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# Transforming Inventory Management at RS Siloam Jantung Diagram: A Lean Driven Approach to Reducing DOI and Strengthening Patient Safety

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Days of Inventory (DOI);
Current Reality Tree (CRT);
Patient Safety;
Healthcare Supply Chain.

**ABSTRACT**
This research examined inventory management challenges at RS Siloam Jantung Diagram and proposed improvement initiatives to enhance operational efficiency while maintaining patient safety. As a specialized cardiovascular hospital, the availability of medical supplies is critical to ensuring uninterrupted patient care and supporting clinical outcomes. The hospital experienced persistent inventory inefficiencies, reflected in Days of Inventory (DOI) levels that consistently exceeded the organizational target of 23 days and reached a peak of 55 days. These conditions resulted in excess inventory, expired consumables, emergency procurement, redundant activities, and delayed operational decision-making, thereby increasing operational costs while posing risks to service reliability and patient safety. A mixed-method approach was employed, combining quantitative analysis of inventory performance data with qualitative insights obtained through focus group discussions, direct observations, and a 5S assessment across key operational units. The Current Reality Tree analysis identified relationships among operational issues and revealed four primary root causes: the absence of an integrated inventory management system, lack of clear ownership, unclear roles and accountability, and reliance on manual processes. These factors reduced inventory visibility, weakened cross-functional coordination, and limited timely decision-making. Based on these findings, the study proposed improvements in governance, process standardization, forecasting practices, role clarification through RACI alignment, real-time monitoring, and preparation for Warehouse Management System and hospital information system integration. The research demonstrated that addressing systemic causes rather than isolated symptoms could improve inventory performance while strengthening patient safety. The proposed framework provides a practical reference for healthcare organizations seeking sustainable inventory management practices and operational excellence.

## INTRODUCTION

Hospitals operate within a complex environment where clinical excellence, operational efficiency, and patient safety must be managed simultaneously. Among the supporting systems that enable safe and effective healthcare delivery, inventory management plays a critical role, particularly in specialty hospitals where medical supplies are high-value, sensitive, and directly linked to clinical outcomes. Ineffective inventory practices may result in excess stock, expired consumables, emergency procurement, and inconsistent availability of essential items, all of

which contribute to financial inefficiencies and potential risks to patient safety (Organization 2023; Peter 2023; Rubigha 2020; Shamsan et al. 2024; Thomsen 2024).

RS Siloam Jantung Diagram is a specialized cardiovascular hospital providing advanced cardiac services, including outpatient care, inpatient treatment, emergency response, catheterization laboratory procedures, and surgical interventions. In such a high-acuity clinical setting, uninterrupted availability of medical consumables and pharmaceuticals is essential to ensure timely procedures and continuity of care. Inventory disruptions in this context affect not only operational performance but may also delay critical interventions, increase clinical workload, and expose patients to avoidable risks (Anozie et al. 2024; Dzreke et al. 2025; Kubheka 2026; Makowane et al. 2026; Shore et al. 2022).

Over the observed period, RS Siloam Jantung Diagram experienced persistent challenges in inventory management, reflected in Days of Inventory (DOI) levels that consistently exceeded the hospital's strategic target of 23 days and reached a peak of 55 days in December 2024. This prolonged imbalance between supply and demand resulted in multiple operational consequences, including excess inventory, expired items, duplicate ordering activities, and frequent emergency purchases. These conditions placed increasing financial pressure on hospital operations and reduced flexibility in resource allocation (Barasa et al. 2017; Bera et al. 2023; Ebel 2025; Ordu et al. 2021; Yusefi et al. 2022).

Beyond financial implications, fluctuating inventory levels also raised concerns regarding patient safety. Stockouts of essential cardiac consumables may delay scheduled procedures or require last-minute substitutions, while excessive stock increases the likelihood of near-expiry or expired items entering clinical workflows. These risks are further exacerbated by the absence of fully integrated digital inventory systems, inconsistent implementation of inventory policies, and unclear coordination among departments involved in planning, procurement, storage, and clinical utilization (Adhikari et al. 2024; Akande et al. 2024; Furstenau et al. 2022; Nabelsi et al. 2017; Rashid et al. 2026).

The coexistence of increasing inventory costs and patient safety risks indicates that the challenges faced by RS Siloam Jantung Diagram are not isolated operational problems but systemic issues. Inventory inefficiencies are closely associated with broader organizational factors, including process design, role clarity, data visibility, and cross-functional alignment. Addressing these challenges therefore requires a structured, system-based approach that extends beyond short-term cost reduction and focuses on sustainable improvement.

This study was conducted to analyze the underlying causes of high DOI and inventory inefficiencies at RS Siloam Jantung Diagram and to develop improvement initiatives that strengthen inventory governance while prioritizing patient safety. By applying Lean-aligned principles and structured analytical tools, this research provides practical insights into how inventory management can function not only as an operational support system but also as a critical mechanism for ensuring safe, reliable, and high-quality patient care.

RS Siloam Jantung Diagram is a specialized cardiovascular hospital that is part of a larger hospital group in Indonesia. Established in 2006, the hospital was developed as a center of excellence for cardiovascular services, providing comprehensive care across diagnosis, intervention, surgery, and rehabilitation. Its service scope includes outpatient clinics, inpatient care, emergency services, catheterization laboratory (Cath Lab), operating theatre, medical rehabilitation, pharmacy, laboratory, and supporting diagnostic units.

As a cardiac specialty hospital, RS Siloam Jantung Diagram operates in a high-acuity clinical environment where service reliability, rapid response, and clinical precision are essential. The hospital maintains 24-hour cardiologist standby coverage to support emergency and elective cardiovascular procedures. This operational model requires a high level of readiness, particularly in maintaining the availability of medical consumables, pharmaceuticals, and procedure-specific supplies that directly support patient care activities.

Inventory management at RS Siloam Jantung Diagram is organizationally positioned under the Operations and Services Division, with a dedicated Inventory Planner responsible for demand planning, stock monitoring, and coordination with pharmacy, procurement, and user departments. Inventory flows across multiple clinical and non-clinical units, including outpatient departments (OPD), inpatient departments (IPD), operating theatre, Cath Lab, emergency department, and supporting diagnostic services. The complexity of this multi-unit environment creates challenges in aligning demand forecasting, stock replenishment, and consumption tracking.

The hospital's inventory system supports a wide range of consumables and medical supplies with varying characteristics, including high-value cardiac items, fast-moving routine consumables, and products with strict expiry and storage requirements. These characteristics require accurate forecasting, disciplined stock rotation, and timely coordination among departments. Any disruption in these processes may affect not only operational efficiency but also clinical workflows and patient safety.

In recent years, increasing service demand, procedural complexity, and reliance on manual or partially integrated systems have placed additional pressure on inventory planning and control. Although existing processes support daily operations, limitations in real-time visibility, system integration, and cross-functional coordination have contributed to inefficiencies in stock management. These conditions make RS Siloam Jantung Diagram an appropriate case for examining how inventory management practices can be strengthened to support both operational performance and patient safety in specialized hospital settings.

RS Siloam Jantung Diagram has experienced persistent inefficiencies in its inventory management system, as reflected in consistently high Days of Inventory (DOI) levels that exceeded the hospital's strategic target of 23 days over an extended period. This condition culminated in December 2024, when DOI reached 55 days, indicating that inventory levels were more than twice the intended threshold. The prolonged nature of this situation suggests a structural imbalance between inventory planning, actual consumption patterns, and replenishment decisions rather than a temporary operational deviation.

Excessive inventory has resulted in recurring waste, particularly from expired and slow-moving consumables, leading to direct financial losses through disposal activities. Beyond disposal costs, inefficient inventory practices have created indirect financial burdens, including increased storage requirements, duplicate administrative processes, and suboptimal allocation of operational resources. Capital tied up in excess stock has reduced the hospital's capacity to reinvest in service quality, technological advancement, and workforce development, thereby contributing to increased operational costs.

Paradoxically, despite overall overstock conditions, the hospital has continued to experience emergency procurement for specific items. This reflects uneven stock distribution and limited inventory visibility across departments, where surplus inventory in certain

categories coexists with shortages in others. Emergency procurement disrupts standard purchasing processes, often incurs higher costs, and increases operational complexity, highlighting weaknesses in demand forecasting, inventory monitoring, and interdepartmental coordination.

Importantly, these inventory inefficiencies extend beyond financial and operational performance and may pose risks to patient safety. In a high-acuity cardiovascular hospital setting, shortages of critical consumables may delay procedures or require clinical teams to make suboptimal substitutions under time constraints. Conversely, excessive inventory increases the risk that near-expiry or expired items may enter clinical workflows if stock rotation and monitoring processes are inadequate. Such conditions create latent safety risks that may compromise treatment continuity and clinical outcomes.

Overall, the observed challenges indicate that the business issue is systemic in nature. Dependence on manual processes, limited integration among inventory-related systems, inconsistent implementation of stock policies, and unclear roles and accountability have collectively reduced inventory visibility and decision-making effectiveness. These interrelated factors have reinforced recurring patterns of excess stock, waste, emergency procurement, and operational instability, highlighting the need for a structured, organization-wide approach to inventory management improvement that balances operational efficiency with patient safety priorities.

This study sought to answer three main research questions. First, what operational inefficiencies and root causes contributed to persistently high Days of Inventory (DOI) and inventory waste at RS Siloam Jantung Diagram? Second, what improvement alternatives could enhance inventory visibility and reduce DOI while maintaining patient safety and continuity of care? Third, how could the hospital implement targeted inventory process improvements to achieve a sustainable DOI of 23 days or less through the integration of structured and Lean-aligned practices? Accordingly, the objectives of this study were to identify the root causes of high inventory levels and inefficiencies through quantitative analysis and qualitative investigation, evaluate alternative inventory management approaches that could improve visibility, coordination, and efficiency while safeguarding patient safety, and develop practical implementation initiatives aimed at reducing DOI to 23 days or below to ensure sustainable inventory performance and uninterrupted clinical services.

This study was limited to the management of medical consumables and routine medical supplies that directly supported daily clinical operations at RS Siloam Jantung Diagram, with particular emphasis on high-utilization units such as the Operating Theatre, Pharmacy Main Store, and Laboratory. The analysis excluded capital equipment and implantable medical devices, as these items are governed by distinct procurement cycles, regulatory requirements, and inventory control mechanisms that differ fundamentally from routine consumables.

From a process perspective, the research examined the end-to-end inventory management flow, including demand planning, replenishment, storage, distribution, and usage tracking. The study focused on inventory planning practices, stock monitoring routines, adherence to stock policies (including minimum–maximum inventory levels and stock rotation), and coordination among clinical and non-clinical units. The research also considered the role of information systems and data visibility in supporting operational decision-making and ensuring continuity of care.

Organizationally, the scope included units directly involved in inventory planning, handling, and utilization, particularly the inventory planning function under the Operations and Services Division, Pharmacy, Procurement, and key clinical user units such as the Operating Theatre and catheterization laboratory. Cross-functional interactions among these units were examined to identify coordination gaps and governance issues contributing to persistent inventory inefficiencies.

Methodologically, the study adopted a mixed-method approach by integrating quantitative analysis of inventory performance indicators, such as Days of Inventory (DOI), stock levels, and disposal trends, with qualitative insights obtained through focus group discussions, direct observations, and structured assessments. Analytical tools, including the Current Reality Tree (CRT), 5S assessment, and gap analysis, were employed to identify systemic root causes and evaluate improvement alternatives within the hospital context.

Several limitations should be considered when interpreting the findings. The analysis relied on operational data and system records available during the study period, where variations in data completeness, historical consistency, and reporting practices may have affected analytical precision. As a single case study conducted in a specialized cardiovascular hospital, the findings provided in-depth contextual insights but were not intended for direct generalization to hospitals with different service profiles or organizational structures. In addition, this research focused on problem analysis and solution design rather than full-scale implementation; therefore, long-term sustainability and post-implementation performance were beyond the temporal scope of the study. Regulatory requirements, contractual considerations, and external supplier factors were considered only to the extent that they directly influenced inventory operations.

## METHOD

### Data Collection

This section explains the data collection strategy employed Data collection is designed to ensure triangulation and credibility of findings.

Multiple sources of evidence are used to capture both systemic patterns and operational realities:

1. Document Review

   Internal reports Q4 2024 until Q4 2025 approximately within 11 months inventory policy, standard operating procedures, DOI performance data started from Q4 2024 until Q3 2025 (11 months) , and waste disposal record (Q4 2024 , Q1 – Q2 2025 are reviewed to establish baseline conditions and historical trends started on October 2024 (Q4) until April 2025 (Q2).

2. Focus Group Discussions (FGDs)

   FGDs are conducted with key stakeholders, including inventory planners, Head of Pharmacy Department, Head of Ancillary and Medical Affairs Division, Head of Finance Division, Head of Operational Division, Hospital Director and Chief Executive Director. These discussions aim to uncover practical challenges, coordination gaps, and behavioural factors influencing inventory performance.

   FGD Guide Questions (English)

1. What day-to-day challenges do frontline staff face in managing and moving stock within their units (e.g.,PHA, Lab, OT)?
2. What common workarounds or informal processes are being used to compensate for stock or system limitations?
3. Can you describe any recurring issues related to space organization, labeling, or cleanliness in your storage or usage areas?
4. What difficulties arise from the lack of standard operating procedures or inconsistencies between shifts?
5. How is stock usage or replenishment typically recorded, and what limitations are experienced with manual systems?
6. Have there been situations where manual stock tracking led to overstocking, shortages, or expired items?
7. Which organizational elements (Structure, Systems, Staff skills, etc.) currently support or hinder better inventory performance?
8. If you could propose one key change—process, leadership style, system, or cultural value—that could improve inventory flow and reduce excess, what would it be and why?

3. Patient Safety Leadership Walk Around (PSLW)

   Direct observation conduct within 6 months started on October 2024 and 7 times of inventory related activities is undertaken to understand actual workflows, deviations from standard procedures, and informal practices.

   Identification of informal practices was conducted through a combination of structured observation and follow up clarification with staff involved in the activities. Informal practices were recognized when operational behaviours differed from written procedures yet were consistently applied in daily operations. Examples included adjustments in stock handling, alternative communication mechanism between units, and manual workaround used to address system limitations or operational constrains. All observations documented using structured field notes, capturing the sequence of activities, observed deviations, and contextual explanations provided by staff during the walk around sessions. These observations were subsequently triangulated with finding from Focus Group Discussion (FGDs) and document reviews to ensure consistency and validity of the identified operational patterns. that may contribute to inefficiencies.

4. Descriptive Performance Indicator

   Quantitative indicators such as DOI levels, frequency of emergency order, and expired stock volumes are used to support qualitative insights and assess improvement outcomes.

**Research Methodology**

This section explained the rationale for selecting the research methodology and analytical tools used in this study. The methodological choices were grounded in established approaches within operations management and healthcare improvement literature while being adapted to the contextual realities of RS Siloam Jantung Diagram as a specialized cardiovascular hospital. Rather than applying a single perspective, this research adopted a

structured combination of qualitative and quantitative methods to address the multifaceted nature of inventory inefficiencies and patient safety risks.

Existing healthcare inventory management research commonly relies on quantitative techniques, such as demand forecasting models, exponential smoothing, Economic Order Quantity (EOQ), and Fixed Order Quantity (FOQ) systems, to optimize stock levels and reduce holding costs. While these methods are effective in stable and standardized environments, their application in acute hospital settings is often constrained by demand variability, emergency cases, and fragmented information systems. In the context of RS Siloam Jantung Diagram, relying solely on quantitative optimization was insufficient to explain persistent high Days of Inventory (DOI), recurring expired stock, and frequent emergency procurement.

To address these limitations, this study integrated qualitative diagnostic methods with quantitative analysis. Focus Group Discussions (FGDs), direct observations, and 5S assessments were conducted to capture operational behaviors, coordination gaps, and discrepancies between formal procedures and actual practices. These methods enabled deeper exploration of issues such as unclear role ownership, inconsistent policy implementation, and manual workarounds that were not visible through system-generated data alone. The qualitative component also supported triangulation, ensuring that numerical indicators were interpreted within their organizational and clinical contexts.

The Current Reality Tree (CRT), derived from the Theory of Constraints, was selected as the primary root cause analysis tool. Compared with conventional cause-and-effect diagrams, CRT provides a structured approach for linking multiple undesirable effects, such as high DOI, expired items, and stockouts, into a coherent causal chain. This approach was particularly relevant for complex healthcare systems, where problems are rarely isolated and are often reinforced by systemic interactions among people, processes, and technology. To ensure analytical validity, the CRT developed in this study was validated through a confirmation process involving relevant stakeholders. After the initial CRT was constructed based on quantitative findings and qualitative insights from FGDs and observational data, the identified causal relationships were reviewed with key operational participants involved in inventory management, including inventory planners, procurement personnel, and warehouse representatives. This validation process aimed to confirm whether the identified cause-and-effect relationships accurately reflected operational realities and whether any critical causal factors had been overlooked.

The confirmation process also refined the CRT by incorporating practitioner feedback and ensuring that the resulting causal structure represented a shared understanding of the underlying problems. Through this iterative validation process, the final CRT became not only an analytical tool but also a practical representation of the systemic conditions contributing to inventory inefficiencies.

The contribution of this research lies in the deliberate integration and adaptation of these methodologies into a coherent applied framework tailored to a cardiovascular hospital setting. Rather than treating qualitative and quantitative methods as separate analytical components, this study positioned qualitative findings as the foundation for refining quantitative evaluation and designing improvement strategies. Inventory models and forecasting approaches were therefore evaluated not only based on cost efficiency but also on their compatibility with patient safety requirements, workflow discipline, and system integration readiness.

Through this methodological adaptation, the research moved beyond conventional inventory optimization and provided a context-sensitive approach that balanced analytical rigor with practical feasibility. This integrated methodology enabled the development of improvement solutions that were both operationally effective and applicable to the requirements of a high-risk healthcare environment, addressing limitations identified in existing methodologies.

The methodological framework presented in the diagram integrated Lean-based diagnostics, qualitative inquiry, and quantitative analysis to support evidence-based inventory decision-making. This approach was designed to systematically progress from operational diagnosis to model selection, ensuring that forecasting and inventory control decisions were grounded in empirical data and actual process conditions.

1. Lean Diagnostic and Compliance Assessment.

   Analysis begins with a lean oriented diagnostic phase, combining 5S analysis, time motion analysis, and compliance assessment to evaluate the physical and procedural conditions of inventory handling.

   a. 5S analysis is applied to assess workplace organization, visual management and discipline, with a specific attention to the presence of obsolete or slow moving items.
   b. Time motion analysis examines material handling activities to identify inefficiencies related to searching, movement and rework.
   c. Compliance assessment evaluate adherence to establish inventory policies and regulatory requirements, including storage standards and stock rotation practices.

This stage establishes a factual baseline regarding process reliability, waste sources and behavioural discipline, which informs subsequent qualitative inquiry.

a. Qualitative Inquiry through Focus Group Discussions

   Following the diagnostic phase, Focus Group Discussion (FDGs)are conducted to explore the underlying decision making processes and coordination mechanisms influencing inventory outcomes.

   1) Purposive sampling is used to select participants from relevant functions to ensure representation of key operational perspectives.
   2) Guided questions structure the discussions to elicit insights related to planning assumptions, exception handling and coordination across units.
   3) Discussion are transcribed and documented systematically to preserve analytical traceability.
   4) Findings are then cross checked with documentary evidence example like policies, procedures, and reporting) to enhance validity and reduce repetitive bias.

This qualitative stage provides contextual explanations for issues identified during the Leand diagnostic phase and supports a deeper understanding of behavioural and organizational drivers.

a. Quantitative Model Identification and Validation

   Insight from the diagnostic and qualitative phase inform the selection and evaluation of quantitative model.

1) For demand planning: alternative forecasting approaches are assessed to determine the best forecasting model, based on historical demand patterns and variability.
2) For inventory control, two classical inventory policies are evaluated:
   The fixed order quantity model
   The selection of the best inventory model is guided by empirical performance, operational feasibility, and alignment with observed process conditions. Quantitative analysis is not conducted in isolation: instead informed qualitative findings and compliances considerations to avoid technically optimal but operationally impractical solutions

2. Integrations and Performance outcome

The final stage integrates qualitative insights and quantitative results to assess their combined impact on cost efficiency. And cost efficiency is treated as an outcome of improved alignment between forecasting accuracy , inventory policy selection and process discipline, rather than a standalone optimization objective.

This integrated approach ensures that improvements in inventory performance are supported by reliable process, appropriate behavioural practices, and data driven decision rules.

The methodological contribution of this approach lies in its explicit integrations of lean diagnostic qualitative analysis and quantitative modelling. Rathen than treating these methods as parallel or independent , the structure positions qualitative and lean based findings as inputs to quantitative model selections. This sequencing enhances the practical relevance of analytical results and strengthens the robustness of inventory decisions in complex, inventory intensive environment.

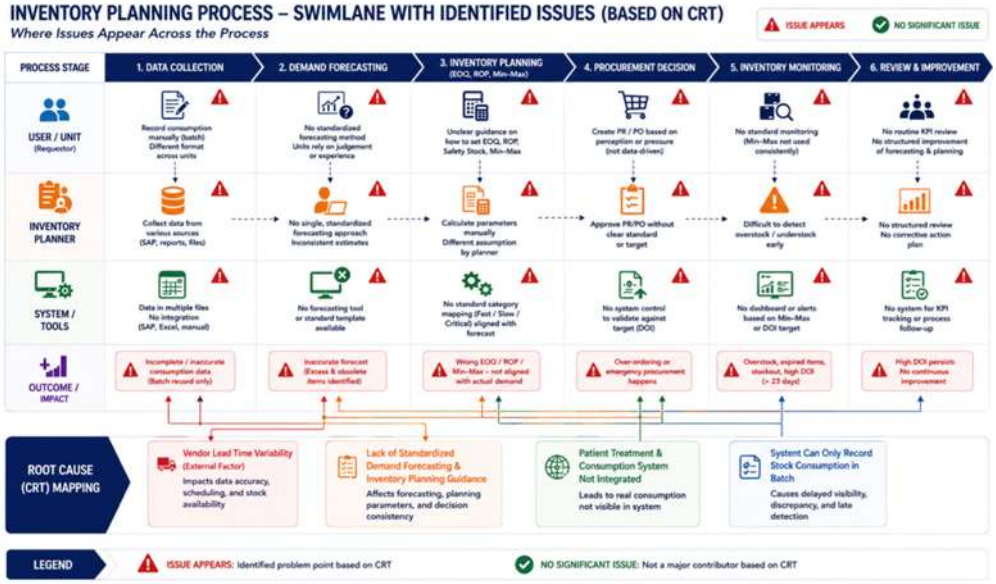



**Figure 1. Swim Lane an Identified Issues**

Source: Primary data compiled from FGD findings, direct observations, and document reviews at RS Siloam Jantung Diagram, 2025

## Research Design

This study adopts a sequential mixed method research design aimed at diagnosing and addressing inventory management problem within a specialized.

Cardiovascular hospital. The design is structured to ensure that problem identification, analysis and solution formulation are conducted in a systematic and evidence-based manner.

The research process begins with the formulation of a problem statement, derived from observable deviations in inventory performance. Initial gap analysis is conducted using quantitative operational data to compare current conditions with established organizational targets. Key indicators examined at this stage include Days of Inventory (DOI), incidence of emergency procurement, and inventory disposal due to expiration. This step establishes the scale and persistence of the problem, and provides a factual basis for further investigation.

Following gap analysis, data collection is carried out through parallel quantitative and qualitative streams. Quantitative data are extracted from internal inventory system and analysed using Power BI identify trends, variability and concentration of inventory issues across categories and time periods. In parallel, qualitative data are collected through Focus Group Discussions (FGDs), direct observations, and structured workplace assessment using a 5S approach. This combination allows performance outcomes to be examined alongside operational practices and coordination mechanism.

The core analytical stage of the research is root cause analysis, conducted using the Current Reality Tree (CRT). CRT is applied to integrate quantitative findings and qualitative insights into coherent cause – effect structure. This approach enables multiple undesirable effects such as high DOI, expired stock, and emergency purchasing to be traced back to limited number of systemic root causes that span planning, process execution and governance.

Subsequent data analysis integrates quantitative indicators and qualitative evidence to evaluate critical components of inventory management, including demand forecasting accuracy, master planning practices, and inventory control effectiveness. The integration of data sources supports triangulation and enhances the validity of analytical conclusions.

Base on the analytical results. Solution alternatives are developed with a focus on level improvement rather than isolated corrective actions. The research design then concludes with the formulation of implementation plan outlining priority initiatives, sequencing considerations, and organizational implications. While full implementation is beyond the temporal scope of the study, the proposed plan is designed to be operationally feasible and aligned with existing hospital structures.

## RESULTS AND DISCUSSION

This chapter presents the findings of the study and develops the proposed business solution based on systematic analysis of inventory management practices at RS Siloam Jantung Diagram. It was conducted to identify the underlying factors contributing high DOI and to establish a foundation for designing and an appropriate inventory planning improvement model.

### Analysis

The analysis follows structured sequence. First pareto analysis identifies the inventory areas where's the problem appears. Second, operational evidence from data, document reviews, Gemba Observation and FGD examined to understand how the problem are reflected in daily operational. Third, the current reality tress is used to determine the underlying causes of observed issues. Last, the identified root cause is validated through 5S assessment to ensure that the proposed business solution is supported operational evidence.

**Problem Identification Through Pareto Analysis**

The analysis begins with Pareto analysis to identify the areas contributing most significant inventory waste. The result show that inventory waste is highly concentrated in three stores which are Laboratory, Pharmacy Main Store and Operating Theater. Those units accounted around 94.9% of the total inventory waste, indicating that inventory related problems were not evenly distributed across all départements. This finding suggests that improvement effort must focusing on these priority areas, where the biggest impact can be achieved.

Further understanding the inventory conditions within these stores, has been conducted 9 representatives of high value inventory items. Identified recurring issues, including overstock, inventory levels exceeded established min max limits, duplicate purchasing, and purchase decision who wasn't aligned with actual consumption. It is indicating weaknesses inventory planning rather than isolated purchasing errors.

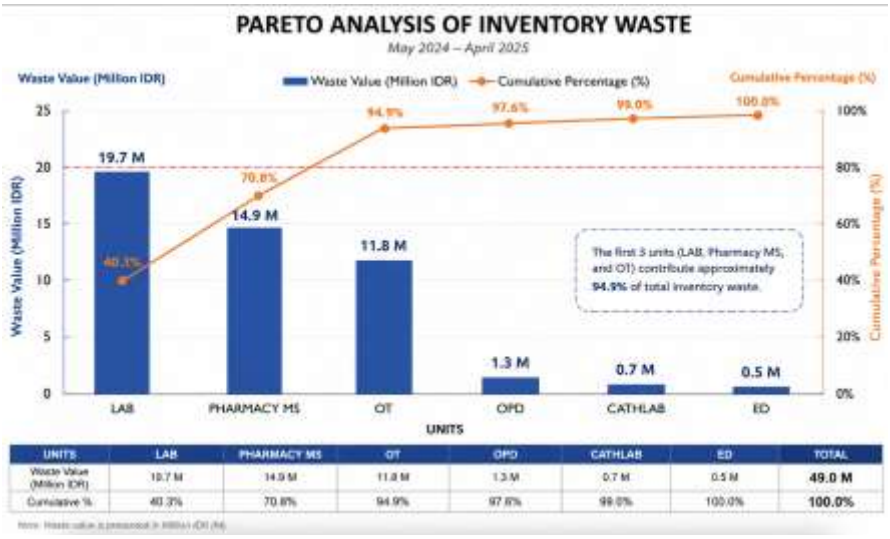



**Figure 2. Pareto Analysis of Inventory Waste**

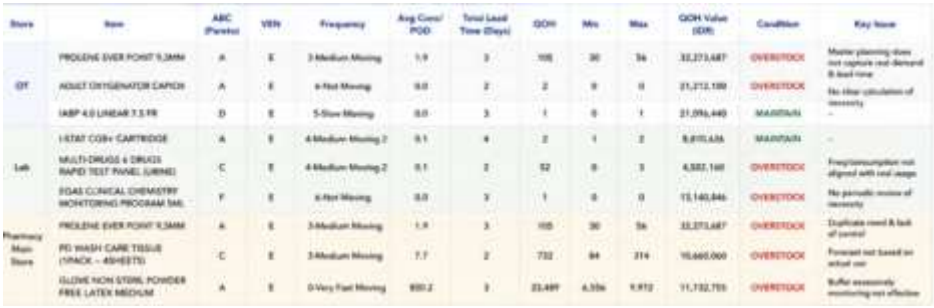
Source: Primary data processed from inventory waste records and SAP transaction reports at RS Siloam Jantung Diagram, 2025

**Operational Evidence**

Operational observations were conducted through document reviews, SAP transaction reports, Power BI dashboard, Gemba observation or Patient Safety Leadership Walkaround, and focus group discussions. The evidence itself revealed several recurring operational practices that contributed to inefficient inventory management. First, inventory replenishment decision was not supported by a standardized inventory planning model. Forecasting activities variability across planers and relied on most of individual judgement rather than a consistent analytical approach. Second, inventory visibility was limited because the patient treatment system or sales was not integrated with inventory consumption records. The system also recorded stock usage only in batch quantity, difficult for consumption Realtime visibility. As an impact planners were unable accurately monitor actual demand or validate purchasing decisions using reliable consumption data. Also, vendor lead time

variability created further uncertainty, encouraging units to maintain excessive buffer stock as a precaution against potential stock shortage

**Table 1. Evidence of 9 Items Waste**



| Store | Item | ABC (Pareto) | VEN | Frequency | Avg Cons/ POD | Total Lead Time (Days) | QOH | Min | Max | QOH Value (IDR) | Condition | Key Issue |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OT | PROLENE EVER POINT 9,3MM | A | E | 3-Medium Moving | 1.9 | 3 | 105 | 30 | 56 | 32,273,687 | OVERSTOCK | Master planning does not capture real demand & lead time |
| | ADULT OXYGENATOR CAPIOX | A | E | 6-Not Moving | 0.0 | 2 | 2 | 0 | 0 | 21,212,100 | OVERSTOCK | No clear calculation of necessity |
| | IABP 4.0 LINEAR 7.5 FR | D | E | 5-Slow Moving | 0.0 | 3 | 1 | 0 | 1 | 21,096,440 | MAINTAIN | - |
| Lab | I-STAT CG8+ CARTRIDGE | A | E | 4-Medium Moving 2 | 0.1 | 4 | 2 | 1 | 2 | 8,815,636 | MAINTAIN | - |
| | MULTI-DRUGS 6 DRUGS RAPID TEST PANEL (URINE) | C | E | 4-Medium Moving 2 | 0.1 | 2 | 52 | 0 | 3 | 4,582,160 | OVERSTOCK | Freq/consumption not aligned with real usage |
| | EGAS CLINICAL CHEMISTRY MONITORING PROGRAM 5ML | F | E | 6-Not Moving | 0.0 | 3 | 1 | 0 | 0 | 15,140,846 | OVERSTOCK | No periodic review of necessity |
| Pharmacy Main Store | PROLENE EVER POINT 9,3MM | A | E | 3-Medium Moving | 1.9 | 3 | 105 | 30 | 56 | 32,273,687 | OVERSTOCK | Duplicate need & lack of control |
| | PD WASH CARE TISSUE (1PACK – 40HEETS) | C | E | 3-Medium Moving | 7.7 | 2 | 732 | 84 | 314 | 10,660,000 | OVERSTOCK | Forecast not based on actual use |
| | GLOVE NON STERIL POWDER FREE LATEX MEDIUM | A | E | 0-Very Fast Moving | 800.2 | 3 | 23,489 | 4,306 | 9,972 | 11,732,755 | OVERSTOCK | Buffer excessively monitoring not effective |

Source: Primary data processed from inventory system records and SAP transaction reports at RS Siloam Jantung Diagram, 2025

**Root Cause Analysis Using Current Reality Tree (CRT)**

Following the operational assessment, a Current Reality Tree (CRT) was developed to identify the underlying causes of the observed inventory problems. The CRT demonstrated that the identified issues were interconnected rather than independent operational events. There are four fundamental root cause were identified:

a. Vendor lead time variability
b. Lack of standardized demand forecasting and inventory planning guidance
c. Lack of integration between the patient treatment and inventory consumption systems.
d. System limitation that records inventory consumptions.

Among those factors, lack of standardized demand forecast and inventory planning guidance was identified for most appropriate root cause improvement within the scope of this research. Unlike the remaining cause which is dependent on external suppliers or corporate level information system development, this root cause can be addressed through improvement in inventory planning practices and organizational standardization.

The CRT will explain more that the absence of standardized forecasting results in inconsistent inventory parameters, inaccurate replenishment decisions, excessive inventory, expired stock, emergency procurement and ultimately a day of inventory exceeds the target.

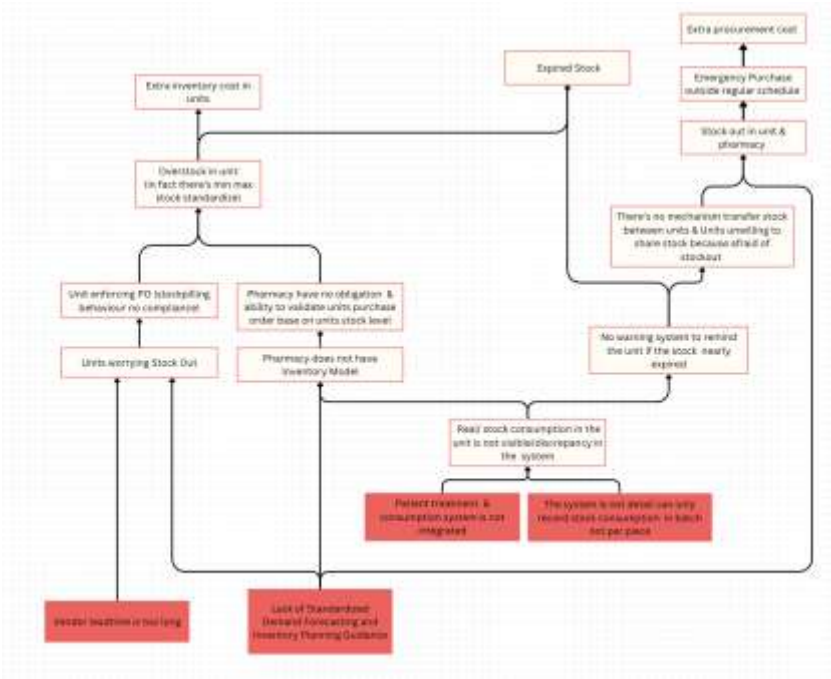



**Figure 3. Current Reality Tree (CRT)**

Source: Primary data, 2025

**Root Cause Validation Using the 5S Assessment**

To verify the CRT findings, root cause identification was evaluated using structured 5S assessment supported by document reviews, system data, Gemba observations, and focus group discussion. The assessment itself confirmed deficiencies were consistently observed across several dimensions of inventory management. The *Seiri* (Sort) identified the absence of structured forecasting method and ineffective control of excess inventory. *Seiso* (Shine) revealed forecast accuracy was not routine reviewed, resulting in expired inventory and delayed corrective actions. *Seiketsu* (standardized) demonstrated the absence of standardized forecasting procedures, inventory planning guidelines, and consistent min max policies across departments. Finally, *Shitsuke* (sustain) showed that forecasting performance and DOI compliance were not routinely monitored through defined Key Performance Indicators (KPIs).

Although *Seiton* (set in order) highlighted weaknesses in inventory categorization, this dimension primarily supports the identified root cause rather than serving as the principal validation.

Overall, 5S assessment confirming lack of standardize demand forecasting and inventory planning guidance is consistently reflected across daily inventory management practices. The validation therefore strengthens the CRT findings and supports the selection of this root cause as the primary focus for the proposed inventory planning improvement model.

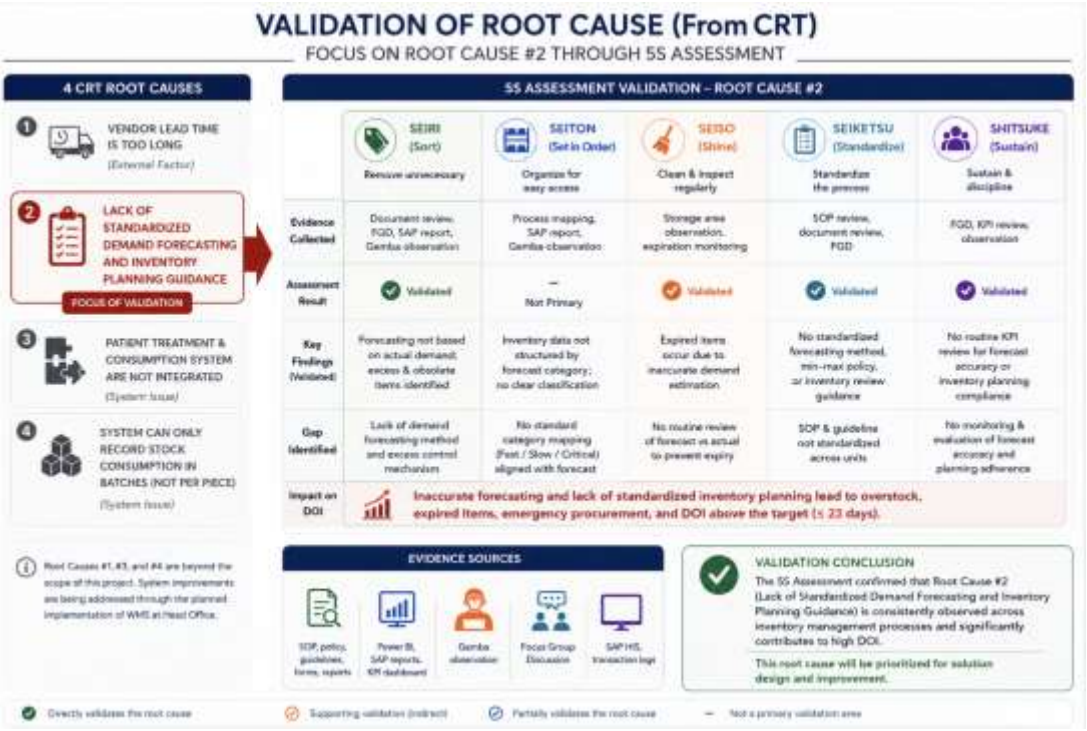



**Figure 4 5S Analysis**

Source: Primary data, 2025

**Interpretation of FGD Findings**

One of the most prominent patterns is the persistent accumulation of slow moving and underutilized inventory. At surface level, this condition appears to be the result of procurement decisions such as a minimum order quantities or buffer stock policies. However, a deeper examination suggest that these decisions are largely driven by uncertainty in demand and limited visibility into actual consumption. In the absence of reliable and timely data, stakeholders tend to adopt conservative strategies by increasing stock levels as a safeguard against potential shortages.

Another critical pattern relates to delays in consumption reporting. Although inventory transactions are recorded within the system, the timing of data entry is often inconsistent. This delay creates a gap between actual usage and recorded data , which subsequently affects the accuracy of inventory monitoring. As a result , decisions are made based on outdated information, reducing their effectiveness.

The FGDs also highlight inconsistencies in operational practice across units. Forecasting approaches, buffer stock decision and substitution practices vary depending on individual preferences and experiences. This variability indicates the absence of a unified framework that govern inventory related decisions.

In addition, coordination among stakeholders is found to be fragmented. Responsibilities overlap across different function, yet accountability for outcomes is not clearly defined. This lack of clarity limits the ability of the organization to respond cohesively to inventory related challenges.

Taken together, these patterns suggest that the observed inefficacies are not merely operation in nature but reflect deeper issues related to system design, process discipline and organizational alignment.

Table 2. Integrated FGD Coding and Root Cause Mapping Based on MOM Evidence

| Code | MoM Ref | Affected Area | Stakeholder | Evidence / Symptom | FGD Theme | GAP Dimension | Root Cause | CRT Link |
|---|---|---|---|---|---|---|---|---|
| **FGD-01** | 4,5 | Inventory & Forecast | PT, KA | Buffer push; forecast mismatch with actual usage | Forecast not demand-adjusted | Forecasting | System | IC-1 → UDE-1 |
| **FGD-02** | 1,3,4 | Inventory & Data Flow | MAA, PRA, PT | Power BI vs HOPE delay; duplicate reporting | Delayed & fragmented data | Monitoring / System | Manual Process | IC-5 → UDE-5 |
| **FGD-03** | 1,3,6 | Reporting & Planning | MAA, PRA | Dual/manual reporting | Manual process dependency | Monitoring | Manual Process | IC-5 |
| **FGD-04** | 2,5,6 | OT & Cath Lab | KA, AGP, JH | Unclear approval; substitution not applied | Weak coordination & control | Governance / Stock | - Governance - Standardization | IC-4 |
| **FGD-05** | 7 | Formulary Management | JH, PRA | Formulary drift; obsolete drugs | Poor FEFO & substitution discipline | Stock Management | Standardization | IC-2 → UDE-2 |
| **FGD-06** | 6,7 | Redistribution & Retur | AGP, PRA | Delayed redistribution; unclear responsibility | Reactive redistribution process | Governance | Governance | IC-4 |
| **FGD-07** | Multiple | Inventory Distribution | Cross-unit | Uneven stock across store/substore | Imbalanced stock placement | Monitoring / Governance | -Manual Process - Governance | IC-3 |
| **FGD-08** | Multiple | Inventory Constraint | Clinical & Procurement | MOQ, non-returnable items, must-have stock | Structural inventory constraint | Stock Management | Standardization | IC-1 / IC-2 |
| **FGD-09** | Multiple | Clinical Behavior | Doctor / Pharmacy | Substitution not followed; preference-driven usage | Weak enforcement of standardization | Stock / Governance | Standardization - Governance | IC-2 |
| **FGD-10** | Multiple | Procurement | Procurement / Inventory | Emergency buying due to vendor & lead time | Reactive procurement behavior | Forecasting / System | - System -Manual Process | UDE-3 |

Source: Primary data processed from FGD transcripts, document reviews, and internal reports, 2025

## Solution and Proposed Implementation Plan

The preceding analysis established the inventory waste was concentrated in the Laboratory, Pharmacy Main Store and Operating Theater, while the Current Reality Tree and 5S assessment identified lack of standardized demand forecasting and inventory planning guidance as the main principal process gap within the scope of this study. The proposed business solution is designing as an end-to-end inventory planning model consisting of four connected elements those are demand forecasting, fixed quantity inventory planning, inventory monitoring and governance. The intention is not merely to calculate a purchasing quantity but establish a repeatable planning discipline who link historical consumption, replenishment parameters, stock monitoring and management review.

The solution starts with exponential smoothing to obtain an item level estimate of future demand and then translated into economic order quantity (EOQ) , reorder Point (ROP), safety stock , and min max levels under fixed quantity model. Inventory performance is subsequently monitored through quantity in hand comparisons, DOI status, slow moving review and exception alerts. Final component strengthens accountability through standard operating procedures, defined ownership, routing KPI review and continuous improvement

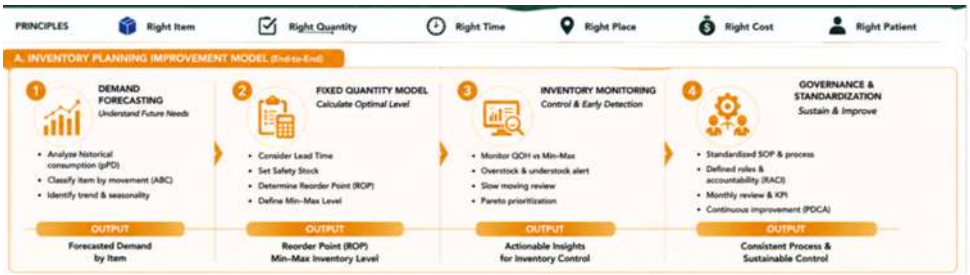



**Figure 5. Proposed Inventory Planning Improvement Model**

Source: Developed based on findings from Current Reality Tree (CRT) analysis, 5S assessment, and literature on inventory management models (EOQ, Safety Stock, ROP, and Min-Max), 2025

## Demand forecasting using exponential smoothing

Demand forecasting forms the first stage of the proposed inventory planning model because replenishment decisions cannot be standardized without a common estimate of future consumption.

In the current process, purchasing quantifies are influences a single calculation method can be applied consistently across selected inventory items and reviewed periodically.

Exponential smoothing was chosen because the availability data inventory is short, recently recorder, and have provided insufficient reliable basis for more complex forecasting models, also suitable for series that fluctuate around a relatively stable level without a clearly established long term or seasonal pattern. Gives greater weight to recent observations to recent observations while retaining information from earlier periods, allowing the forecast to response gradually to changes in consumption.

This characteristic is relevant to the hospital context, consumption of routine medical supplies is influenced by patient volume, clinical activities, procedures schedules, physician references and case mix. That factors create monthly variation, but not every item demonstrated a consistent trend, a simple smoothing method should be appropriate than a model that requires several stable and complete observations. Exponential also offers practical advantages such as transparent formula can be easily implemented in MS Excel, can be reviewed by inventory planners and doesn't require specialized forecasting software.

The use of Exponential smoothing does not imply that all hospital items have the same manner, indeed most useful for fast and medium moving with recuring consumption. Slow moving, not moving, case depended items should remain subject to clinical review periodic ordering. The proposed model therefore combines statistical forecasting with item classification rather than applying one method uniformly to the entire inventory portfolio.

Forecasting Formula and Parameters calculate as follows:

$$\mathbf{F_{t+1} = \alpha A_t + (1 - \alpha) F_t}$$

Where $F_{t+1}$ is the forecast for the next period, $A_t$is actual consumption in the current period, $F_t$ is the current forecast, and $\alpha$is the smoothing constant. The simulation uses an alpha value of 0.30, provides moderate responsiveness: recent consumption receives sufficient weight to reflect changes, while the forecast itself not excessively influence by a single unusual month.

The proposed inventory planning model is justified for application at RS Siloam Jantung Diagram based on several practical considerations. The model accommodates the hospital's limited historical consumption data, as recording processes were only recently established, while offering operational transparency through easy-to-understand Excel-based calculations that can be readily reproduced and audited. It demonstrates responsiveness to recent clinical activity by reflecting current usage in subsequent forecasts without discarding previous information, and carries a low implementation burden as it can be introduced without system development, serving as an interim planning standard while the Warehouse Management System is being developed. The model is particularly appropriate for recurring fast and medium-moving consumable items, which provide repeated observations that can be smoothed into practical short-term forecasts, and supports continuous review through monthly evaluation of forecast accuracy using MAD, MSE, and MAPE metrics, allowing parameters and processes to be refined over time.

The forecasting results, however, must be interpreted as a methodological simulation rather than a final operational forecast. The historical quantities used are illustrative and not verified hospital consumption data, with simulations covering October 2024 to October 2025 and demand patterns constructed to approximate average daily consumption and movement

categories. Several limitations must be acknowledged: the use of simulated historical data requires replacement with verified SAP, HIS, or WMS transaction records before implementation; the 12-month observation period is insufficient to confirm seasonality or structural trends; recent and incomplete recording practices may affect forecast reliability; batch-level consumption creates visibility delays; clinical variability from emergency cases and changes in protocols generates unpredictable demand; cost assumptions remain illustrative until confirmed by finance and procurement; and item heterogeneity requires ongoing evaluation. Despite these limitations, Single Exponential Smoothing (SES) performs credibly for recurring items such as Prolene, wash care tissue, and non-sterile gloves, which produce relatively low percentage errors due to regular and frequent demand. Laboratory medium-moving items show higher error levels reflecting lower volumes and greater sensitivity to monthly fluctuations, while slow-moving and non-moving items produce very high percentage errors, indicating that percentage-based metrics are less appropriate for these categories and that such items require periodic review with clinical confirmation and risk-based safety stock.

The Economic Order Quantity (EOQ) analysis converts forecasted monthly demand into annual demand to determine replenishment quantities that balance annual ordering and holding costs. At the basic model, ordering cost declines as order quantity increases because fewer purchase orders are placed, while holding cost rises because larger average inventory is maintained. At the EOQ point, annual ordering and holding costs are approximately equal and total relevant cost is at its minimum. Item-level analysis reveals important insights: Prolene, stocked in both Operating Theater and Pharmacy Main Store, has a calculated EOQ of 59 pieces with current QOH of 105 pieces, indicating stock on hand materially above economic replenishment, though this does not mean immediate reduction to 59 pieces as EOQ is an order quantity rather than a maximum stock level—replenishment should be temporarily held until QOH approaches the reorder point. I-STAT CG8+ Cartridge has an EOQ of 4 kits with QOH of 2 kits, suitable for fixed quantity replenishment only when QOH reaches ROP and after confirming open purchase orders and clinical requirements. Multi Drugs Rapid Test Panel shows EOQ of 26 pieces with QOH of 52 pieces, equivalent to approximately two EOQ batches, requiring avoidance of replenishment until reorder conditions are met. PD Wash Care Tissues have EOQ of 538 packs with QOH of 732 packs, where current stock exceeds EOQ though high recurring consumption makes the excess less severe than for low-volume items. Non-Sterile Gloves Latex show EOQ of 30,501 pieces with QOH of 23,489 pieces, where the high EOQ reflects very high annual demand and low holding cost per unit, though the 23-day DOI target must be considered to avoid temporary inventory increases beyond desired coverage. Items such as Adult Oxygenator Capi ox, IABP, and EQAS Clinical Chemistry generate QOH values close to 1 unit, indicating case-dependent demand that makes them inappropriate for standard EOQ replenishment, requiring periodic review with clinical confirmation and risk-based safety stock due to their lifesaving nature.

The Fixed Quantity Model (Q Model) determines when and how much to order through continuous monitoring, triggering replenishment when inventory reaches the reorder point with order quantity based on EOQ. Suitable for fast and medium-moving items, the model integrates four parameters—forecast demand, safety stock, reorder point, and min-max levels—replacing judgment-based purchasing with consistent, auditable decisions. This transforms inventory planning from reactive purchasing into preventive control, with clear accountability: Inventory

Planners maintain forecast and parameters, unit representatives confirm clinical requirements, procurement validates orders, and management reviews KPIs monthly.

The implementation plan integrates four components: demand forecasting using exponential smoothing, inventory planning via the Fixed Quantity Model, continuous monitoring, and governance through SOPs and performance reviews. It addresses inconsistent planning that drove high DOI and waste. Success requires collaboration across pharmacy, planning, purchasing, finance, clinical units, and management. Implementation follows four stages: forecasting consumption using SES, converting forecasts into EOQ, safety stock, ROP, and min-max levels, monitoring inventory against these parameters, and establishing governance through SOPs, RACI, KPIs, and monthly PDCA reviews to sustain long-term performance across priority locations—Operating Theater, Laboratory, and Pharmacy stores.

## CONCLUSION

This study concludes that the persistently high Days of Inventory (DOI) at RS Siloam Jantung Diagram was primarily driven by weaknesses in inventory planning rather than inventory volume alone. Four validated root causes were identified: the absence of standardized forecasting guidelines, limited system integration, weak governance, and vendor lead-time variability. To address these issues, the study developed an integrated inventory planning model that combined demand forecasting using exponential smoothing, a fixed quantity model incorporating Economic Order Quantity (EOQ), safety stock, and reorder point calculations, along with standardized monitoring and governance procedures.

A phased implementation roadmap was proposed, beginning with pilot implementation at priority locations, followed by process standardization, performance monitoring through key performance indicators (KPIs), and continuous improvement initiatives. The success of this approach depends on cross-functional collaboration, standardized governance mechanisms, and strong management commitment. Ultimately, this study affirms that inventory management in a hospital setting should be viewed as a strategic operational capability directly linked to patient safety, service continuity, and organizational sustainability, particularly in a specialized cardiovascular hospital where effective inventory control ensures timely clinical interventions and minimizes operational disruptions.

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