Southeast Asian Business Review
https://e-journal.unair.ac.id/sabr

Original Research

OPEN ACCESS Volume 3, Issue 2, 2025

Risk Mitigation of Sterile Linen Provision Process of CSSD RSUD Dr. Soetomo Using the House of Risk Method

Andhika Rayhan Hilmy, ***Yetty Dwi Lestari**
Department of Management, Faculty of Economics and Business, Universitas Airlangga, Surabaya, Indonesia

Correspondence*:
Address: Airlangga 4-6, Surabaya City, Indonesia, 60286 | e-mail: yettydl76@feb.unair.ac.id

Abstract

The present research explores risk mitigation in the sterile linen provision process at the Central Sterile Supply Department (CSSD) of RSUD Dr. Soetomo, a leading referral hospital in East Indonesia. Addressing operational vulnerabilities in the sterilization process, this study adopts the House of Risk (HOR) methodology to identify and minimize risks that may hinder service delivery proactively. Utilizing a qualitative single-case study approach, data were gathered through in-depth interviews with eight informants directly or indirectly involved in the CSSD operational workflow. The analysis identified 13 critical risk agents, with boiler malfunction emerging as the highest-priority risk (ARPj: 2166), followed by inadequate implementation of Standard Operating Procedures (ARPj: 1374), and goods lift malfunction (ARPj: 1352). In the second phase of HOR, key preventive actions were proposed, including SOP Control, Monitoring & Internal Audit, Training & Development, and Digitalization. Among these, SOP Control was identified as the most effective strategy based on mitigation priority (ETDk: 44380.5). This study offers a structured framework to improve risk management and operational resilience in hospital sterilization services.

Keywords: CSSD, House of Risk, Risk Mitigation, Sterile Linen Provision

JEL Classification: I18, D81

DOI: https://doi.org/10.20473/sabr.v3i2.74122
Received: June 12, 2025; Accepted: Aug 22, 2025

1. Introduction

Indonesia, the fourth most populous country in the world with 278 million people in 2023, continues to experience rising demand for healthcare services along with its steady population growth (Badan Pusat Statistik, 2023). This trend is reflected in RSUD Dr. Soetomo, one of the largest referral hospitals in eastern Indonesia, where emergency patient visits rose from 2,998 in January to 3,541 in December 2023, and inpatient days peaked at least about 29,337 in October, as shown in Figure 1.1. In 2023, 84.4% of emergency cases (30,654 out of 36,334 patients) were referrals from other facilities, underscoring the hospital's critical role in providing advanced care for the region (Instalasi Teknologi Komunikasi dan Informasi RSUD Dr. Soetomo, 2024; Prakoeswa, 2023). Such patient surges increase the operational burden on supporting units, particularly the Central Sterile Supply Department (CSSD), which ensures the continuous availability of sterile linens and medical equipment for daily surgical and inpatient activities.

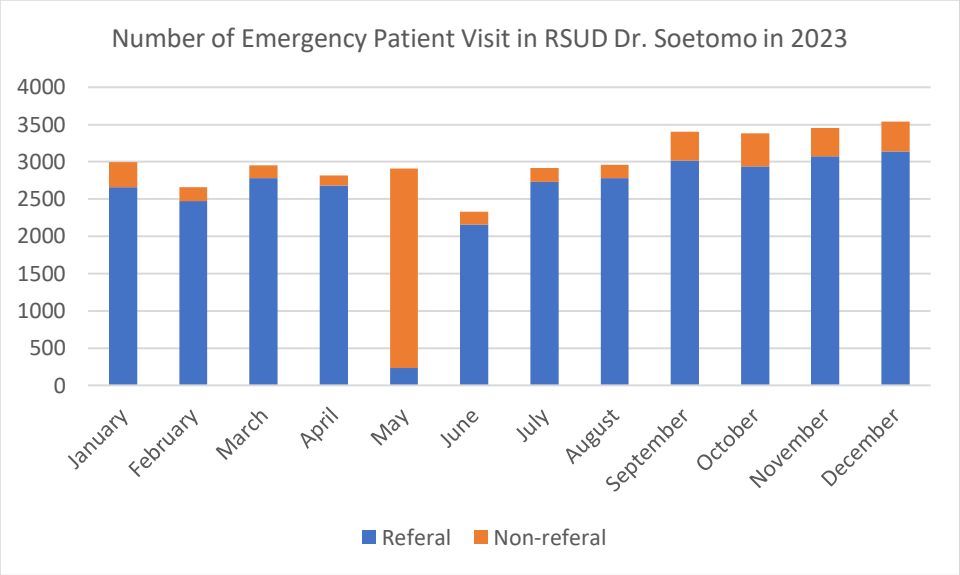

Figure 1.1 Histogram of RSUD Dr. Soetomo's Emergency Patient Visit Amount in 2023

The importance of CSSD operations becomes even more evident when considering the risk of Surgical Site Infections (SSI), which remain one of the most common hospital-acquired infections, affecting 2–4% of postoperative cases (Kostares et al., 2023). Contaminated reusable linens, such as surgical gowns and bedding, have been identified as potential vectors of infection (Palma & Dalziel, 2020). In fact, studies report bacterial and fungal contamination in more than 63% of used hospital linens (Cheng et al., 2016; Saegeman et al., 2024)lapses in sterilization procedures can compromise patient safety and overall care quality. Thus, the reliability of CSSD processes is a critical factor in hospital performance.

At RSUD, Dr. Soetomo's interviews with CSSD staff revealed that maintaining such reliability is challenging due to several recurring operational risk issues. Delays in transporting soiled linens from operating rooms often occur, caused by unavailable staff, damaged transport facilities, or late surgical schedules. Preventive maintenance on washing and drying machines is rarely implemented, with repairs carried out only after breakdowns. In addition, workload surges often force the acceleration of washing cycles, which leads to excessive chemical use, rising costs, accelerated machine wear, and potential declines in linen quality. These issues are further complicated by the unit's limited optimal working windows (07.00–10.00 and 14.00–19.00), during which the demand for sterilized linen is at its highest. With an average of 60 surgeries and around 80 sterilized linen sets required daily, these risks pose direct threats to service continuity and patient safety. To address them, this study applies the House of Risk (HOR) method (Pujawan & Geraldin, 2009), which integrates elements of FMEA and

HOQ, to identify, prioritize, and mitigate risk agents in CSSD operations, thereby strengthening both efficiency and reliability in hospital service delivery.

2. Literature Review and Hypothesis Development

Operational Management

Operational management refers to the coordinated activities involved in transforming inputs into outputs in the form of goods and services (Heizer et al., 2023). While historically associated with manufacturing, this function now plays a vital role in various service industries, including hospitals, where efficient service delivery depends on structured operational systems (Slack & Brandon, 2021). As a fundamental pillar alongside marketing and finance, operational management ensures that resources are utilized effectively to generate patient-centered outcomes (Krajewski et al., 2016).

Strategic decision areas in operational management—such as design of services, quality management, capacity planning, human resources, and supply chain management—are integral to aligning service output with organizational goals (Heizer et al., 2023). For healthcare providers, managing these elements is crucial to ensure consistent service delivery while adapting to patient needs and medical standards.

Operational Risk

Operational risks are threats that disrupt the flow of goods, services, or information within an organization (Slack & Brandon, 2021). In healthcare, these risks may arise from various sources including human resources, processes, technology, or external factors (Krajewski et al., 2016). Kartikasari (2023) categorized these into four types: human resource risk, technological risk, process risk, and external/environmental risk. Each of these categories reflects vulnerabilities that, if left unmanaged, may jeopardize service quality and patient safety.

In clinical settings, operational risks frequently result in adverse events (AEs), which refer to unintended harm caused during patient care. Jiménez-Rodríguez et al. (2018) emphasize that these may stem from medical errors or lapses in procedural compliance, making operational risk identification a critical area in healthcare management.

Risk Management in Organizations

ISO 31000 defines risk management as coordinated activities to direct and control an organization about risk (International Organization for Standardization, 2018). The framework involves systematic steps—identifying, analyzing, evaluating, and mitigating risks—aligned with organizational goals (Slack & Brandon, 2021). Post-risk analysis and root-cause identification tools, such as accident investigation, fault-tree analysis, and traceability, are often used to understand how and why risks occur. Mitigation measures may involve economic tools (e.g., insurance), operational redundancy, or process redesigns. Krajewski et al. (2016) also advocate for strategic alignment, demand visibility, flexibility, and lead-time reduction as effective strategies in reducing operational disruptions.

Hospital Risk Management

Hospital risk management targets both clinical and non-clinical risks that may compromise patient safety and institutional performance (The American Society of Hospital Risk Management, 2020). Clinical risks include infections, such as Surgical Site Infections (SSIs), while non-clinical risks often involve human error in operations like linen handling. According to Kartikasari (2023), managing these risks requires identifying hazards in operational environments and introducing controls that ensure both patient and staff safety.

Indonesia's Ministry of Health has issued regulations (Peraturan Menteri Kesehatan Republik Indonesia Nomor 7 Tahun 2019 Tentang Kesehatan Lingkungan Rumah Sakit, 2019; Peraturan Menteri Kesehatan Republik Indonesia Nomor 27 Tahun 2017 Tentang Pedoman Pencegahan Dan Pengendalian Infeksi Di Fasilitas Pelayanan Kesehatan, 2017) For managing hospital linen. Guidelines mandate proper handling, labeling, and disinfection of reusable linen, especially those contaminated with blood or bodily fluids. Processes must adhere to temperature standards and use approved disinfectants (e.g., sodium hypochlorite). Additionally, laundry infrastructure must meet strict zoning, ventilation, and safety equipment requirements to minimize contamination risks.

House of Risk Analysis

House of Risk (HOR) is a proactive risk management framework that integrates Failure Modes and Effects Analysis (FMEA) with the House of Quality (HOQ) for prioritizing risk agents and selecting effective mitigation strategies (Jittamai et al., 2025; Kartikasari, 2023; Kristanto & Kurniawati, 2023; Partiwi et al., 2023; Pujawan & Geraldin, 2009; Susanto et al., 2025). It shifts focus from merely identifying risk events to targeting their root causes. In HOR Phase 1, risk agents are evaluated using the Aggregate Risk Potential (ARP), calculated from likelihood (Oi), severity (Si), and the correlation with risk events (Rij). Phase 2 uses the Effectiveness to Difficulty ratio (ETDk) to rank preventive actions.

HOR has proven applicable in-service operations by offering structured, data-driven decision support. Its emphasis on proactive planning aligns well with high-risk environments such as hospital sterilization units, where operational disruptions may impact patient care. Applying this framework within the CSSD unit allows for the identification of critical failure points and the development of actionable, prioritized mitigation strategies.

Previous research demonstrates the versatility of the House of Risk (HOR) method across sectors, from healthcare to manufacturing and agriculture. In the healthcare setting, a study at YARSI Dental and Oral Hospital revealed that operational risks often stemmed from inadequate systems and human errors, leading to issues such as expired consumables and unsafe tools; HOR identified insufficient logistics and lack of integrated hospital information systems as primary risk agents, with mitigation strategies centered on web-based inventory and HIS integration (Kartikasari, 2023). Similar system-focused risks also appear in the food sector. Kristanto & Kurniawati (2023) applied HOR to halal frozen food supply chains, identifying risks in raw material compliance and sanitation, proposing SOPs, hygiene monitoring, and facility upgrades. However, their focus on two firms limited generalizability. In contrast, agricultural applications such as Jittamai et al. (2025) in Thai durian cultivation, highlighted environmental and farming practice risks, with training, monitoring, and technology as key mitigations, though constrained by small sample sizes and geographic specificity.

Manufacturing studies further illustrate HOR's adaptability. Susanto et al. (2025) applied the method to tofu production, finding that standardized procedures and equipment maintenance could reduce defects by up to 50%, while Partiwi et al. (2023) emphasized multi-stakeholder coordination in the automotive industry, where forecasting errors and supplier inconsistencies dominated. Synthesizing across these cases, several patterns emerge, such as HOR consistently helps organizations move beyond reactive responses by targeting root causes, its effectiveness depends heavily on accurate data and stakeholder involvement, and contexts shape the dominant risks, technical and supply chain related in agriculture and manufacturing, systemic and human-related in healthcare. However, a gap persists in hospital applications; existing studies often examine outpatient or administrative risks, while high-stakes units such as CSSD remain underexplored. Addressing this gap, the present study applies HOR to CSSD operations at a major referral hospital, thereby extending prior insights on systemic, human, and technical vulnerabilities to a context directly tied to surgical quality and infection prevention.

3. Data and Methodology

This study adopts a qualitative descriptive method with a case study approach. According to Sekaran & Bougie (2016), qualitative data consists of non-numerical inputs such as interview transcripts, institutional reports, or field notes. The method allows for an in-depth understanding of real-time phenomena within specific organizational context. Zikmund et al. (2013) emphasize that qualitative research is instrumental in transforming unstructured data into meaningful insights.

The case study approach is chosen due to the contemporary nature of the operational risk issues in RSUD Dr. Soetomo's CSSD. Yin (2018) argues that case studies provide a comprehensive understanding of complex processes by incorporating multiple data sources and perspectives. This research thus integrates contextual analysis with on-site validation.

Primary data were collected through direct interviews with stakeholders involved in the CSSD's sterile linen process (Sekaran & Bougie, 2016). These included CSSD staff, supervisors, and supporting departments. The nine informants were selected using purposive sampling, with the criteria that they were directly engaged in or responsible for activities related to the provision of sterile linen. This ensured that only participants with relevant experience and operational knowledge were included. The number of nine informants was considered sufficient, as it already covered all critical activities within the sterile linen process, allowing the study to capture comprehensive insights without leaving major functions unrepresented. Secondary data were drawn from RSUD Dr. Soetomo's annual reports, government publications, and academic references related to operational risk and the House of Risk method. To enhance data validity, this study applies data triangulation. Sekaran & Bougie (2016) state that triangulation involves using multiple sources or methods to ensure the consistency and reliability of findings. In this study, triangulation is achieved by cross-referencing interview data from nine informants with direct field observations.

This research followed a structured and sequential process to ensure valid and actionable outcomes. The study began with a comprehensive review of literature related to operational risk, hospital service operations, and the House of Risk framework. Initial site observations and surveys were conducted to identify relevant operational issues at RSUD Dr. Soetomo, focusing particularly on the CSSD's sterile linen provision process. Following this, data collection activities included identifying key informants and developing interview guides. Primary data were gathered through interviews, while secondary data were sourced from institutional reports, internal hospital documentation, and publicly available regulatory guidelines. The collected data were organized and processed to map out the operational flow, identify associated risks, and support the construction of the HOR model.

The processed data informed the HOR Stage 1 analysis to calculate ARP values for each risk agent, followed by HOR Stage 2 which involved assigning and ranking preventive actions using ETDk values. The analysis concluded with the formulation of risk mitigation strategies prioritized for implementation. Final recommendations were drawn from these findings and refined through discussion and supporting literature, aiming to strengthen operational resilience in RSUD Dr. Soetomo's CSSD unit.

4. Results and Discussion

The sterile linen provision process at RSUD Dr. Soetomo is a key operational activity managed by the CSSD in collaboration with the hospital's laundry unit. Linen in the hospital includes all types of reusable textiles such as bed sheets, blankets, towels, patient gowns, surgical drapes, and staff clothing (Palma & Dalziel, 2020) The process starts from the operating room (OR), where used linen is collected by the Storage and Distribution Unit and sent to the laundry for washing, drying, ironing, and folding. Once clean, linen is delivered back to the CSSD for further preparation. In CSSD, staff inspect and set the linen according to surgical needs before sterilization via autoclave. Sterilized linen is then stored under strict environmental controls and distributed back to the OR using a designated lift. This cycle repeats continuously as part of hospital operations.

To mitigate potential risks in this process, the House of Risk (HOR) method was applied. HOR focuses on reducing the likelihood of risk agent occurrence, since one risk agent may lead to multiple risk events (Pujawan & Geraldin, 2009). Input data were derived from interviews, public documents, and field observations involving authorized personnel at RSUD Dr. Soetomo's sterilization and laundry divisions. The activity mapping used the Supply Chain Operation Reference (SCOR) model. One relevant activity was found in the plan element, two in source, five in make, and three in deliver. No activities were recorded under the return element due to the one-way nature of linen flow. Each stage was observed and re-inspected to detect potential defects.

Table 4.1 Risk events and severity assessment in sterile linen provision

Main Process	Activity	Risk Event	Severity	Code
Plan	Planning procurement of raw materials for operational needs	Unexpected operational needs	5	E_1
Source	Procurement of new linen	Decreasing amount of linen	8	E_2
	Procurement of raw materials for operational needs	Wasteful detergent usage	5	E_3
Make	Washing and drying dirty linen	Washing machine / dryer error	8	E_4
		Steam boiler down	10	E_5
		Delay in completion of activities	8	E_6
	Clean linen ironing and folding process	Ironing machine jammed and broken cord	3	E_7
		Defect on laundry results	3	E_8
	Clean linen packing/setting process	Discovery of linen that is no longer suitable for use	5	E_9
		Discovery of linen that has not been washed perfectly	8	E_{10}
	Clean linen sterilization process	Linen that is wet after sterilization	10	E_{11}
		Incorrect linen settings	1	E_{12}
	Sterile linen storage process	Labeling machine jammed	7	E_{13}
		Longer waiting time / lead time for the sterilization process	7	E_{14}
		Double labeling of one set of linen	1	E_{15}
		Boiler for autoclave is problematic	10	E_{16}
Deliver	Dirty Linen Distribution from OR to Laundry	Time-consuming distribution process	8	E_{17}
		Faulty goods lift	9	E_{18}
		Damaged dirty linen transport trolley	3	E_{19}
		No employees on duty	1	E_{20}
		Exposure to disease / pathogens	9	E_{21}
	Clean Linen Distribution from Laundry to CSSD	Distribution process obstacles	3	E_{22}
	Sterile Linen Distribution to OR	Damaged goods lift	8	E_{23}
		Linen has not been taken from the lift	5	E_{24}
		Delay in the distribution process	7	E_{25}

Risk Event Identification and Evaluation

The identification of risk events and risk agents followed the SCOR mapping. Risk events were defined as operational disruptions potentially affecting the smooth flow of linen provision. Based on interviews and a structured questionnaire, a total of 25 risk events were identified, as seen in Table 4.1. These risks include exposure to pathogens, incomplete washing, machine failure (washers, dryers, boilers), lift errors, delays, and emergency demands. Each risk event was assessed for severity, and each risk agent was rated for occurrence probability based on closed questionnaires completed by selected informants. The data were then used in the HOR analysis to calculate ARP values and prioritize further action.

Table 4.2 Risk events and severity assessment in sterile linen provision

Risk Agent	Occurrence	Code
Linen moved to another departmen without any report	8	A_1
New service opening	1	A_2
Late arrival of procurement goods	1	A_3
Inconsistent detergent pouring treatment	9	A_4
Standard operating procedures that are not well implemented	5	A_5
Steam that does not come out / boiler interference	6	A_6
High frequency of use	10	A_7
Linen clogged in the ironing machine	10	A_8
Passed inspection from the laundry (which is still dirty or unusable)	3	A_9
Too much linen when put into the autoclave	7	A_{10}
Negligence of officers during the linen setting process	1	A_{11}
Fast use of the label machine / high frequency of use	10	A_{12}
Uncertain high and low steam pressure	2	A_{13}
Conduct label machine testing first	10	A_{14}
Label machine jammed	10	A_{15}
Still in the distribution process/some boilers have not been turned on	10	A_{16}
Autoclave getinge 1 error	10	A_{17}
Linen scattered / not put into the packaging bag	10	A_{18}
Employees on leave / sick	2	A_{19}
Broken folding machine	3	A_{20}
Broken goods lift	8	A_{21}
Too much load	7	A_{22}
The OR party is not on standby / takes a long time to pick up sterile linen	10	A_{23}

Risk Agent Identification and Evaluation

In the provision of sterile linen, effective risk management involves not only identifying potential risk events but also understanding the risk agents responsible for the potential risks. Risk agents are sources or causes of risks that can have a negative impact on the operational process of sterile linen. Identifying and evaluating these risk agents is essential to implement effective control measures and reduce the impact of risk. It is assumed that a single risk agent can trigger several risk events, and conversely, a risk event can be influenced by several risk agents (Pujawan & Geraldin, 2009)The results of the identification and evaluation of risk agents in the sterile linen operational process are shown in Table 4.2.

Evaluation of the Relationship of Risk Event and Risk Agent

Correlation between the identified risk events and risk agents was evaluated. The understanding of these correlations is presented in the House of Risk (HOR) 1 risk table, shown in Table 4.3. Evaluating the correlation between risk events and risk agents requires a comprehensive understanding of the entire operational process and the interrelation of risks across different functional units. The Head of the ISB Department, who holds both structural and functional responsibility over the Sterilization and Laundry Installation, possesses an integrated and overarching perspective of the activities ranging from linen washing to the distribution of sterile linen. Therefore, the department head was deemed the most competent individual to provide correlation assessments.

Table 4.3 HOR 1: Results regarding sterile linen provision.

Risk Event (E_i)	Risk Agent (A_j)																						S_i
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}	A_{21}	A_{22}	A_{23}	
E_1	1	9	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
E_2	9	3	9	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	8
E_3	0	3	0	9	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
E_4	0	0	0	1	3	9	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	8
E_5	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
E_6	0	1	3	1	1	9	0	0	0	0	0	0	0	0	0	0	0	0	3	9	0	0	0	8
E_7	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
E_8	0	0	0	1	3	0	0	0	9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
E_9	0	0	1	0	0	0	1	0	9	0	0	0	0	0	0	0	0	0	3	0	0	0	0	5
E_{10}	0	0	0	0	3	0	0	0	9	0	0	0	0	0	0	0	0	0	3	0	0	0	0	8
E_{11}	0	0	0	0	0	3	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	10
E_{12}	0	0	0	0	3	0	0	0	0	0	9	0	0	0	0	0	0	0	3	0	0	0	0	1
E_{13}	0	0	0	0	0	0	1	0	0	0	0	9	0	9	9	0	0	0	0	0	0	0	0	7
E_{14}	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	9	3	0	0	0	0	0	0	7
E_{15}	0	0	0	0	3	0	0	0	0	0	0	3	0	3	1	0	0	0	3	0	0	0	0	1
E_{16}	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	10
E_{17}	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	9	3	0	8
E_{18}	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	0	9
E_{19}	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	3
E_{20}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	1
E_{21}	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	9
E_{22}	1	0	3	0	1	0	0	0	0	0	0	0	0	0	0	9	0	0	3	0	3	1	0	3
E_{23}	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8
E_{24}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	5
E_{25}	3	0	3	0	3	1	0	0	1	3	3	0	1	0	0	1	1	0	3	0	1	0	3	7
Oj	8	1	1	9	6	6	10	10	3	7	1	10	2	10	10	10	10	10	2	3	8	7	10	
ARPj	808	92	131	711	1374	2166	880	270	453	777	30	660	200	660	640	970	1180	1050	222	216	1352	945	740	
Pj	9	22	21	12	2	1	8	17	16	10	23	13	20	14	15	6	4	5	18	19	3	7	11	

A correlation matrix was applied using a scale of 0, 1, 3, and 9, where 0 indicates no correlation, 1 indicates a weak correlation, three a moderate correlation, and nine a strong correlation. For instance, based on the risk table 4.3, risk agent A6 shows a strong correlation with risk events E4, E5, and E6. Evaluating the extent to which a risk agent contributes to a risk event is key to developing targeted strategies for risk mitigation and management. The correlation scores between each risk agent and risk event were used to calculate the aggregate risk potential (ARPj). A high ARPj score indicates a significant impact of the risk agent on the sterile linen provision process, thus making it a priority for preventive and mitigation actions. One determines the ARPJ score by first finding the collective sum of various products, where each product is formed by multiplying the severity of a risk event Si by the correlation value Rij between that event and risk agent j. This sum is then multiplied by the probability of risk agent Oj.

Risk Evaluation and Mitigation Strategies Planning

The main objective of the Pareto diagram principle is to identify and focus on elements that contribute to 80% of the total ARP. This ranking helps identify the most significant risks that contribute to most problems or losses in the provision of sterile linen. By implementing this analysis, RSUD Dr. Soetomo can focus its resources and efforts on managing the most important risks, leading to more effective risk mitigation, better CSSD performance, and optimized productivity.

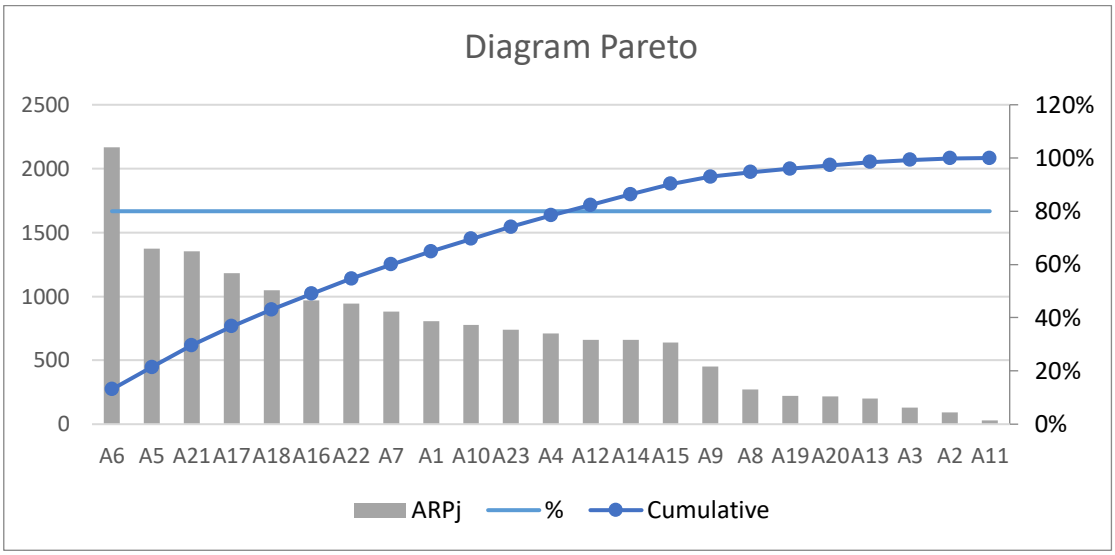

Figure 4.1 Pareto diagram of ARP score for all risks

The Pareto diagram in Figure 4.1 is formed using the results of the ARPj value ranking to identify the risk agents that have the most impact on the sterile linen supply process. Risk agents A6, A21, A17, A5, A18, A16, A22, A7, A1, A10, A23, A4, and A12 were selected as risk agents that can represent the risk impact on the entire sterile linen supply process than other risk agents. The selected risk agents will be further analyzed in HOR 2 to prioritize the most suitable preventive actions for this sterile linen supply process.

A total of four preventive or mitigation actions are recommended based on the results of discussions with department heads and relevant informants on sterile linen provision activities to control the impacts caused by this risk agent. These actions include SOP Control (PA1), Monitoring & Internal Audit (MA2), Training and Development (PA3), and Digitalization (PA4). Each preventive action can handle several risk agents. The relationship between each preventive action and the risk agent is given a value of 0, 1, 3, or 9, which respectively describe no correlation, low, medium, or high. This correlation indicates how high or large the role of preventive actions is in minimizing the risk of the agent. The overall effectiveness of each action k or (TEk) is determined for the evaluation of the impact on each preventive action, where Ejk represents the correlation value between risk agent j and preventive action k, multiplied by the related ARPj, and added in aggregate to each risk agent.

The TEK score is used to rank each preventive action k in order from highest to lowest based on its effectiveness value. In the implementation of preventive actions, appropriate actions are often not completely cost-effective or efficient in terms of resource utilization. Therefore, it is important to assess the ease of implementing each action, which is represented by the degree of difficulty of performing action k (Dk) (Pujawan & Geraldin, 2009). This level reflects the challenges involved in implementing each risk mitigation action in the sterile linen supply process, such as time, resources, costs, and technology. The determination of the Dk score is categorized using a scale of 1-5, ranging from very easy, not difficult, moderate, difficult, or very difficult. The overall effectiveness of each action k (TEk) and the degree of difficulty of each action (Dk) are obtained from the opinion of the installation head. They are used to measure the total ratio of effectiveness to difficulty (ETDk). Finally,

each management action is ranked (Rank of Priority) in order of highest to lowest score based on the ETDk score to prioritize proactive actions. Actions with higher ETDk scores are the recommended approaches to managing risk in the overall sterile linen supply process, as seen in Table 4.4.

Table 4.4 Results of sterile linen risk mitigation (HOR2)

To be treated risk agent (Aj)		*Preventive Action (PAk)*				*Aggregate Risk Potentials (ARPj)*
		SOP Control	*Monitoring & Audit Internal*	*Training and Development*	Digitalisasi untuk Keperluan Operasional	
Code	*Detail*	PA_1	PA_2	PA_3	PA_4	
A_6	Steam not coming out / boiler problems	3	9	1	3	2166
A_5	Standard operating procedures are not well implemented	9	3	9	3	1374
A_{21}	Broken goods lift	9	9	0	3	1352
A_{17}	Autoclave getinge 1 error	3	9	3	1	1180
A_{18}	Linen scattered / not put into the packaging bag	9	3	3	1	1050
A_{16}	Still in the distribution process/some boilers have not been turned on	9	3	0	3	970
A_{22}	Too much load	9	9	9	1	945
A_7	High frequency of use	3	3	0	3	880
A_1	Linen moved to another departmen without any report	9	9	3	3	808
A_{10}	Too much linen when put into the autoclave	9	9	3	3	777
A_{23}	The OR party is not on standby / takes a long time to pick up sterile linen	3	1	1	3	740
A_4	Inconsistent detergent pouring treatment	9	3	3	9	711
A_{12}	Fast use of the label machine / high frequency of use	3	3	9	0	660
Total effectiveness of action k (TE_k)		88761	82727	43295	36775	

Discussion

Based on the results of HOR stage 2 as presented in table 4.4, PA1 (SOP Control) has a high correlation with risk agents A1, A4, A5, A10, A16, A18, A21, and A22 which shows that by controlling the standard operating procedures for operational staff providing sterile linen can reduce the possibility of problems regarding the location of linen moving around (A1), inconsistent detergent pouring (A4), SOPs that are not implemented properly (A5), too much linen entering the autoclave (A10), boilers that have not been turned on IPSM (A16), linen that is scattered and not wrapped (A18), broken freight elevators (A21), and too much load in freight elevators (A22). In line with the research of McLellan et al. (2024)The implementation of good SOPs in the admission of outpatient cardiology patients reduces the number of patient transfers to the intensive care unit (ICU) and heart attacks, indicating a significant increase in patient safety and reduced risk in the healthcare sector. Followed by research by Alexander et al. (2021) Implementing SOPs in the patient handover process reduces transfer time and variability, thereby increasing operational efficiency. On the other hand, PA3 (Training and Development) does not correlate with A7, A16, and A21, which means that training and development for operational employees is not relevant to high frequency of use, unlit boilers, and broken freight lifts.

5. Conclusion

The results of this study revealed 25 risk events and 23 risk agents distributed across four key activities planning, sourcing, making, and delivering in the sterile linen provision process at CSSD RSUD Dr. Soetomo. Using the House of Risk (HOR) Stage 1, the three highest priority risk agents were identified based on ARPj scores and Pareto ranking: steam malfunction (A6), poor SOP implementation (A5), and freight elevator failure (A21). These agents pose significant threats to operational continuity and patient safety.

HOR Stage 2 analysis proposed four preventive actions: SOP Control, Monitoring and internal Audit, Training and development, and Digitalization. Among these, SOP Control was identified as the most proactive and effective mitigation strategy, with the highest ETDk score of 44380.5. This supports previous findings that strong SOP adherence improves operational safety and efficiency (McLellan et al., 2024; Alexander et al., 2021).

This study recommends several operational improvements. First, SOP control should be enhanced through structured supervision, regular updates, and improved dissemination. Second, Monitoring and internal Audit should be strengthened to ensure compliance and performance evaluation. Third, structured Training and development should be expanded to improve staff capacity in executing SOPs. Although digital tools have been introduced (e.g., WhatsApp and Intercom for inter-department communication), their impact remains limited due to inadequate implementation. Future focus should explore more integrated and systemized digitalization to support real-time coordination.

This research was limited to the CSSD unit and focused only on operational risks associated with the sterile linen provision process. Future studies should consider applying the HOR framework to other hospital departments or broader service areas. Moreover, integration with quantitative risk modeling and economic impact assessment may offer more holistic mitigation planning.

It is recommended that RSUD Dr. Soetomo adopt the HOR methodology for ongoing risk management in CSSD and other critical units. Prioritize SOP Control, supported by enhanced auditing and capacity-building efforts, to minimize recurring operational disruptions. Further studies are encouraged to explore risk mitigation across different healthcare sectors or expand the HOR application to digital transformation and supply chain logistics in medical services.

References

Alexander, C., Rovinski-Wagner, C., Wagner, S., & Oliver, B. J. (2021). Building a Reliable Health Care System. *Journal of Nursing Care Quality*, *36*(3), 195–201. https://doi.org/10.1097/NCQ.0000000000000519

Badan Pusat Statistik. (2023). *Hasil Long Form Sensus Penduduk 2020*. https://www.bps.go.id/id/pressrelease/2023/01/30/2039/hasil-long-form-sensus-penduduk-2020.html

Cheng, V. C. C., Chen, J. H. K., Wong, S. C. Y., Leung, S. S. M., So, S. Y. C., Lung, D. C., Lee, W.-M., Trendell-Smith, N. J., Chan, W.-M., Ng, D., To, L., Lie, A. K. W., & Yuen, K.-Y. (2016). Hospital Outbreak of Pulmonary and Cutaneous Zygomycosis due to Contaminated Linen Items From Substandard Laundry. *Clinical Infectious Diseases*, *62*(6), 714–721. https://doi.org/10.1093/cid/civ1006

Heizer, Jay., Render, Barry., & Munson, Chuck. (2023). *Operations management : sustainability and supply chain management*. Pearson.

Instalasi Teknologi Komunikasi dan Informasi RSUD Dr. Soetomo. (2024, October 5). *Sejarah - RSUD Dr. Soetomo - Pemerintah Provinsi Jawa Timur*. Https://Rsudrsoetomo.Jatimprov.Go.Id/Profil/Sejarah.

International Organization for Standardization. (2018). *ISO 31000:2018*. https://www.integralskills.com.au/wp-content/uploads/ISO-31000-2018-Risk-Management-Definitions-in-Plain-English.pdf

Jiménez-Rodríguez, E., Feria-Domínguez, J., & Sebastián-Lacave, A. (2018). Assessing the Health-Care Risk: The Clinical-VaR, a Key Indicator for Sound Management. *International Journal of Environmental Research and Public Health*, *15*(4), 639. https://doi.org/10.3390/ijerph15040639

Jittamai, P., Toek, S., Sathaporn, P., Kongkanjana, K., & Chanlawong, N. (2025). Risk Mitigation in Durian Cultivation in Thailand Using the House of Risk (HOR) Method: A Case Study of Pak Chong GI Durian. *Sustainability (Switzerland)*, *17*(1). https://doi.org/10.3390/su17010222

Kartikasari, N. (2023). *Pengendalian Risiko Operasional Dengan Metode House Of Risk Di Pelayanan Rawat Jalan Rumah Sakit Gigi Dan Mulut Yarsi* [Thesis]. Universitas Indonesia.

Kostares, E., Kostare, G., Kostares, M., & Kantzanou, M. (2023). Prevalence of surgical site infections after open reduction and internal fixation for mandibular fractures: a systematic review and meta-analysis. *Scientific Reports*, *13*(1). https://doi.org/10.1038/s41598-023-37652-6

Krajewski, L., Malhotra, M., & Ritzman, L. (2016). Operations Management Processes and Supply Chains: Eleventh Edition Global Edition. In *Pearson* (11th ed.). Pearson.

Kristanto, D., & Kurniawati, D. A. (2023). Development of halal supply chain risk management framework for frozen food industries. *Journal of Islamic Marketing*, *14*(12), 3033–3052. https://doi.org/10.1108/JIMA-04-2022-0112

McLellan, M. C., Irshad, M., Penny, K. C., Rufo, M., Atwood, S., Dacey, H., Ireland, C. M., de Ferranti, S., Saia, T., Fisk, A. C., & Saleeb, S. F. (2024). Enhanced Safety and Efficiency of Ambulatory Cardiology Admissions: A Quality Improvement Initiative. *Pediatric Quality & Safety*, *9*(3), e726. https://doi.org/10.1097/pq9.0000000000000726

Palma, N., & Dalziel, C. (2020). *Safe Management of Linen: Standard Infection Prevention & Control and Transmission Based Infection Control Precautions*. https://www.nipcm.hps.scot.nhs.uk/media/1671/2020-09-11-sicp-lr-linen-v3.pdf

Partiwi, S. G., Islami, V. N., & Firmanto, H. (2023). House of Risk (HOR) Approach to Manage Risk involving Multi-stakeholders: The Case of Automotive Industry Cluster of Multifunctional Rural Mechanized Tool (MRMT). *OPERATIONS AND SUPPLY CHAIN MANAGEMENT*, *16*(1), 133–139.

Peraturan Menteri Kesehatan Republik Indonesia Nomor 7 Tahun 2019 Tentang Kesehatan Lingkungan Rumah Sakit , Pub. L. No. No 7 Tahun 2019, Database Peraturan JDIH BPK (2019). https://peraturan.bpk.go.id/Details/111721/permenkes-no-7-tahun-2019

Peraturan Menteri Kesehatan Republik Indonesia Nomor 27 Tahun 2017 Tentang Pedoman Pencegahan Dan Pengendalian Infeksi Di Fasilitas Pelayanan Kesehatan, Pub. L. No. Nomor 27 Tahun 2017, Database Peraturan JDIH BPK (2017). https://peraturan.bpk.go.id/Details/112075/permenkes-no-27-tahun-2017

Prakoeswa, C. (2023). *Laporan Tahunan Satu Data RSUD Dr. Soetomo Tahun 2023*.

Pujawan, I. N., & Geraldin, L. H. (2009). House of risk: A model for proactive supply chain risk management. *Business Process Management Journal*, *15*(6), 953–967. https://doi.org/10.1108/14637150911003801

Saegeman, V., Cossey, V., & Schuermans, A. (2024). Contamination of hospital linen in critical care wards: still a hazard? *Journal of Hospital Infection*, *145*, 140–141. https://doi.org/10.1016/j.jhin.2024.01.004

Sekaran, U., & Bougie, R. (2016). *Research methods for business : a skill-building approach* (Seventh). John Wiley & Sons. www.wileypluslearningspace.com

Slack, N., & Brandon, A. (2021). Operations and Process Management Principies and Practice for Strategic lmpact Sixth Edition. In *Pearson* (6th ed.). Pearson. www.pearson.com/uk

Susanto, H., Salma, S. A., & Rahmani, H. (2025). Risk Mitigation Analysis for Tofu Production Process to Minimize Product Defects Using House of Risk Approach. *The 8th Mechanical Engineering, Science and Technology International Conference*, 19. https://doi.org/10.3390/engproc2025084019

The American Society of Hospital Risk Management. (2020). *Enterprise Risk Management for Health Care Boards: Leveraging the Value*. https://www.ashrm.org/system/files/media/file/2020/11/ERM_A%20Primer%20for%20Health%20Care%20Boards_2020_final.pdf

Yin, R. K. (2018). *Case Study Research and Applications. Sixth Edition* (Sixth Edition). SAGE Publications, Inc.

Zikmund, Wi., Carr, J., Babin, B., & Griffin, M. (2013). *Business Research Methods*. South-Western Cengage Learning.