

Digitalization to Reduce Office Paper: A Path Toward Sustainable Hospital on Cost Efficiency and CO₂ Emission Reduction Through Kaizen-Based Green Intervention

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Abstract. The use of green intervention and lean technologies is gaining more widespread acceptance across a variety of business sectors. The purpose of this case study is to enhance the effectiveness of operating procedures. Utilizing Lean technologies, namely kaizen, in conjunction with a green intervention throughout the quality control cycle is the focus of this research. The transfer of the reporting of physical documents to digital or paperless forms has been effectively accomplished by the use of the kaizen-based green intervention approach. As a consequence of the findings, the efficiency of the timely reporting of expired drug and medical device returns was dramatically enhanced to 100%, surpassing the original aim of 90%. Moreover, it decreases the amount of paper that is used by 16,200 sheets annually, which results in a savings of IDR 1.6 million and a reduction of CO₂ emissions by 75.17 kg. The findings can be used to inform recommendations for utilizing lean tools with a green intervention to improve operational efficiency. This will result in a reduction in waste and material usage, as well as cost savings and a reduction in CO₂ emissions. All of these factors can contribute to sustainability in the healthcare industry through the context of Green Hospital.

Keywords: Lean, Kaizen, Green Intervention, Green Hospital, Digitalization

1 Introduction

In recent decades, a competitive market, knowledgeable customers, and stringent regulations have compelled industrial companies to prioritize sustainability within operational efficiency [1], including the healthcare sector, which has increased pressure to address the negative consequences of global issues such as climate change and environmental degradation [2]. Because of the rapidly changing healthcare environment, it has become further complex [3], particularly for hospitals, which currently deal with the challenging task of ensuring high expectations of patient care while simultaneously enhancing operational efficiency, minimizing costs, and adjusting to the increasing standards of stakeholders [4]. They are responsible for a considerable carbon footprint [5]. Health care contributes to 4.4% overall global emissions [6] and about 5% of global greenhouse gas (GHG) emissions [7]. Amid these issues, hospitals are under increasing pressure to minimize waste, streamline processes, and remain competitive while adhering to strict environmental standards [8]. In this sense, it is increasingly evident that

hospitals must consider the quality of patient care and their ecological impact. Adoption of sustainable methods that prioritize environmental friendliness is thus critical. Hospitals must adapt to satisfy ecological requirements and public expectations for sustainability, including eco-friendly activities into their fundamental operating plans to ensure their competitiveness and long-term profitability [9].

In the hospital context, pharmaceutical services are a crucial part of the healthcare system, focusing on patient care and providing pharmaceutical preparations, medical devices, and consumable medical supplies [10]. It is following the Regulation of the Minister of Health of the Republic of Indonesia No. 72 of 2016 concerning Pharmaceutical Service Standards in Hospitals regarding that the purpose of controlling the inventory of Pharmaceutical Preparations, Medical Devices, and Medical Consumables is to ensure effective and efficient inventory or there is no excess and shortage/emptiness, damage, expiration, and loss as well as return of orders for Pharmaceutical Preparations, Medical Devices, and Medical Consumables. One way is by stockopname, which is carried out periodically and regularly. Administration, including recording and reporting, must be carried out in an orderly and continuous to facilitate tracking of past activities [11]. Moreover, pharmacy services are an integral part of healthcare services, supporting 90% of healthcare services in hospitals and generating approximately 50% of hospital revenue from managing these supplies [12].

ABC Hospital is a private hospital in Indonesia that was established 87 years ago. However, challenges remain in the healthcare management system, particularly in the pharmacy unit. One unresolved issue concerns stock management, where monthly drug and medical device inventory and those reaching their expiration dates are not monitored. It is due to the analog or paper-based reporting and monitoring system, which requires more time for reporting and is prone to inconsistencies in monitoring. This Problem can result in difficult-to-access stock compliance reports due to inconsistent and disorganized reports. Stockholders are challenging to identify, and the person in charge is unclear. Drugs and medical devices approaching expiration dates are not reported, resulting in losses from expired drugs and medical devices and shortages of needed medications due to late returns to suppliers. A study by Dwi Setyaningrum and Dwi Saputra (2021) [13] explains that expired drug stocks require effective and efficient management of the hospital pharmacy unit because it will result in material losses borne by the hospital. Meanwhile, their unavailability will determine the quality of patient care for a hospital's operational activities.

Furthermore, waste related to the use of office paper materials also increases the operational costs of pharmaceutical units, further increasing office paper waste and contributing to carbon emissions from its use. This non-medical waste originates from healthcare units [14]. According to Environment Canada, producing 1 kg of paper requires at least 324 liters of water. Even a curled A4 sheet of paper consumes up to 20 liters of water during its production process [15], and each A4 sheet of office paper contributes 4.64 g CO₂-eq according to the ISO 14040/14044 [16]. Increased operational expenses concern healthcare organizations and hospitals [17]. Moreover, environmental sustainability data is becoming important in decision-making throughout modern businesses, with the discourse regarding sustainable health care rising and highlighting the necessity for efficient, resilient, and productive systems [18]. The healthcare sector is transformed due to shifting medical care, patient expectations, developing technologies, climate change, and sustainability. However, existing hospital policies frequently overlook the interplay between the hospital sector and underlying socio-environmental circumstances [19]. Therefore, a systematic, easy, fast, and sustainable approach is needed to address this Problem.

One approach that is starting to be widely adopted is the integration of Lean Management and environmental sustainability principles, also known as green intervention. Effective health services management is crucial in hospitals, where operational efficiency and cost containment are top priorities, and Lean management is one of the effective management paradigms [20]. Lean is the latest management technique in healthcare, also known as Lean healthcare [5]. This practice is recognized as improving quality and efficiency in operations [21], assisting health personnel to establish a flexible and reliable organization [22]. All are in line with the overall goals of the many stakeholders concerned. There is a rising view that healthcare can benefit from Lean management [23]. There are several strategies to reduce direct and indirect emissions created by healthcare providers by changing or intervening in the reduction of resource consumption [24]. Various green interventions successfully reduce healthcare's carbon footprint and can have a significant impact if adopted consistently [7].

Lean and environmental sustainability have a synergistic relationship, with lean potency ensuring ecological sustainability while boosting the effects of sustainability initiatives [25]. Over time, many lean methods and tools have emerged, each with a distinct specialization. Lean tools reduce waste and improve efficiency, lowering operational expenses [26]. Some of these are particularly helpful in promoting environmental sustainability in the hospital setting. To achieve pollution avoidance goals, an organization must use lean tools [5]. A scoping review study on lean healthcare from Marin-Garcia et al. (2021) [22] suggests developing lean healthcare tools that address environmental indicators in the healthcare sector. A research by Santandreu (2020) [27] on lean tools, i.e., kaizen in the healthcare industry and its relevance to sustainability, confirms that kaizen is a relatively new concept that is constantly evolving and growing, and it has the potential not only to improve economic, social, and environmental sustainability.

There are several studies in healthcare settings utilizing kaizen tools, related to business process i.e. operational efficiency problems [28], reduction of process lead time and the error [29] and also its integration with green practices related to environmental indicators, i.e., controlling waste [30], relationship with sustainable performances [31], waste segregation in the management of healthcare waste [32]. One exploratory survey study on kaizen expertise outside the healthcare sector from Lizarelli (2025) [33] regarding the mediation of digital systems between kaizen practices and ESG performance. The study findings found that kaizen practices affected environmental and governance performance. However, no effect was seen on social performance without digital system mediation. However, no one has explored the impact of minor improvements on overall economic benefits, contributing to environmental indicators, such as reduced office paper use in healthcare settings, i.e., hospitals. Although there is one study that addresses the impact of hospital digitization on paper savings, this study only addresses healthcare time savings [34] and paper savings [35] without utilizing kaizen tools and their contribution to environmental indicators.

The position of this research is a case study research that discusses the implementation of lean tools, i.e., kaizen with green interventions, which we hereinafter call Kaizen-based green intervention through the Digitalization of the reporting and monitoring system in the hospital pharmacy service unit. This study aims to improve operational efficiency by enhancing the timeliness of reporting expired medicine and medical device returns, thereby improving the quality of hospital services, which are vital components in hospitals. Moreover, to give evidence on the healthcare system's role in reducing CO₂ from using materials while promoting a green hospital to an environmentally sustainable hospital. Our research focuses particularly on the advantages of green interventions and operational policy decisions taken within the health systems in hospitals on the environment through digitalization.

2 Literature Review

2.1 A Path Toward Sustainable Hospital

Environmental sustainability is the capacity to conserve ecosystems, which entails consuming and replenishing the natural resources that sustain life on Earth [36]. Regardless of the varied environmental conditions in which an organization operates, deploying digital technologies and Lean methodology reduces expenses. Combining Lean techniques with digital technologies increases operational efficiency and improves operational management. Organizations embracing Lean techniques can enhance their financial situation while developing a safe and effective operational management style [37]. The elements that enable transformation for more sustainable healthcare delivery require urgent attention [7]. Hospitals might establish institutional digital assets to boost healthcare and administrative procedures through Healthcare Digital Transformation [38]. Moreover, one green intervention that aims to reduce GHG emissions is reducing the use of consumables [39]. In the context of healthcare, these three can form a green hospital.

One of the dimensions of the green hospital model is the reduction, recovery, and use of paper by minimizing paper consumption as much as feasible in the hospital, utilizing digital versions, or utilizing recycled paper in the hospital [40]. Transforming paper use by using soft files can reduce paper usage [14]. Digital transformation has been implemented in various areas, involving healthcare [41], i.e., Healthcare Digital Transformation (HCDT) [42], which deals with numerous digital technologies that have been implemented and integrated to improve and modernize healthcare systems, with the goal of efficient processes and satisfaction for patients [43]. HCDT has been concerned from an organizational perspective with the use of digital technologies to assist hospital administration management [44], in addition to an operational standpoint to conduct hospital activities [45]. Digital transformation is one of the most successful ways to address stakeholder stresses, improve healthcare quality, and minimize costs [46]. Furthermore, digital health services, including monitoring equipment and web and cloud-based tools, if utilized in specific ways, have an opportunity to reduce health inequalities and improve services delivered to patients [47].

In other words, hospitals that carry out green interventions in their operations to reduce their environmental footprint are included in green hospitals, encouraging them to become sustainable hospitals. Because focused green interventions and ecologically sustainable systems for providing healthcare have the potential to decrease healthcare's adverse environmental effects while also bringing economic, institutional, and health advantages [7], and this refers to the definition that green hospitals enhance public health while consistently reducing their environmental effect [48]. A green hospital acknowledges the relationship between the health of humans and the environment and exhibits this awareness by incorporating strong ecological sustainability practices into its governance, approach, and activities [40]. Green hospitals are distinguished by their dedication to sustainability and environmental responsibility. These institutions utilize several kinds of conceptual and operational approaches to reduce their ecological footprint [49] and have tremendous potential to reduce climate change while enhancing medical outcomes. The medical sector has a unique chance to set a precedent in the worldwide battle against climate change [50].

3 Methods

This case study was conducted in the Pharmacy Unit of a private hospital in Indonesia from early January to early June 2025. This research utilized the core lean tool, i.e., kaizen and green intervention, which we call "Kaizen-based green interventions". Kaizen utilization is crucial in improving efficiency and addressing issues in the healthcare sector [51] because it is systematic and has a big picture by involving many people who become a work team [52]. Green interventions and sustainability initiatives are employed in the health sector methodically and continuously, and GHG emissions reduction might be significant [7]. We implemented a simple green intervention through digitalizing healthcare services in the pharmacy unit.

The research began with direct observation, a Kaizen step called the Pre-Kaizen Survey. It was done to identify problems in the research locus and understand the initial conditions when defining a problem. Furthermore, it also determined the final goals to be achieved in implementing kaizen through Small Group Activity meetings. The eight core steps of kaizen, following Toyota Business Practice, are as follows [53]:

1. Clarify Problem is the step for defining the problem while understanding the current condition
2. Breakdown Problem & Specify Point of Cause is the step for discovering the causes of the problem which must be addressed.
3. Set Target is the step for setting target to attain improvement goals by by creating an agenda of action.
4. Root Cause Analysis is the step for completing through observation and brainstorming by employing a fishbone diagram to recognize the root causes of the problem.
5. Develop Countermeasure is the step for identifying the underlying cause of the problem.
6. See Countermeasure Through is the step for documenting before and after the kaizen.
7. Evaluate Both Results & Processes is the step for describing before and after of kaizen execution.
8. Standardization & Expansion is the stage for standardizing to avoid repeating problems.

4 Results

4.1 Problem Identification and Improvement Prioritization

Direct observation at the Inpatient Pharmacy Installation, known in the Kaizen approach as Pre-Kaizen Survey, was carried out as part of the Small Group Activity to collect data on areas requiring priority improvement. The purpose of this activity was to compile a Matrix Diagram of potential Kaizen themes at Pharmacy Units, as presented in Table 1.

Table 1. Matrix Diagram for Possible Kaizen Themes in Inpatient Pharmacy.

Problem	Impact	Urgency	HR	Cost	Difficulty	Feasibility	Rank	Description
Unmonitored: Stocked and expired medicine and medical devices	3	3	2	1	3	12	1	Timely Return Level Percentage of 82.5%
Inadequate medication storage space	1	1	1	3	2	8	2	

Unsuitable pharmacy unit ceiling	1	1	1	3	1	7	3
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4.2 Implementation of the Kaizen Method

Clarify Problem

The step is performed by defining the Problem and understanding the current condition: Determine the KPI item, observation results/Pre Kaizen Survey (where and when), and the final goal. The Problem and current condition can be seen in Figure 1.

Step 1: Clarify Problem

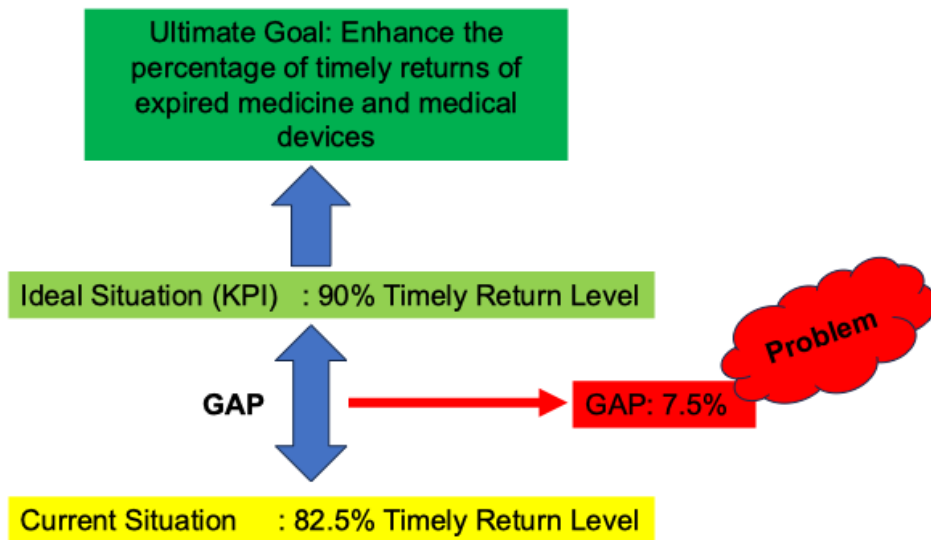


Fig. 1. Clarify Problem Step

Figure 1 above shows that the ultimate target was to create an easily accessible stock and expiration reporting system and achieve a timely return of 90% of expired medicine and medical devices. In the Current Situation, the timely return percentage is 82.5%. So, there is a GAP of 7.5%.

Breakdown Problem and Specify the Point of Cause

The step is performed by outlining the causes that led to the Problem. The description of the causes of the Problem is in Figure 2.

Step 2: Breakdown Problem & Specify Point of Cause

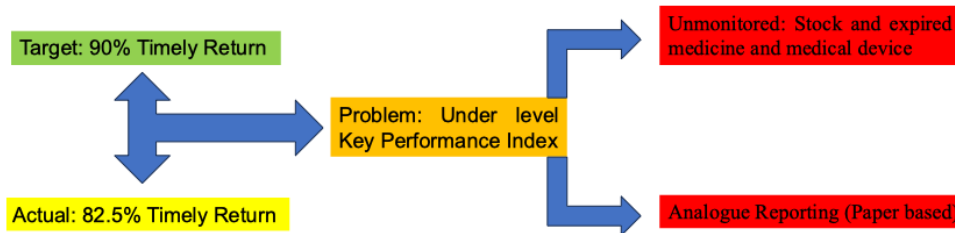


Fig. 2. Breakdown Problem & Specify Point of Cause

Figure 2 above shows that the Problem is the Key Performance Index in the target. Unmonitoring Stock causes it, expired medicine, and medical devices because of Analogue Reporting (paper-based).

Set Target

In this step, the target must be SMART: Specific, Measurable, Achievable, Reasonable, and Timely. SMART analysis supports improvement targets through a plan of improvement steps. The steps for setting targets can be seen in Figure 3.

Step 3: Set The Target

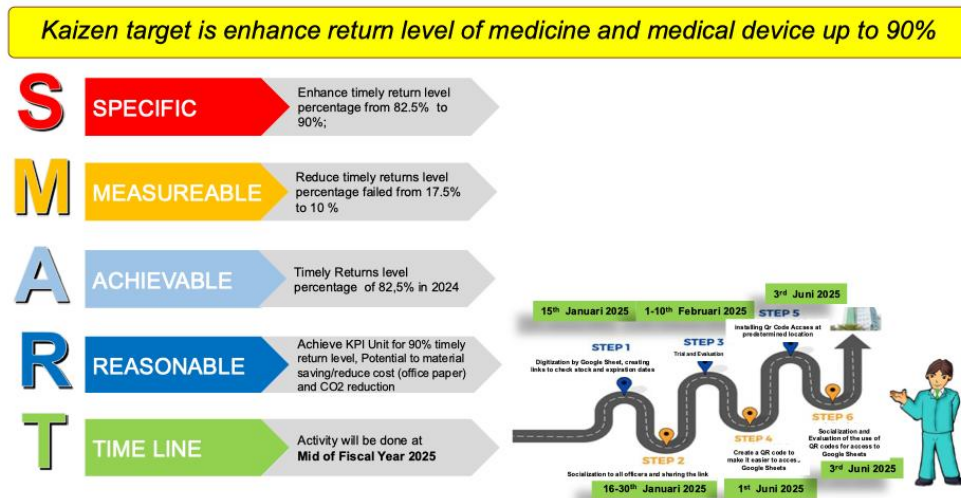


Fig. 3. Set Target

Figure 3 shows the Set target based on the SMART strategy, where Specific is enhancing the timely return percentage from 82.5% to 90%. Measurable reduces the number of timely returns that failed from 17.5% to 10%. Achievable is Timely Returns of 82.5% in 2024. Reasonable is achieving the KPI Unit for 90% timely return, which has the potential to material savings/reduce cost (office paper) and CO2 reduction. The timeline starts from early January until early June, when the activities begin with making the system and continue until the overall evaluation of its utilization.

Root Cause Analysis

The investigation and idea discussion process was carried out using a Fishbone Diagram tool to identify the root causes of the problem. This step is carried out through investigation and brainstorming. A tool such as a cause-and-effect diagram can be utilized. This step is used to identify the root cause of the Problem. The root cause analysis steps can be seen in Figure 4.

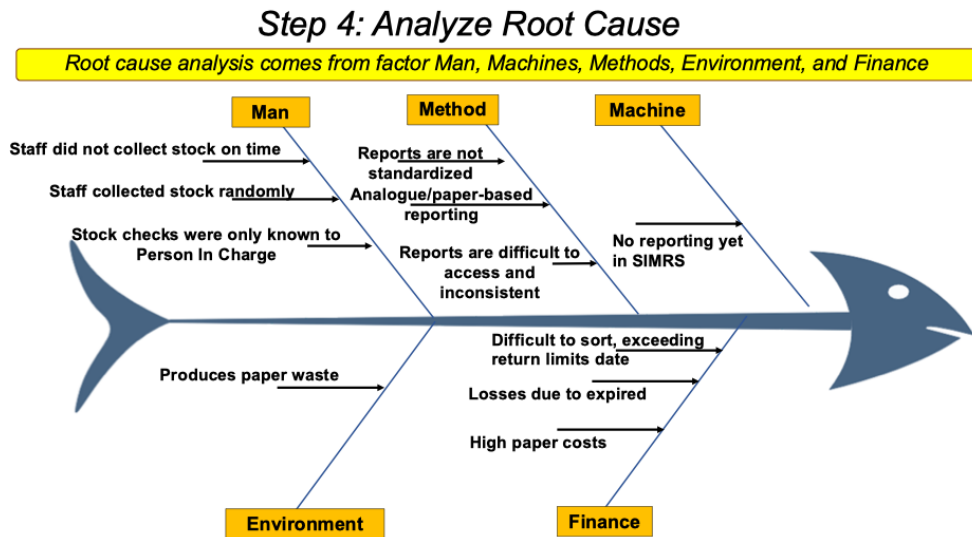


Fig. 4. Root Cause Analysis

Figure 4 shows the diagram groups the leading causes and root causes into five categories: Man, Machines, Methods, Environment, and Finance, all of which contribute to the timely return of failed, and also potentially to enhance paper waste and contribute to CO₂ emissions from utilized paper.

Develop Countermeasure

This step is the opposite of Root Cause. It contains an activity plan: describe the root cause of the Problem and the Kaizen plan, including the Person in Charge (PIC) and the deadline. The Develop countermeasure step can be seen in Figure 5.

Step 5: Develop Counter Measure

Countermeasures are carried out to resolve activity plan					
Problem (What)	Reason (Why)	PIC (Who)	Area (Where)	Date (When)	Counter Measure (How)
1 No digital reporting and monitoring system	Analogue/Paper-based reporting	All SGA	Pharmacy Unit	15 th January 2025	Create a digital reporting and monitoring system by google sheet
2 Lack of system usage skills	Knowledge transition period			16 th January-10 th February	Socialization, Trial and Evaluation
3 No flexible access	Manual search process or entering a long URL			1 st - 3 rd June 2025	Create QR Code, installing QR Code Access at predetermined location, Socialization and Evaluation of the use of QR codes for access to Google Sheets

Fig. 5. Developing Countermeasure

Figure 5 shows the Countermeasures carried out to resolve the activity plan, which has several problems: No digital reporting and monitoring system, Lack of system usage skills, and no flexible access. The countermeasures include creating a digital reporting and monitoring system using Google Sheets, Socialization, Trial and Evaluation, creating a QR Code, installing QR Code access at predetermined locations, and Socialization and Evaluation of using QR codes for access to Google Sheets.

See Countermeasure Through

This step is done through documentation with photos before and after the kaizen. The steps to see the countermeasure through the steps can be seen in Figure 6.

Step 6: See Countermeasure Through

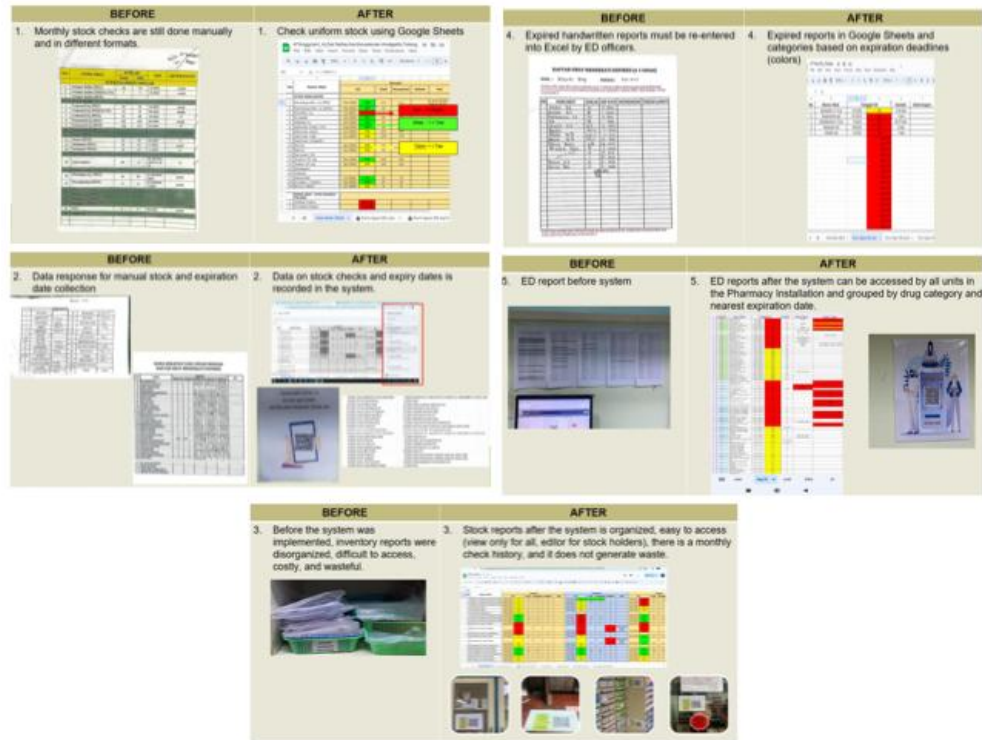


Fig. 6. See Countermeasure Through

Figure 6 illustrates the improvement in the reporting and monitoring process for drug and medical device stock and expiration dates, from the previous paper-based process to the Digitalization of the system using Google Sheets and QR codes. At least five process improvement benefits are derived from the activities carried out through the Kaizen stages.

Evaluate Both Results & Processes

This step describes the before and after implementation of kaizen. It examines whether it contributed to achieving the Ultimate Goal. If it fails, repeat the PDCA (Plan, Do, Check, Action) cycle of the Toyota Business Practice. The steps for evaluating both results and processes can be seen in Figure 7.

Step 7: Evaluate Both Results & Processes

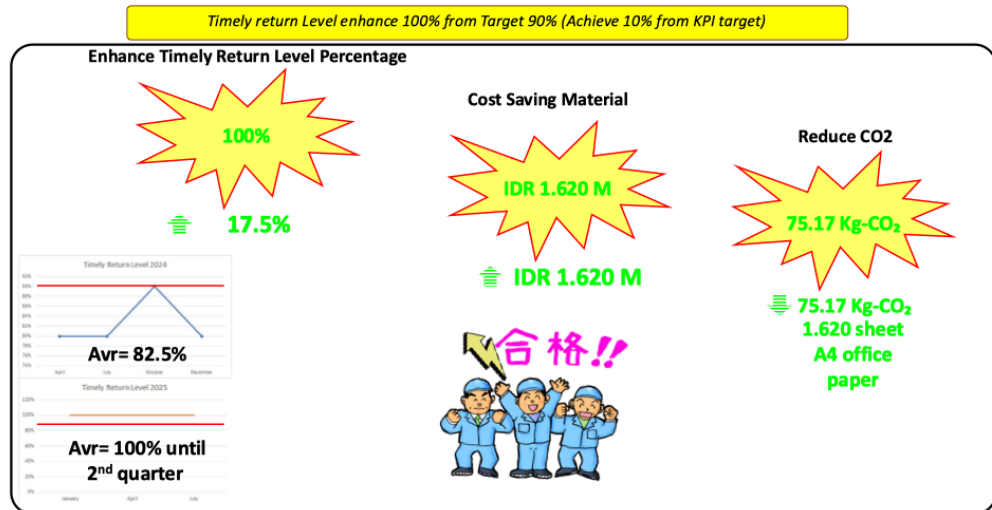


Fig. 7. Evaluate Both Results & Processes

Figure 7 above illustrates several overall benefits from the improvements made, including an enhanced timely Return of up to 100% from the average timely return in 2024, about 82.5%, which exceeds the initial KPI target of 90%. Utilizing the digitization of reporting and monitoring systems has the potential to save about IDR 1.62 million annually from reducing 1,620 sheets of A4 office paper, which in turn also can reduce CO₂ emission by about 75.17 Kg-CO₂ (1,620 x 4.64) from zero office paper savings. One sheet A4 office paper is 4.64g CO₂-eq [16].

Standardization and Expansion

Good countermeasures must be established as standards to prevent recurring problems. Without standards, improvements made over time will be forgotten. Old methods will be reused, resulting in the recurrence of previously resolved issues. Without clear standards, problems are likely to arise if there is a change in personnel [1]. The steps for Standardization and Expansion can be seen in Figure 8.

Step 8: Standardization & Expansion

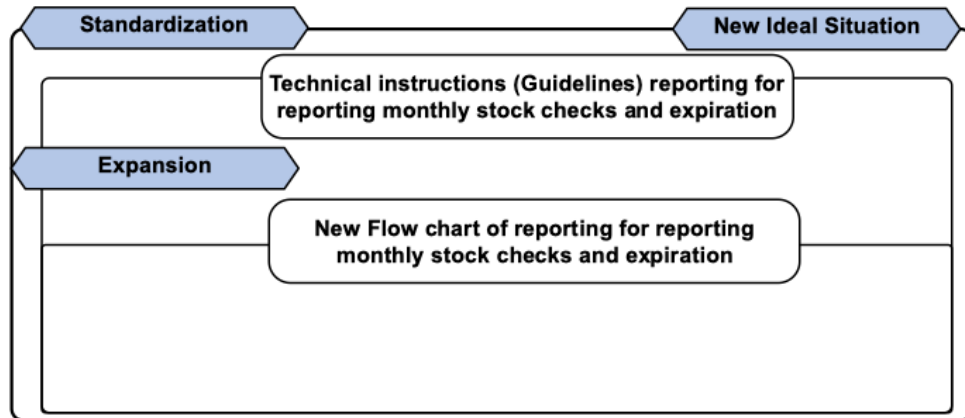


Fig. 8. Standardization and Expansion

Figure 8 shows the Standardization is the New Ideal Situation, which is performed by making technical instructions (Guidelines) for reporting monthly stock checks and expiration. Moreover, Expansion is performed by making a new Flow chart for reporting monthly stock checks and the expired date of medicine and medical devices.

5 Discussions

Implementing lean management in healthcare or lean healthcare through kaizen-based green intervention has successfully transitioned the reporting of physical documents to digital or paperless formats, adopting the green hospital approach and supporting sustainability through environmental indicators. Green Kaizen enhances productivity by reducing waste, reducing costs, and improving environmental aspects of production systems, while increasing sound output [54]. Prioritizing sustainability allows hospitals to reap future economic gains, enhance the patient experience, and promote a healthier, more resilient society [55]. Digitalization enables a more efficient and environmentally friendly work process within the hospital system. Align with research by Volkan et al. (2024) [34] found that Digitalization in hospitals leads to significant time and paper savings for nurses delivering healthcare and also work efficiency [56] and paper saving [34] [35]. Similarly, research by Tarpani and Gallego-Schmid (2024) [57] states that digital healthcare services can improve patient care and reduce costs. However, assessing and reducing environmental impacts is crucial for sustainable development in the healthcare sector. Then, the timeliness of reporting expired medicine and medical device returns should be enhanced. The management information system in hospital pharmacy addresses issues like response time and inaccurate medicine stock data [58]. Moreover, reducing paper waste and promoting green hospital practices that minimize non-pharmaceutical waste and CO₂ emissions. Digital transformation in healthcare can reduce waste and cost, and improve effectiveness while maintaining quality and promoting sustainability [59]. In other words, hospitals implementing green interventions in their operational activities are green. It refers to the green hospital approach, tracking and monitoring the environmental impact of healthcare providers' practices, which can significantly reduce CO₂e emissions and promote public health [60]. Green hospitals are a necessary paradigm shift in healthcare, focusing on resource efficiency and minimizing environmental impact, while addressing challenges like pollution. To fulfill the health demands of a rising and aging global population, healthcare systems must be reformed to fit with eco-

friendly and sustainable methods. It includes reducing CO₂ emissions and better managing resources and waste [61]. Integrating continuous improvement methodologies like Kaizen and Lean with green innovations can lead to sustainable business practices and reduce ecological footprint [62]. For future research, Kaizen and green practices are in the early stages of development, with more research needed on the application of Kaizen tools and more academic and rigorous studies [63].

6 Conclusion

The case study results through Kaizen-Based Green Intervention significantly increased the efficiency of the timeliness of reporting expired medicine and medical device returns to 100%, exceeding the initial KPI target of 90%. The results can improve the accuracy of medicine and medical device stock data. Moreover, it reduces paper usage by 16,200 sheets of A4 office paper per year, thereby saving IDR 1.62 million, and in turn minimizes CO₂ emissions by 75.17 Kg-CO₂ from zero paper usage. The findings can inform recommendations for utilizing lean tools, i.e. kaizen, with a green intervention to improve operational efficiency, thereby reducing waste and paper material usage, achieving cost savings, and lowering CO₂ emissions, all of which can contribute to sustainability in the Healthcare industry through the context of a Green Hospital.

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