected studies and classified into six main categories, with the three most common being the development of new processes or systems, provision of tools or instruments, and redesign of layouts. Impact evaluation, using five main indicator categories, showed that Lean and Six Sigma generally had positive effects, such as reducing service time, medication errors, and costs, as well as improving quality, production volume, and patient satisfaction. Further research is needed in various hospital pharmacy contexts to explore other relevant indicators.

Keywords *: hospital pharmacy, implementation, lean, quality improvement,, six sigma*

INTRODUCTION

In recent years, patient satisfaction has become a crucial component of hospital services and a key indicator of healthcare quality. It reflects how well providers meet patients' expectations and influences patients' future healthcare decisions (Xesfingi & Vozikis, 2016).

Service quality plays an equally important role, as it has been positively linked to patient satisfaction and financial performance (Lim et al., 2018). It is assessed based on patients' actual experiences with the care they receive (Isfahani et al., 2019). Therefore, hospital policies and procedures must place patients at the center, valuing their experiences alongside clinical effectiveness and tailoring services to meet diverse needs (Gabutti et al., 2017). To achieve this, hospital administrators often adopt structured quality improvement frameworks (Isfahani et al., 2019).

The pharmacy department plays a central role in delivering patient-centered pharmaceutical care, encompassing both managerial and clinical functions. Efficient and effective management is essential to ensure high-quality pharmaceutical services (Peraturan Menteri Kesehatan Republik Indonesia Nomor 72 Tahun 2016 Tentang Standar Pelayanan Kefarmasian Di Rumah Sakit, 2016). Many hospitals have adopted industrial process improvement methods to achieve this goal (Ilangakoon et al., 2022). Among these, Lean and Six Sigma have been widely implemented in the United States, yielding improvements in patient experience scores (Shortell et al., 2021). However, adapting these approaches to healthcare requires consideration of factors such as organizational culture, staff engagement, and the complexity of patient care processes (Talero-Sarmiento et al., 2024).

Lean focuses on eliminating waste and delivering greater value to patients, while Six Sigma aims to reduce variations in processes, products, and services (Bertolaccini et al., 2015). Both share the goal of maximizing efficiency, but they differ in defining the root causes of inefficiency and in their methods to address them. Lean is a set of principles and practices that seek to optimize value by reducing waste and wait times, ultimately reshaping organizational culture (Lawal et al., 2014). Its five principles are: defining value from the customer's perspective, mapping the value stream, creating smooth workflow, responding quickly to customer needs, and continuously eliminating waste (Found & Harrison, 2012). Six Sigma, on the other hand, is a project-based approach focused on minimizing defects to improve quality, productivity, and financial outcomes (Kwak & Anbari, 2006).

Applying Lean begins with identifying waste and determining strategies to reduce or eliminate it (Graban, 2016). In pharmacy systems, inefficiencies may lead to waste, but Lean can help expedite services, improve quality, reduce errors, and increase employee engagement (Hlubocky et al., 2013). Although Lean has been successfully applied in various hospital services—such as emergency departments, internal medicine, operating rooms, and overall hospital operations (Bender et al., 2015; Breen et al., 2020; Matos et al., 2016; Ortíz-Barrios et al., 2017)—research specifically focused on hospital pharmacy settings remains scarce. A systematic review by Isfahani, Tourani, and Seyedin (2019) found that out of 48 studies on Lean management in hospitals, only three examined pharmacy departments. Similarly, Niñerola et al. (2020) reviewed Six Sigma in healthcare and found just three studies involving non-hospital pharmacy contexts, such as home delivery, long-term care, and retail pharmacies.

The purpose of this literature review is to analyze internationally published research on Lean and Six Sigma in hospital pharmacy settings. Specifically, it examines the methodologies used, interventions implemented, and their impacts on performance indicators. This review aims to provide a clear understanding of how these approaches have been applied globally and to identify opportunities for wider adoption in diverse healthcare contexts.

METHOD

This literature review was conducted in March 2025 following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The process consisted of three main stages: (1) conducting a comprehensive search for relevant studies, (2) screening and evaluating studies against eligibility criteria, and (3) extracting and

reviewing data from the included studies. The search was performed using three electronic databases—Scopus, PubMed, and Science Direct. A preliminary manual search was also conducted to identify additional relevant titles. Search terms included "lean," "six sigma," and "pharmacy," combined with the Boolean operators AND and OR. The final search strategy was: (lean OR "six sigma") AND pharmacy. As the search produced articles from various pharmacy fields, titles and abstracts were screened to ensure they met the primary criterion of being in a hospital pharmacy setting. Full texts were then reviewed for relevance.Studies were included if they used quantitative measures to assess the impact of interventions. Mixed-method studies were included only if they reported quantitative outcomes.

Articles had to provide explicitly defined measures for the variables of interest. Studies were eligible for inclusion if they were conducted in a hospital pharmacy setting, designed as intervention studies, published in English between 2013 and 2025, indexed in international databases, and available in full text. Mixed-method studies were also considered if they reported quantitative outcomes. Studies were excluded if they were review articles, letters, or comments, or if the interventions were only proposed or conducted through modeling without real-world implementation. The quality of included studies was assessed using the Joanna Briggs Institute (JBI) Checklist for Quasi-Experimental (Non-Randomized Experimental) Studies (Tufanaru et al., 2020). All studies employed a design similar to a single-group pre-test/post-test, measuring indicators before and after intervention. The checklist consists of nine questions, with quality rated as: high (>80% criteria met), medium (50–80%), or low (<50%) (Reilly et al., 2016; Mbuzi, Fulbrook & Jessup, 2018). This grading was not used to exclude studies. All included studies were rated as medium quality. Common weaknesses included the absence of control groups and the possibility of other concurrent factors influencing results. Given that these studies were conducted in ongoing service settings, processes were inherently susceptible to variations between the pre- and post-intervention periods.

RESULTS

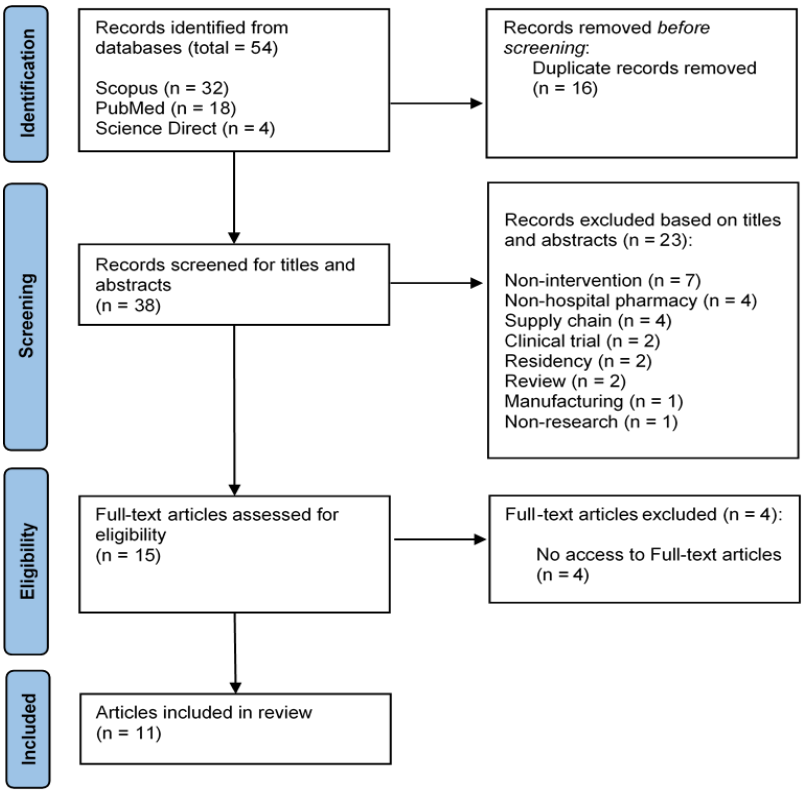

Figure 1. PRISMA diagram of retrieved studies

The initial literature search generated 54 articles from 3 databases (Scopus, PubMed and Science Direct). After the removal of article duplication, 38 titles and abstracts were assessed to determine whether the articles were relevant to this systematic review. Only 15 articles were assessed for eligibility and full text reviewed. Finally, 11 completely related articles were included in the analysis. Figure 1 provides an overview of the selection process.

Study Characteristics

There were eleven studies that described the method of implementing Lean and Six Sigma and measured its impact in the specified setting. As Table 1 shows, the studies were carried out in several different countries. Two studies were carried out in Indonesia (Iswanto & Rosady, 2020; Yuliati & Andriani, 2021), two in Saudi Arabia (Al Kuwaiti, 2016; Al Nemari & Waterson, 2022), two in China (Gao et al., 2020; Lv et al., 2025), one in Jordan (Hammoudeh et al., 2021), one in Spain (Rico & Jagwani, 2013), one in Thailand (Trakulsunti et al., 2022), one in United Arab Emirates (Sallam et al., 2024) and one in United States (Sullivan et al., 2014).

Among the eleven studies, six were conducted in the outpatient pharmacy setting (Al Kuwaiti, 2016; Al Nemari & Waterson, 2022; Hammoudeh et al., 2021; Iswanto & Rosady, 2020; Lv et al., 2025; Yuliati & Andriani, 2021), three were in aseptic dispensing setting, including IV admixture and oncology pharmacy (Gao et al., 2020; Rico & Jagwani, 2013; Sullivan et al., 2014), one was conducted in inpatient pharmacy (Trakulsunti et al., 2022), and one was conducted in both outpatient and inpatient pharmacy (Sallam et al., 2024).

Table 1. Characteristics of The Included Studies

Studies	Country	Setting	Pharmacy Area	Concept Terminology	Type of study
(Rico & Jagwani, 2013)	Spain	Hospital Universitario Doctor Negrin	Aseptic Dispensing	Lean method	Quantitative
(Al Kuwaiti, 2016)	Saudi Arabia	King Fahd Hospital of the University	Outpatient	Six Sigma	Quantitative
(Gao et al., 2020)	China	Jinan Central Hospital	Aseptic Dispensing	Lean management	Quantitative and qualitative
(Yuliati & Andriani, 2021)	Indonesia	Grha Permata Ibu Hospital	Outpatient	Lean Kaizen	Quantitative and qualitative
(Iswanto & Rosady, 2020)	Indonesia	RSIA Grand Family Jakarta	Outpatient	Lean method	Quantitative
(Trakulsunti et al., 2022)	Thailand	Hospital under Thailand's Ministry of Public Health	Inpatient	Lean Six Sigma	Quantitative
(Hammoudeh et al., 2021)	Jordan	King Hussein Cancer Center (KHCC)	Outpatient	Lean management	Quantitative
(Al Nemari & Waterson, 2022)	Saudi Arabia	King Fahad Medical City	Outpatient	Six Sigma	Quantitative
(Sullivan et al., 2014)	USA	Smilow Cancer Hospital	Aseptic Dispensing	Lean method	Quantitative
(Lv et al., 2025)	China	Tongde Hospital of Zhejiang Province	Outpatient	Lean management	Quantitative
(Sallam et al., 2024)	UAE	Mediclinic Parkview Hospital	Inpatient and Outpatient	Lean management	Quantitative

The data extraction showed result that eight studies adopted Lean concept terminology (Gao et al., 2020; Hammoudeh et al., 2021; Iswanto & Rosady, 2020; Lv et al., 2025; Rico & Jagwani, 2013; Sallam et al., 2024; Sullivan et al., 2014; Yuliati & Andriani, 2021), two studies

used Six Sigma (Al Kuwaiti, 2016; Al Nemari & Waterson, 2022), and one study used Lean Six Sigma (Trakulsunti et al., 2022), a combination technique between Lean and Six Sigma used to achieve continuous improvement in quality-related issues (Vaishnavi & Suresh, 2020).

Study Methodologies

The aim of this review was to identify methodology and intervention used in implementing Lean and Six Sigma concept in varying settings of hospital pharmacy. It also aimed to review the impact of the implementation in the selected indicators. Table 2 shows an overview of the characteristics of the study methodology. The most used methodology was DMAIC methodology as it was used in five studies. DMAIC methodology stands for Define, Measure, Analyze, Improve and Control. Those phases allow quality improvement of any procedure at the project level or across the entire of the organization (Niñerola et al., 2020). For example, Al Nemari and Waterson (Al Nemari and Waterson, 2022), explained that Define phase was carried out by outlining in-depth the internal customers and external customers (patients and family) and what each type of customer desires and require. The Measure phase was carried out by outlining the quality features that would show enhancement in customer satisfaction and process performance, while the analyze phase was performed to identify required design and process changes for accomplishing customer satisfaction and performance goals (Al Nemari & Waterson, 2022). Improve phase was the step to formulate the intervention suggestion to improve the identified problem in the previous phase. The last phase was Control, in which it was needed to supervise the implementation of the intervention and to achieve sustainable result.

It is notable that all three studies that adopted Six Sigma concept used DMAIC methodology, as it is the method most frequently associated with Six Sigma. DMAIC is generally recognized as improvement procedure within the realm of quality management, showcasing Six Sigma's structured approach (De Mast & Lokkerbol, 2012). One study adopted Plan-Do-Check-Act (PDCA) as the methodology (Yuliati & Andriani, 2021), a predecessors method of DMAIC with similar function, used in manufacturing problem solving (De Mast & Lokkerbol, 2012). Other studies did not explicitly mention the exact term used for methodology, but in general, those studies adopted planning, implementing and evaluating phases as their methodology to assess the current situation, to plan for the improvement, and to measure the impact of implementing the concept.

Table 2. Study Methodology Characteristics

No	Methodology	Studies
1	DMAIC (Define, Measure, Analyze, Improve, Control)	(Gao et al., 2020); (Hammoudeh et al., 2021); (Al Kuwaiti, 2016); (Al Nemari & Waterson, 2022); (Trakulsunti et al., 2022)
2	PDCA (Plan, Do, Check, Act)	(Yuliati & Andriani, 2021)
3	Observation, Planning, Implementation, Measurement	(Rico & Jagwani, 2013), (Lv et al., 2025)
4	Plan, Intervention, Evaluation	(Sullivan et al., 2014)
5	Implementing improvement and analyze	(Iswanto & Rosady, 2020)
6	Orientation, Coordination, Training, Awareness, Governance, Observation, Normalization, and Promotion (OCTAGON-P)	(Sallam et al., 2024)

Study Interventions

There were 40 interventions identified in this review that could be categorized into 6 general classifications; adjusting human resource, developing new process/system, implementing 5S (Sort, Set in Order, Shine, Standardize, and Sustain) method, providing

equipment, instrument and hardware, redesigning layout and training program. Table 3 shows an overview of the intervention characteristics.

Table 3. Study Intervention Characteristics

No	Intervention Classification	Intervention	Author and Year
1	Adjusting human resource	Adjusting the staffing schedule	(Sullivan et al., 2014)
		Providing data entry operators	(Al Kuwaiti, 2016)
		Reducing the staff of certain shift	(Gao et al., 2020)
2	Developing new process/system	Adjusting product amount	(Gao et al., 2020)
		Centralizing admixture process for similar medication	
		Changing the first delivery time schedule	
		Setting delivery elevators prioritization	
		Postponing billing process	(Hammoudeh et al., 2021)
		Reviewing daily stocks	
		Developing sorting inventory system	(Iswanto & Rosady, 2020)
		Implementing better rules and standard	
		Developing 'Patient code number'	(Al Kuwaiti, 2016)
		Developing an acceptable taut time	
		Establishing an algorithm for CSP stocks	(Rico & Jagwani, 2013)
		Generating labels for the CSP	
		Evaluating implemented unified CPOE system	(Sullivan et al., 2014)
		Standardizing documentation	
		Developing a STAT medication ordering process guideline	(Trakulsunti et al., 2022)
		Developing medication orders criteria for nurses	
		Developing medication orders standard practices for nurses	
		Redesigning the existing daily dose medication preparation process	
		Changing staff working habit	(Yuliati & Andriani, 2021)
3	Implementing 5S method	Cleaning and organizing pharmacy room thoroughly	(Iswanto & Rosady, 2020)
		Implementing and operationalizing 5S methodology training	(Al Kuwaiti, 2016); (Sallam et al., 2024)
4	Providing equipment/ instrument	Automation with 2 robotic dispensing units	(Al Nemari & Waterson, 2022)
		Inventing a central oscillator	(Gao et al., 2020)
		Preparing pharmacy workflow video	(Hammoudeh et al., 2021)
		Providing a barcode scanning	(Al Kuwaiti, 2016)
		Providing all the physicians with name seal	
		Replacing old PCs	(Hammoudeh et al., 2021)
		Updating computer information software and replacing computer hardware	(Lv et al., 2025)
5	Redesigning layout	Dividing prescription screening location for BPJS and non-BPJS	(Yuliati & Andriani, 2021)
		Expanding the workbench area	(Gao et al., 2020)
		Organizing inventory storage	(Iswanto & Rosady, 2020)
		Organizing medication alphabetically	(Hammoudeh et al., 2021)
		Relocating PCs to match process sequence	
6	Training program	Developing learning module for pharmacy order entry	(Hammoudeh et al., 2021)
		Involving pharmacist in physician training for order entry	
		Standardizing and implementing appropriate training program	(Al Kuwaiti, 2016)
		Enhancing the training to pharmacy staff	(Lv et al., 2025)

In most studies, interventions were decided after analyzing and identifying the root cause of the problems. The interventions were also in line with the focused area where the improvement needed. Developing new process or system is the most used intervention in implementing both concepts in hospital pharmacy. Developing new process or system was mostly centered around developing new guidelines, standard operating procedures, working schedules, or improving workflow process for pharmacy staffs and/or related stakeholders. This finding is in line with principles of lean which focuses in creating seamless value flow for the process (Found & Harrison, 2012). In attempt to reach that goal, several studies employed Value Stream Mapping tools (Gao et al., 2020; Iswanto & Rosady, 2020; Rico & Jagwani, 2013; Sullivan et al., 2014) to map information and processes flow in the system, resulting in the possibilities of finding waste process and deciding to eliminate the identified waste by proposing a new procedure.

Providing new equipment or instrument for work and redesigning working layout is the second and third most used intervention, as both were utilized in five and four studies respectively. Types of new equipment provided in each study was different, but the general idea is centered around reducing manual work to either decreasing time or reducing errors. The most advanced new equipment applied among these studies was robotics in drug dispensing process (Al Nemari & Waterson, 2022). Redesigning working layout was also selected as one of the most used intervention and it was mostly focused on organizing instruments in order to reduce motion waste. Motion waste was identified as the highest percentage (19%) of waste in an outpatient pharmacy in Indonesian hospital. The lack of standards pertaining to workplace layout is the primary reason for the aforementioned waste motion, leading to a decrease in service efficiency (Putri, 2017). Another study conducted by Rahayu, Sunarni and Saptarini (Rahayu, Sunarni and Saptarini, 2021) in another different Indonesian hospital also revealed the same result where motion waste attained the highest percentage waste at 21,1%. Accordingly, it was deemed important to make interventions in order to eliminate this waste.

Initial implementation of the 5S management method was observed to have enhanced the quality of health services and boosted the morale of the staff in a healthcare facility where the available resources were inadequate and had a cluttered work setting in Senegal (Kanamori et al., 2015). Two studies adapted this method to establish designated locations for all items and ensure that they are consistently kept in their assigned places (Al Kuwaiti, 2016) and to sort out unneeded items and arrange needed items in a manner that facilitated easy accessibility and retrieval (Iswanto & Rosady, 2020). Another study employed more thorough implementation of 5S, starting from identification and removal of unnecessary and outdated either equipment or pharmacy stock, using systematic labelling and visible indicators for storage, regular cleaning and strategic placement, implementing regular checklist for cleaning, and monitoring the adherence level of 5S implementation (Sallam et al., 2024).

Indicators and Impact of Interventions

In total, there were 27 various indicators assessed in different studies that could be categorized into 5 general categories; time, medication error number, production, cost, and patient satisfaction. Time indicator was assessed in inpatient, outpatient and aseptic dispensing pharmacy setting, and mostly were about lead time or waiting time for a certain procedure to be carried out (Al Nemari & Waterson, 2022; Gao et al., 2020; Hammoudeh et al., 2021; Sallam et al., 2024; Sullivan et al., 2014; Yuliati & Andriani, 2021). Time indicator could be calculated as the whole process dispensing time or it could also be broken down into several steps, for examples time required for prescription verification, product verification, and medication delivery (Sullivan et al., 2014). Other time indicators observed are medicine retrieval time and return time (Sallam et al., 2024). Time indicator was found to be the most frequently evaluated measure across the studies (55,56%). As patient satisfaction is closely tied to pharmacy waiting

times (Arafeh et al., 2014), it is important to measure how applying lean concept can help reduce delays in pharmacy services.

Medication error number indicator calculated the errors occurred in dispensing phase and was assessed in outpatient and inpatient pharmacy setting. Some of the example of dispensing errors evaluated in the studies were prescription entry error (Al Kuwaiti, 2016; Trakulsunti et al., 2022), medication label error (Al Kuwaiti, 2016), wrong medication-wrong patient error (Al Nemari & Waterson, 2022), delivering wrong numbers, medication in close proximity, and forgetting to dispense medication (Lv et al., 2025). Two out of three studies in aseptic dispensing pharmacy setting evaluated production indicators, as both production quality and production quantity (Gao et al., 2020; Rico & Jagwani, 2013), while another study in aseptic dispensing pharmacy only evaluated time indicator. Other studies chose cost reduction (Iswanto & Rosady, 2020) and patient's satisfaction (Hammoudeh et al., 2021; Lv et al., 2025) as measured indicators for implementing lean concept. Table 4 shows overview of the indicators chosen in each of the study and the impact of implementing lean and Six Sigma concept in the chosen indicators.

Table 4. Study Indicator and Intervention Impact

No	Author and Year	Indicator Category	Indicator	Intervention Impact
1	(Rico & Jagwani, 2013)	Production	First-time quality (FTQ)	Increase from 56% to 95%
			CSP production	Increase by 94.4%
2	(Al Kuwaiti, 2016)	Medication error	Prescription entry error	Decrease from 56,000 to 5,000 in PPM
3	(Gao et al., 2020)	Production	Admixture production	Increase from 4,200 bags to 5,200 bags per day
			Unqualified production	Decrease from 210 to 50 bags per month (decreased by 76.2%)
		Time	PIVAS daily time	Decrease in daily PIVAS time use from 210 to 180 minutes (decreased by 14.3%)
4	(Yuliati & Andriani, 2021)	Time	Non-compounding time	Decrease from 135.31 minutes to 9.11 minutes (scenario 1) and to 7.49 minutes (scenario 2)
			Compounding time	Decrease from 185.17 minutes to 31.09 minutes (scenario 1) and to 29.15 minutes (scenario 2)
5	(Iswanto & Rosady, 2020)	Cost	Inventory cost	Decrease from US$ 22,494 to US$ 15,128 monthly
			Benefit cost ratio	592% from total saving US$ 22,097 and the implementation cost was US$ 3,733 (in 3 months)
6	(Trakulsunti et al., 2022)	Medication error	Monthly dispensing error	Decrease from 29 incidents to 6 incidents
7	(Hammoudeh et al., 2021)	Time	< 3 item time	Decrease from 22.3 minutes to 8.1 minutes
			≥ 3 item time	Decrease from 31.8 minutes to 16.1 minutes
		Patient satisfaction	Patient satisfaction	Increase from 62% to 69%
8	(Al Nemari & Waterson, 2022)	Time	Patient time	Decrease from 17.093 to 11.812 digital minutes
		Medication error	Dispensing error rate	Decrease from 1.00% to 0.24%
9	(Sullivan et al., 2014)	Time	Order verification	Decrease by 33%
			Product verification	Decrease by 52%
			Medication delivery	Decrease by 47%
10	(Lv et al., 2025)	Medication error	Dispensing error rate	Decrease from 2798 incidents (3.46‰) to 219 incidents (0.27‰)

		Patient satisfaction	Patient satisfaction	Increase from 52.94% to 72.97%
11	(Sallam et al., 2024)	Time	Outpatient retrieval time	Decrease by 50%
			Inpatient retrieval time	Decrease by 40%
			Emergency prescription serving time	Decrease by 16.7%
			Pediatric prescription serving time	Decrease by 11%
			Inpatient return time	Decrease by 67%
			Inventory replenishment time	Decrease by 36%

DISCUSSION

In general, all interventions in included studies resulted in better indicator result post-implementation. Time indicator showed a decrease in inpatient, outpatient and aseptic dispensing area. A significant time decrease in outpatient pharmacy was shown in study applying developing new process and redesigning layout as intervention (Yuliati & Andriani, 2021). The study developed two scenarios with each of the intervention. The first scenario was developing new process that was done by eliminating the prescription stacking process and carrying the process immediately, while the redesigning layout as second scenario was executed by dividing prescription screening location for BPJS and non-BPJS prescription. The result showed a wide decrease from around 135 minutes to 9 minutes for first scenario and 7 minutes for the second one.

Numerous errors are possible to occur throughout different stages of medication usage process within the hospital setting. Among these stages, dispensation is particularly critical as the failure in detecting the errors might increase the risk of patient harm (Poole et al., 2021). Hence, it is crucial to have dispensing systems that are safe, well-organized, and efficient. A study in Lebanon showed that dispensing errors were primarily attributed to significant workload, illegible handwriting, frequent interruptions and distractions, and the resemblance of drug packages (Soubra & Karout, 2021). Another study Jordan stated similar results, with illegible handwriting and high workload being the majority of causes for dispensing errors (Abdel-Qader et al., 2021). Common methods to prevent dispensing errors encompass the use of dispensing alerts, including tall-man lettering, dosage form notifications on each package for similar medications, and implementing double-checks prior to delivery. Nevertheless, despite these alerting strategies, the dispensing process largely depends on human intervention, which continues to make it susceptible to errors (Tu et al., 2023).

Automated dispensing systems have the potential to decrease dispensing errors and administrative error, particularly those related to drug name, dose, and form inaccuracies (Tu et al., 2023). The implementation of lean and Six Sigma also decreased the number of dispensing-stage medication error. automation with robotics in outpatient pharmacy resulted in a reduction of medication error reporting, in-out discrepancies per day, and the number of mislabeling events. The intervention recorded a decrease from an average of 1.0% to an average of 0.24% (Al Nemari & Waterson, 2022).

Most used indicators in aseptic dispensing setting is production, both in quality and quantity. Implementation of lean and Six Sigma also showed positive result in these indicators. Rico and Jagwani (Rico and Jagwani, 2013) measured first-time quality (FTQ) of hospital compounding services, a lean metric that signifies the degree to which components are produced accurately on the initial attempt, without necessitating inspection, reworking, or replacement. The study employed developing new system as intervention by creating an

algorithm for compounding sterile preparations stocks that consider various factors such as demand, initial product cost, ergonomics, quality assurance, and the probability of elaboration error. Demand-adapted stocks ensured a reduction in workflow disruptions and resulted in an increase of FTQ from 56% to 95% (Rico & Jagwani, 2013). Gao *et al*., (Gao et al., 2020) measured unqualified dispensing drug number as its quality production indicator. The impact of developing some new systems, redesigning layout and adjusting human resource resulted in the decrease of unqualified number from 210 bags to 50 bags per month. Quantity production in both studies showed an increase after implementing the interventions.

The implementation of lean concepts has ensured that healthcare organizations can prioritize their primary functions and allocate more time and resources to patients, without additional cost for either the patients or the healthcare system. A sterile service department achieved a remarkable 78% reduction in costs through the implementation of lean practices. Similarly, the pharmacy department successfully implemented a lean system, resulting in a well-organized supply of hospital units and a significant reduction in both stock levels and costs (Kovacevic et al., 2016). The same cost indicator was measured by Iswanto and Rosady (Iswanto and Rosady, 2020). After implementing 5S method for three months as intervention, the inventory cost decreased from US$ 22,494 to US$ 15,128 monthly. Another cost indicator used in this study was benefit-to-cost ratio (BCR), evaluated by calculating the implementation cost and the cost reduction resulted from the implementation. The result showed BCR more than 1, implying that the benefit of implementation was greater than the cost needed to apply the implementation.

CONCLUSION

This review showed that there were still quite limited literatures published internationally about quantitative impact on implementation Lean and Six Sigma in hospital pharmacy setting compared to other hospital healthcare areas. However, the results of this review imply that implementation of Lean and Six Sigma in hospital pharmacy can improve several quality indicators for pharmacy services. By employing methodologies such as DMAIC and PDCA, hospital pharmacy is able to identify the current process and the possible existing problems. Interventions were then made based on the problems identification, and the results show a decrease in time indicator, medication error indicator, and cost indicator. On the other hand, quality production, quantity production and patient's satisfaction show an increase after interventions. Further study about Lean and Six Sigma implementation in other countries or hospital pharmacy settings is needed to generate more insight about other possible impact of the implementation.

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