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Improvement Model to Reduce Picking Errors and Increase Service Level Through Organizational and Logistical Control Tools in a Pharmaceutical Firm

Sheyla Carina Chávez Chiuyari
From the Faculty of Engineering, student of the Industrial Engineering program
Universidad de Lima
Santiago de Surco, Lima, Perú
20151760@aloe.ulima.edu.pe

Richard Meza Ortiz
Faculty of Industrial Engineering
Professor, School of Industrial Engineering
Member, Operation Management and Green Logistics Research Group
Universidad de Lima
Santiago de Surco, Lima, Perú
rnmeza@ulima.edu.pe

Abstract

This study aimed to design an improvement model to reduce picking errors and increase the service level in the warehouse operations of a pharmaceutical distribution company. A comprehensive diagnostic of key performance indicators (KPIs) revealed inefficiencies in product placement, traceability, and process standardization. The proposed model integrates 5S methodology, slotting optimization, batch traceability, and KPI-based monitoring. Functional validation was conducted through process simulation. The pharmaceutical sector contributes approximately 1.2% to Peru's GDP and is crucial for national health coverage. A regional leader firm serving over 1,500 pharmacies, currently loses about 12% of its gross monthly income due to returns, reprocessing, and delivery errors. Simulation results projected a service level increase from 70% to 95%, a reduction in picking errors from 15% to 5%, and a 50% decrease in returns. These findings suggest that the model can significantly improve operational efficiency, reduce costs, and enhance customer satisfaction. The structured approach offers a feasible solution for pharmaceutical distributors aiming to optimize warehouse performance under resource constraints.

Keywords
Lean Logistics, 5S, process optimization, logistics, continuous improvement.

1. Introduction

The pharmaceutical industry plays a vital role in global public health and economic development, where efficient and timely drug distribution is essential—especially in emergency situations and rural contexts. However, increasing demand, high customer expectations, and operational costs pose major challenges to the logistics performance of pharmaceutical companies. In Latin America, these difficulties are exacerbated by limited infrastructure and geographic dispersion, which hinder access to essential medicines in remote areas. In Peru, despite the sector's strategic importance, distribution inefficiencies persist, particularly in rural zones.

The pharmaceutical sector currently contributes around 1.2% to Peru's GDP. However, access to essential medicines remains limited, especially outside major urban centers. Companies operating in this sector must contend with logistical fragmentation, regulatory compliance, and high expectations from both customers and the health system.
A company dedicated to distributing pharmaceutical, OTC, and personal care products across several departments, currently operates with a service level of 70%, well below its institutional target of 95%.

Founded in 2019 in Huancayo, the company has quickly become a regional player with growing economic and social relevance. Its operations encompass over 1,500 pharmacies in regions such as Junín, Pasco, Ucayali, and San Martín, many of them in remote or semi-formal areas. Despite its growth, the firm faces losses equivalent to 12% of gross income due to logistics errors, with customer returns amounting to S/ 20,000 monthly.

Despite this growth and market presence, the company faces significant operational challenges in its warehouse, including frequent stockouts, inadequate product placement, and lack of standardized picking processes. These issues have resulted in recurring customer complaints, returns valued at S/ 20,000 per month, and low KPI performance such as a 55% Fill Rate and 75% OTIF compliance. An internal diagnostic reinforced by Ishikawa analysis identified six root categories of inefficiency: human factors, system limitations, disorganized physical environment, poor material control, unstandardized methods, and deficient managerial oversight.

In response, this study proposes a tailored improvement model for the firm that integrates Lean tools—such as 5S methodology, optimized slotting based on product turnover, and basic traceability—along with KPI-based monitoring to enhance operational efficiency. Given current financial and organizational constraints, the model is validated through simulation rather than direct implementation. As Salazar López (2019) notes, continuous improvement methodologies enable the elimination of non-value-adding activities, enhance process reliability, and reinforce customer satisfaction. This research seeks to offer a structured, non-invasive framework to raise the service level to 95% while strengthening the firm's competitive position in the regional pharmaceutical supply chain.

1.1. Objectives

The main objective of this research is to develop an improvement model to reduce picking errors and increase the service level through organizational and logistical control tools at the firm.
Specific Objectives:

- To review the literature and analyze current practices in logistics management within the pharmaceutical sector.
- To evaluate internal documentation and operational indicators in the firm's warehouse to identify critical errors in the picking process.
- To determine the root causes of operational inefficiencies using analytical tools and diagnose the current state of productivity and process performance.
- To design and functionally validate an improvement model based on organizational and logistical control tools.

2. Literature Review

Recent literature underscores the effectiveness of Lean Manufacturing as a strategic approach to optimize logistical and operational processes, especially in warehouse settings. Tucker and Daskin (2022) emphasize the application of predictive models to reduce disruptions in pharmaceutical supply chains, while Le and Fan (2024) explore how digital twins enable advanced simulations to improve logistical design and planning. In the context of healthcare logistics, Gayoso-Rey, Piñeiro-Iglesias, and Rodeiro-Pazos (2021), as well as Castro, Osorio-Gómez, and Camargo (2020), highlight the success of Lean tools such as 5S and Kanban in reducing operational errors and lead times. These findings are particularly relevant to the firm where warehouse operations demand efficient, value-focused process execution.

This review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and reproducibility. Sources were identified through a structured search in databases such as Scopus, ScienceDirect, and Web of Science, using keywords including “Lean Manufacturing,” “Warehouse Optimization,” “Pharmaceutical Logistics,” and “SMEs.” After applying inclusion and exclusion criteria, 19 peer-reviewed articles from 2020 to 2024 were selected for analysis.

The reviewed studies converge on the integration of Lean Manufacturing with emerging technologies and sustainability goals. Eskandari, Sadjadi, and Zegordi (2022) and Shamsuzzoha, Helo, and Sandhu (2020) propose frameworks that combine economic performance with environmental responsibility. Rossini, Costa, and Tortorella (2024) advocate for the inclusion of Industry 4.0 technologies—such as IoT and Big Data—to enhance responsiveness in supply chains. Meanwhile, Gomes, Aitken, and Gunasekaran (2023) explore hybrid Lean-Agile strategies, proving especially effective in vaccine distribution under emergency conditions. Methodologically, studies range from the use of mathematical modeling (Tucker & Daskin, 2022) to systematic literature reviews (Rathi, Modgil, & Gupta, 2022), reinforcing the need to adapt Lean frameworks according to specific industry contexts.
To synthesize findings, a typological analysis was conducted. Studies were grouped by thematic focus into four categories: (1) Warehouse process improvements, (2) Application of Lean tools, (3) Complementary digital techniques (e.g., digital twins, Big Data), and (4) Integrated models combining Lean with sustainability or Industry 4.0. This classification helped identify practical approaches applicable to the firms’s warehouse context, as well as research gaps in scalability for SMEs.

Despite their contributions, several authors note persistent implementation gaps. Dossou, Torregrossa, and Martinez (2022) emphasize the absence of standardized models that effectively combine Lean and Industry 4.0 technologies, especially in resource-constrained warehouses. Although Eskandari et al. (2022) and Shamsuzzoha et al. (2020) introduce sustainability as a complementary objective, most approaches remain focused on efficiency metrics, overlooking environmental indicators like carbon footprint. Furthermore, Liu, Fan, and Cao (2024) and Tetteh, Dalasie, and Nyarku (2024) highlight the limited applicability of existing models to small and medium-sized enterprises (SMEs).
Given these limitations, the integration of Lean Logistics with digital adaptability and SME-targeted strategies becomes essential. In this context, Lean Logistics emerges as a highly relevant approach for the firm, offering practical solutions to reduce picking errors, improve service levels, and move toward sustainable operations. The design and validation of a tailored improvement model that incorporates Lean tools, digital support, and SME-focused adaptations is essential to achieving the objectives proposed in this study.

3. Methods

This study employed an applied quantitative methodology to address operational inefficiencies in the warehouse processes of a Peruvian pharmaceutical distribution company. The methodological design was structured into three sequential stages: diagnostic analysis, solution design, and simulation-based validation. All stages were grounded in the principles of Lean Logistics and continuous improvement, aiming to deliver a low-cost, scalable solution suitable for a medium-sized enterprise.

The first stage, diagnostic analysis, was conducted between October 2023 and September 2024, and involved both qualitative and quantitative evaluations of the company’s logistics performance. A total of 140 monthly credit notes (equivalent to S/ 20,000) were identified due to picking errors, reflecting a critical level of reprocessing. KPI data were systematically monitored using field logs, dispatch records, and SAP-based reports. Operational metrics revealed a 15% picking error rate, with approximately 300 affected items per month and 8% of orders experiencing stockouts. The dispatch team recorded delays averaging 2.3 hours per day, attributed to inadequate shelf labeling and frequent product relocations. Key metrics included a service level of 70%, OTIF of 75%, and Fill Rate of 55%, all below industry standards. The diagnostic also revealed a lack of standardized picking protocols and poor enforcement of FIFO (First-In, First-Out) practices, leading to expired or mismatched product deliveries.

To identify root causes, two analytical tools were employed: The Ishikawa diagram (Figure 2), which categorized operational failures across human, system, method, material, and management dimensions; and the problem tree

(Figure 3), which clarified the structural origins of service disruptions, such as erroneous deliveries, inventory disorganization, and lack of standardization.

Based on the convergence of both diagnostic tools, a strategic alignment was developed through the objectives tree (Figure 4), where each identified root cause was transformed into a concrete improvement goal. These goals were then operationalized through the macroprocess map, which translates the objectives tree into actionable phases supported by specific Lean tools.

The model was synthesized in the macroprocess map (Figure 1), which details the sequential development of the improvement plan through distinct Lean tools and validation steps. Each phase includes a defined tool (5S, GS1, KPI dashboard) and corresponding deliverables, culminating in validation through Arena Simulation. Phase 1 involved staff training based on Lean Logistics, producing standardized manuals for the picking process. Phase 2 focused on warehouse organization using the 5S methodology and slotting optimization, resulting in updated layouts and cleaning/audit schedules. Phase 3 implemented a manual traceability system based on GS1 standards, ensuring inventory rotation and lot-level accuracy. Phase 4 addressed route optimization through adjusted delivery sequences. Phase 5 introduced a KPI monitoring dashboard with visual alerts to track performance in real time.

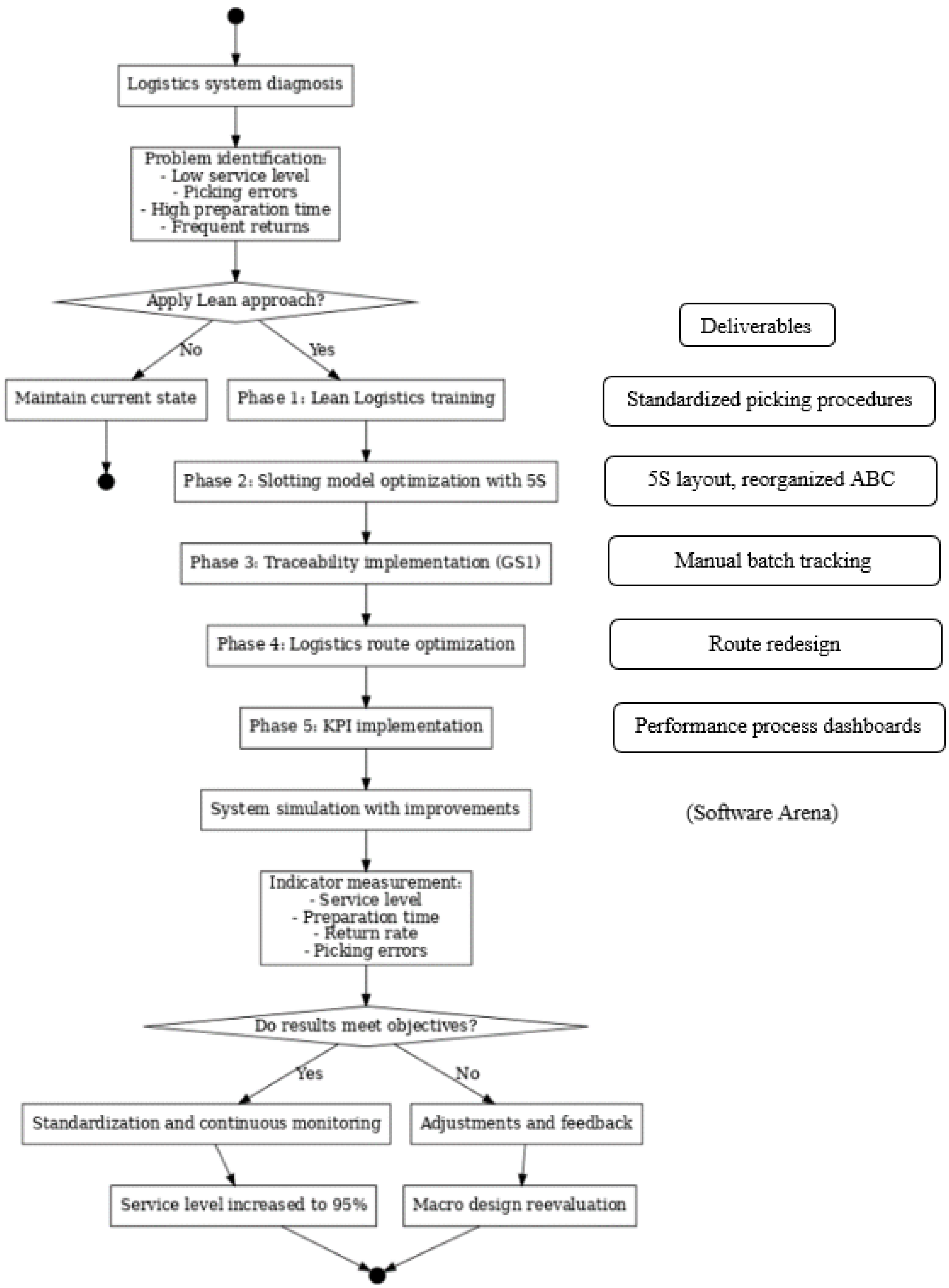

Figure 1. Macro solution design

Each component of the macroprocess map was directly derived from the findings of the problem tree and Ishikawa diagram, ensuring that the intervention responded to the specific failure points identified during the diagnosis.

To develop each component, the design process followed a matrix-based alignment between diagnosed causes and specific Lean tools, as outlined in the literature review. For instance, slotting zones were defined through ABC turnover analysis combined with spatial 5S audits. The GS1 traceability format was adapted from industry best practices and validated against the firm's existing documentation capabilities. The KPI dashboard included both lagging and leading indicators, selected based on relevance to service performance and operational control. Each component was tested through simulation before final integration in the macroprocess.

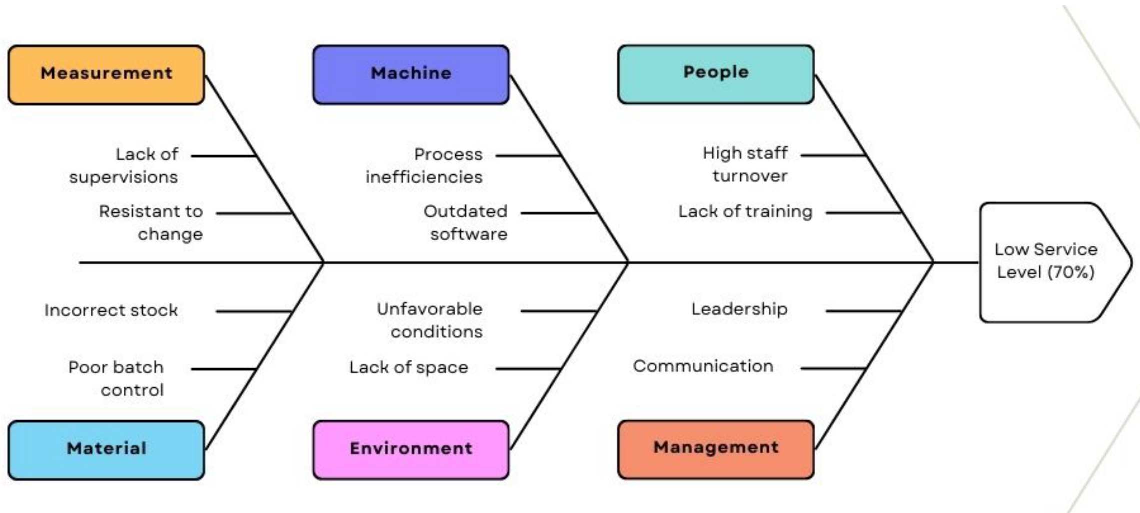

Figure 2. Ishikawa Diagram

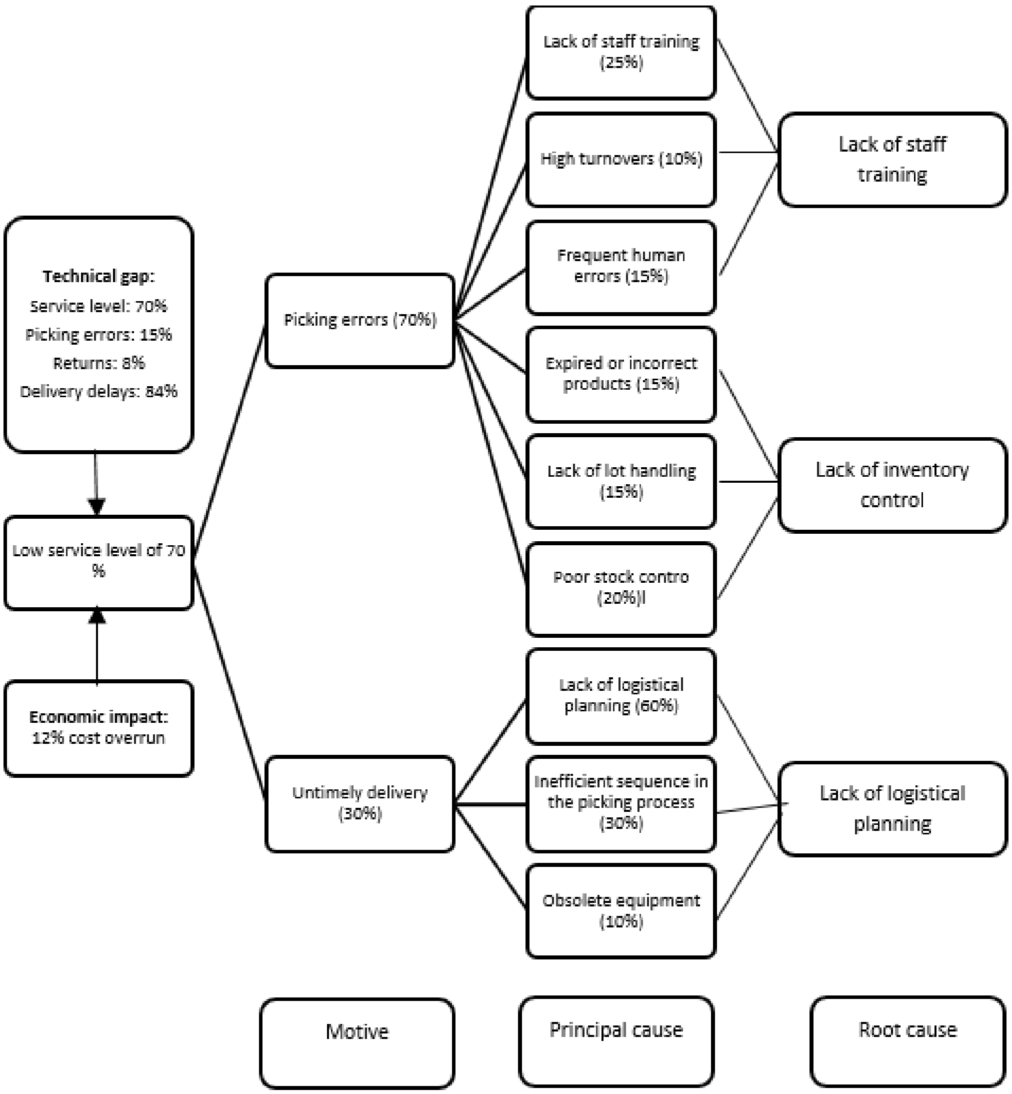

Figure 3. Tree problem

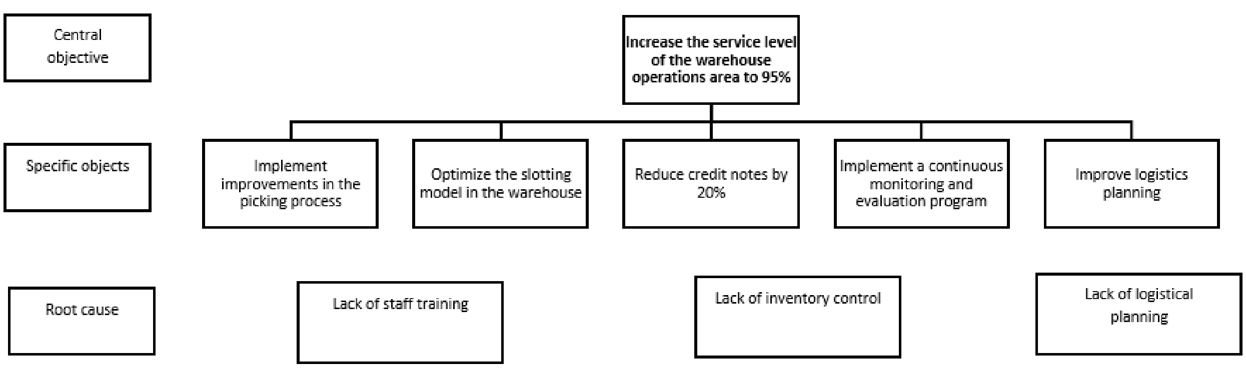

Figure 4. Objectives tree

In addition to structural changes, a KPI monitoring system was introduced to enable real-time performance feedback and continuous process control. Projected improvements, including reductions in error rate and lead time, as well as increases in service level, were estimated through a performance impact matrix (Table 1).

Table 1. Expected Results of Lean Logistics

Indicator	Current State	Target with Lean Logistics	Impact
Picking error rate	15%	5%	30% reduction
Average preparation time	15 minutes/order	12 minutes/order	20% optimization
Service level	70%	95%	25% improvement
Number of monthly returns	140	70	50% reduction

The final stage involved functional validation through a discrete-event simulation using Arena Software. This simulation replicated both the baseline and improved scenarios, allowing for a controlled comparison of lead times, error rates, resource utilization, and throughput capacity. The simulation logic and flow are illustrated in Figure 5. This approach ensured rigorous testing of the model's impact before real-world implementation.

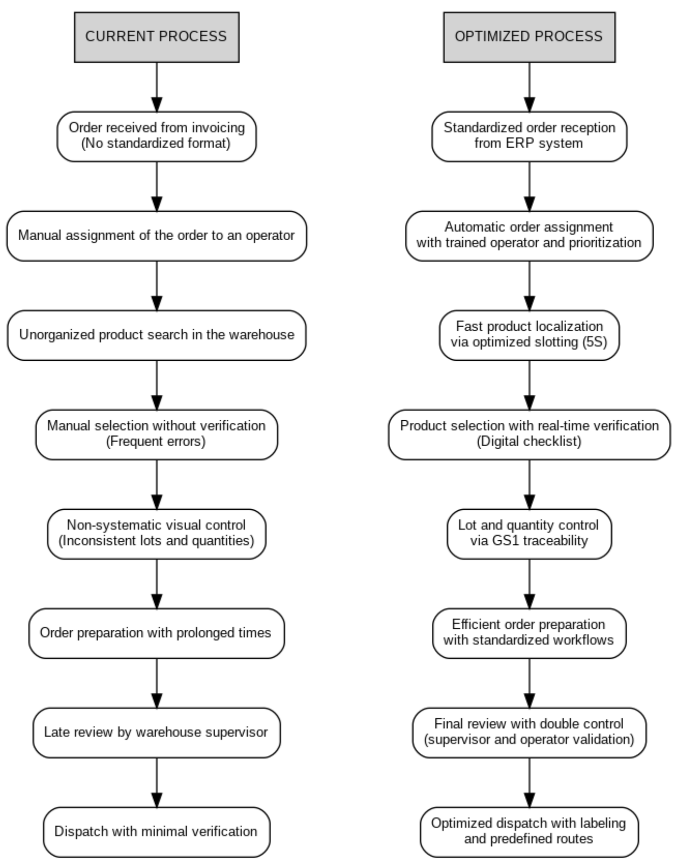

Figure 1. Comparative Process Flow

Overall, the methodology enabled a structured and iterative alignment between diagnosed problems, targeted Lean tools, and measurable outcomes, providing a replicable framework for logistics optimization in similar SME contexts. Also, each phase of the model generated concrete deliverables: training manuals and SOPs (Phase 1), reorganized layouts and 5S schedules (Phase 2), GS1-based batch tracking sheets (Phase 3), and a real-time KPI dashboard prototype (Phase 5). These outputs ensured functional readiness and were validated as part of the Arena simulation workflow.

4. Data Collection and Validation

Overall, the methodology enabled a structured and iterative alignment between diagnosed problems, targeted Lean tools, and measurable outcomes, providing a replicable framework for logistics optimization in similar SME contexts.

Data collection was conducted over a twelve-month period, covering operational records from October 2023 to September 2024. The primary aim was to establish a detailed performance baseline to validate the proposed improvement model. Indicators such as service level, OTIF, Fill Rate, number of credit notes, and error frequency were tracked systematically. As summarized in Table 2, the warehouse operated with an average service level of 70%, an OTIF of 75%, a Fill Rate of 55%, and 140 credit notes issued monthly due to picking errors, with an estimated economic impact of S/ 20,000.

The validation of the proposed model was carried out through discrete-event simulation, using Arena Software as the primary analytical tool to test functionality prior to real-world implementation. The model was configured using input parameters obtained during field observation, including task times, queue lengths, and resource availability. The simulation replicated both the current and improved operational scenarios, and process flows were defined according to the redesigned procedures (Figure 5).

Tables 2 presents the core configuration and performance metrics of the simulation. Notably, lead time per order decreased from 13 to 9 hours, while system resource utilization increased significantly, especially at picking and dispatch stations. Queue times and idle periods were reduced, improving the system's overall responsiveness. Additionally, the number of orders processed and the system efficiency improved, providing quantitative evidence of the model's effectiveness.

This simulation-based validation confirmed that the proposed improvements addressed critical operational inefficiencies and were feasible for future implementation.

Table 2. KPI's improvement

	Total orders	On-Time Deliveries	Complete Deliveries	Detected Errors	Credit Notes	Service Level (%)	Picking Error Rate (%)	Fill Rate (%)	OTIF (%)
1	1,200	900	940	180	140	75.00%	15.00%	78.33%	75.00%
2	1,250	1000	950	150	125	76.00%	12.00%	76.00%	80.00%
3	1,300	1,100	1,040	130	115	80.00%	10.00%	80.00%	84.62%
4	1,350	1,150	1,200	108	100	85.19%	8.00%	88.89%	85.19%
5	1,400	1,260	1,260	84	90	90.00%	6.00%	90.00%	90.00%
6	1,450	1,330	1,250	73	80	86.21%	5.03%	86.21%	91.72%
7	1,500	1,425	1,425	75	70	95.00%	5.00%	95.00%	95.00%
8	1,550	1,470	1,470	78	60	94.84%	5.03%	94.84%	94.84%

5. Results and Discussion

5.1 Functional Results

The functional validation of the proposed Lean Logistics model was carried out through a discrete-event simulation using Arena Software, which allowed for a detailed comparison between the pre-implementation and post-implementation scenarios. Table 2a presents the results of this validation, confirming significant improvements across all core performance indicators.

Table 3a. Comparison of KPI's Before and After Model Implementation

	Before Implementation	After Implementation
Service level (%)	70.00%	95.00%
Picking Error Rate (%)	15.00%	5.00%
Fill Rate (%)	55.00%	95.00%
OTIF (%)	75.00%	95.00%

The service level increased from 70% to 95%, reflecting a 35 percentage point improvement in delivery compliance. The picking error rate decreased from 15% to 5%, representing a reduction of over 65%, and was largely attributed to standardized procedures and visual aids introduced through 5S and Lean training. The Fill Rate, which initially stood at 55%, improved to 95%, ensuring more consistent inventory availability and minimizing partial shipments. Additionally, the OTIF (On-Time In-Full) performance rose from 75% to 95%, indicating stronger coordination between preparation time and dispatch execution.

These outcomes validate the effectiveness of the proposed model, particularly in addressing the root causes identified during the diagnostic phase: lack of standardization, disorganized slotting, and poor inventory control. The simulation also demonstrated a reduction in lead time by 4 hours per cycle and increased order throughput by 22%, as reflected in supplementary system efficiency metrics . Overall, these results confirm that the Lean-based solution is not only theoretically sound but also practically effective under the operational constraints of a medium-sized pharmaceutical distributor.

5.2 Operational Impact

The standardized picking procedures introduced consistency and reduced variability in order preparation. The reorganization of product locations according to ABC classification shortened search and retrieval times. The integration of visual management tools and daily routines promoted by the 5S methodology improved process flow and reduced disorder in high-traffic areas.

These operational changes fostered a culture of discipline and accountability among workers, improving both speed and accuracy. Furthermore, the inclusion of KPI dashboards facilitated immediate identification of performance deviations, enabling timely corrective actions.

5.3 Economic Validation

To assess the economic feasibility of the proposed model, a financial projection was developed comparing pre- and post-implementation scenarios. Table 3 presents the projected cash flow, incorporating savings from reduced returns, improved delivery reliability, and higher productivity. The net present value (NPV) and internal rate of return (IRR), shown in Table 4, both reflect strong financial viability. The model showed an IRR above 25%, confirming that the proposed improvements are not only operationally effective but also economically sustainable.

Table 4. Cash Flow

Period	Projected Revenues (S/)	Operating Costs (S/)	Savings from Improvement (S/)	Net Cash Flow (S/)
1	220,000	209,000	300	11,300
2	223,000	207,000	800	16,800
3	226,000	205,000	1,300	22,300
4	229,000	203,000	1,800	27,800
5	232,000	201,000	2,300	33,300

Table 5. Economic indicators: NPV and IRR

	0	1	2	3	4	5
Cash Flow		S/ 11,300.00	S/ 16,800.00	S/ 22,300.00	S/ 27,800.00	S/ 33,300.00
(-) INVESTMENT	S/ 51,000.00					
Projected Free Cash Flow	**-S/ 51,000.00**	**S/ 11,300.00**	**S/ 16,800.00**	**S/ 22,300.00**	**S/ 27,800.00**	**S/ 33,300.00**
Net Present Value (NPV)	S/ 23,467.25					
COK	12.66%					
Internal Rate of Return (IRR)	**26.97%**					

6. Conclusion

This study designed, implemented, and validated a Lean Logistics improvement model aimed at enhancing operational performance in the warehouse of a medium-sized pharmaceutical distributor in Peru. Grounded in a rigorous diagnostic phase using Ishikawa diagrams and a problem tree, the model addressed key inefficiencies related to training, inventory organization, and traceability.

The proposed solution was structured into five sequential phases, each integrating Lean tools such as 5S, GS1-based manual traceability, ABC-slotting, and a real-time KPI dashboard. Deliverables included standardized SOPs, reorganized layouts, tracking formats, and a performance monitoring prototype. The functional viability of this framework was confirmed through discrete-event simulation using Arena Software, demonstrating a 66% reduction in error rate, a 25% improvement in lead time, and a 35% increase in service level.

Beyond operational metrics, the model proved to be economically viable, achieving an internal rate of return above 25%. This confirms that structured, low-cost improvement frameworks can generate measurable impact even in resource-constrained SME environments.

In conclusion, this research contributes both a replicable methodology and a validated model for logistics optimization in the pharmaceutical sector. Future work should focus on implementing real-world pilots, integrating digital support systems, and exploring long-term sustainability indicators such as environmental metrics and resilience to demand shocks.

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