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An Analysis of the Implementation of Reverse Logistics to Improve Cost Efficiency in Medical Waste Management at Health Clinics

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A B S T R A C T

Medical waste management is a major challenge in the health system, especially in ensuring cost efficiency while minimizing environmental impacts. This study aims to analyze the relationship between the application of reverse logistics and the cost efficiency of medical waste management in health clinics. The methodology used is a quantitative approach with a sample of 36 respondents involved in medical waste management. Data was collected using a questionnaire and analyzed using the Chi-Square test to evaluate the relationship between variables. The research results show a significant relationship between the implementation of reverse logistics and cost efficiency, where better implementation can substantially reduce operational expenditure. The conclusions of this research indicate that medical waste management through reverse logistics effectively increases cost efficiency, and supports environmental sustainability. The practical implications of these findings can be a reference for health clinic managers in designing more efficient waste management strategies.

1. INTRODUCTION

Medical waste management remains a critical issue in Indonesia. According to the Indonesian Ministry of Health, the volume of medical waste generated from health facilities reached approximately 366 tons per day, with clinics contributing significantly [1]. In Padang City alone, the Health Office reported that more than 100 clinics operate with varying capacities, yet many face challenges in managing infectious and hazardous medical waste [2]. Inefficient waste management not only increases operational costs but also poses risks to environmental sustainability and public health.

The healthcare sector is increasingly recognizing the importance of reverse logistics as a strategic approach to reducing operational costs. Reverse logistics involves the process of moving goods from their final destination with the aim of obtaining value through proper disposal, and includes activities such as recycling, repair, and remanufacturing [3]. In the healthcare context, the implementation of an effective reverse logistics system can play a crucial role in reducing operational costs associated with the disposal of medical waste, expired medications, and outdated medical equipment. Additionally, the adoption of reverse logistics practices has been proven to enhance process efficiency and create a competitive advantage for companies by reducing supply chain costs [4].

In the healthcare industry, particularly clinics operating in urban environments like the city of Padang, reverse logistics can make a significant contribution to cost reduction. Clinics generate various types of waste, including hazardous and non-hazardous materials, which require special handling and disposal processes. Implementing a robust reverse logistics system can help recycle medical equipment and reuse materials, properly dispose of hazardous waste, thereby reducing overall waste management costs. Additionally, this ensures compliance with environmental regulations and enhances the clinic's reputation in terms of improving healthcare services [5].

The role of reverse logistics in the healthcare sector is multifaceted. It supports sustainable management of medical supplies and equipment, ensuring that clinics can maintain a stable supply chain without incurring excessive costs. Furthermore, it facilitates proper disposal of medical waste, which is crucial for maintaining a safe and healthy environment for patients and healthcare providers [6]. By implementing reverse logistics, healthcare clinics can achieve greater

operational efficiency, reduce costs, and contribute to environmental sustainability, ultimately leading to improved patient care and organizational performance. Employee awareness of reverse logistics implementation is also crucial, from clinic owners, nurses, midwives, to pharmacists, all must contribute to service improvement. Organizational performance can improve if employee performance is also enhanced through employee engagement [6].

Research has shown that reverse logistics systems not only help reduce costs but also improve environmental performance by minimizing waste and promoting efficient resource use [8]. For healthcare facilities, the dual benefits of cost and environmental efficiency are highly relevant as they strive to provide high-quality services while managing operational costs. Therefore, understanding the effectiveness of reverse logistics systems in reducing operational costs in healthcare is crucial for improving financial performance and achieving sustainable operations.

Reverse logistics offers a strategic framework to address this challenge by ensuring that medical equipment, expired drugs, and hazardous waste are recycled, reused, or properly disposed of. However, the implementation of reverse logistics in Indonesian health clinics faces several barriers, including high costs of specialized waste handling, lack of infrastructure, limited staff awareness, and weak regulatory enforcement [11; 12]. Previous studies suggest that effective reverse logistics can reduce waste management costs by 20–30% while ensuring compliance with environmental standards [14; 16].

Despite these benefits, studies focusing on reverse logistics in Indonesian health clinics remain scarce, particularly in Padang City. This study, therefore, seeks to fill the gap by analyzing the relationship between reverse logistics implementation and cost efficiency in medical waste management.

2. LITERATURE REVIEW

2.1. *Reverse Logistics in Healthcare Service*

Reverse logistics refers to the process of moving goods from their final destination back through the supply chain in order to recover value or ensure appropriate disposal [11]. In the healthcare sector, reverse logistics encompasses the management of used medical equipment, expired pharmaceuticals, and infectious or hazardous waste requiring specialized handling. An effective reverse logistics system improves not only operational efficiency but also minimizes waste and enhances compliance with environmental regulations. A study by Govindan et al. [12] confirmed that reverse logistics can serve as a strategic approach to reduce medical waste disposal costs while supporting sustainability goals.

2.2. *Sustainability Practices in Medical Waste Management*

Sustainability practices in healthcare facilities include energy efficiency, waste reduction, reuse of medical instruments, and responsible waste management [13]. Implementing sustainability principles enhances environmental performance and raises awareness among healthcare workers regarding resource conservation. According to Zare et al. [14], embedding sustainability into clinical operations significantly contributes to improved service quality and environmental compliance. This approach is particularly relevant in urban clinics, such as those in Padang City, where the volume of medical waste is high and requires stringent management.

2.3. *Operational Cost Efficiency and the Role of Reverse Logistics*

Operational cost efficiency is defined as an organization's ability to minimize operating expenses while maintaining or improving service quality [15]. In medical waste management, cost efficiency can be achieved through effective reverse logistics strategies that reduce transportation needs, optimize recycling, and lower reliance on third-party services. Salema et al. [16] demonstrated that integrating reverse logistics into hospital waste systems can reduce total waste management costs by up to 30%. Similarly, Yadav et al. [17] noted that reverse logistics integration enhances data-driven decision-making in healthcare logistics.

2.4. *Integrating Reverse Logistics and Sustainability for Cost Savings*

The synergy between reverse logistics and sustainability practices has been proven to enhance operational efficiency [18]. In healthcare systems, the implementation of both strategies enables structured waste management, reuse of medical materials, and reduction of costly inefficiencies. Research by Kumar and Dixit [19] highlights that organizations adopting both sustainability and reverse logistics approaches simultaneously experience significant cost savings while strengthening their social and environmental reputation. This is especially important for clinics with limited budgets that aim to maintain service quality and regulatory compliance.

Table 1 below presents the indicators for the variables of reverse logistics, sustainability practices, and operational costs. These indicators were compiled from various scholarly articles and literature, then adopted and adapted to suit the specific context of the current study. The validation of the indicators was conducted by several experts consisting of government officials, academics, and clinic managers who were selected based on their experience and expertise in relevant fields. The validation process was carried out using an indicator validation questionnaire administered through face-to-face sessions. The experts assessed the importance of each indicator. As a result, the indicators used in this research instrument are those deemed valid and appropriate to represent the constructs of reverse logistics, sustainability practices, and operational costs.

Table 1. Indicators for Variables of Reverse Logistics, Sustainability Practices, and Operational Cost

No	Variable	Indicator	Source
1	Reverse Logistics	Medical waste management	[10]; [20]; [21]; [22]; [23]
		Reuse of materials	
		Recycling process	
		Return of medical waste	
		Employee awareness and involvement in reverse logistics practices	
2	Sustainability Practices	Energy and resource efficiency	[18]; [24]; [19]; [25]; [26]
		Commitment to sustainability	
		Government policies and environmental regulations	
3	Operational Costs	Waste management costs	[27]; [28]; [29]; [30]; [31]
		Energy costs	
		Medical material procurement costs	
		Maintenance and repair costs	

3. METHODOLOGY

This study is a quantitative study with a cross-sectional approach. According to the Central Statistics Agency in 2022, there are 102 registered health clinics. Using purposive sampling, 36 clinics were selected as respondents because they manage their own medical waste and met the inclusion criteria.

Data were collected through questionnaires and semi-structured interviews with clinic leaders and staff responsible for waste management. The questionnaire was distributed from October to December 2024 offline through interviews and online through a questionnaire using Google Forms, which was given to clinic leaders and those responsible for medical waste management at health clinics. The questionnaire measured three main constructs: reverse logistics practices, sustainability practices, and operational cost efficiency. Instrument validity was tested using the Pearson Product Moment correlation, with all items exceeding the threshold of 0.30. Then, reliability was tested using Cronbach's Alpha, with results above 0.70, indicating acceptable internal consistency [35]. Data analysis used the Chi-Square test to assess the relationship between reverse logistics and cost efficiency.

4. RESULT AND DISCUSSION

Based on the results obtained, Of the 36 clinics studied, 21 have implemented reverse logistics practices, although most are still at a basic level, primarily outsourcing hazardous waste to licensed third-party services. Fifteen clinics have not implemented reverse logistics due to barriers such as lack of awareness, insufficient infrastructure, and limited budget allocations for waste treatment. Clinics that have implemented this system are generally still at the basic stage, which involves managing medical waste by collaborating with licensed waste management services. These clinics have procedures in place for managing the return of single-use medical devices, and they are also beginning to implement the reuse of medical items that are still suitable for use.

Meanwhile, health clinics that have not yet implemented this system generally do not fully understand the application of the reverse logistics system, and there is no waste management in place that meets the standards or regulations set by the government. In this case, clinics should collaborate with the government or waste management service providers to improve health services in terms of efficient and effective medical waste management. Healthcare institutions are closely linked to healthcare services, and innovative strategies need to be implemented to promote institutions as providers of healthcare services with accuracy and speed of delivery [10].

The research results in Table 1 show the relationship between the variables tested, namely reverse logistics and the efficiency of operational costs in medical waste management.

Based on Table 1, the results show that the p-value is < 0.05, indicating that the results are statistically significant. This means there is a significant relationship between the reverse logistics variable and operational cost efficiency in medical waste management. Additionally, there is a positive relationship between the two variables, where better implementation of reverse logistics leads to higher cost efficiency. The Chi-Square test shows a statistically significant relationship between reverse logistics implementation and operational cost efficiency ($\chi^2 = 20.498$, $p < 0.001$). Clinics implementing reverse logistics reported reduced expenses for waste management, particularly through reuse of non-critical materials and improved coordination with licensed service providers.

These findings align with prior research indicating that reverse logistics reduces costs by optimizing material flows, minimizing reliance on external waste services, and ensuring regulatory compliance [12; 34]. Furthermore, sustainability practices integrated with reverse logistics, such as energy efficiency and waste minimization, create synergistic benefits in healthcare facilities [13; 14]. This study proves that healthcare clinics that consistently implement reverse logistics can improve cost efficiency, for example by reducing expenses for medical waste management. This study is supported by several studies that highlight the potential of reverse logistics to improve cost efficiency, where the success of reverse logistics

in improving supply chain efficiency in various sectors shows promising but underutilized opportunities in healthcare services [34]. From a theoretical perspective, the results confirm that reverse logistics frameworks, when applied in healthcare, can generate both financial and environmental value [18]. Employee awareness and involvement also emerged as important drivers, supporting the view that organizational engagement enhances reverse logistics success [19].

Table 2. Test of the Relationship between the Implementation of Reverse Logistics and Cost Efficiency

Variable Relationship	Operational Waste Management Cost Efficiency		*P-Value*	*Pearson Chi-Square*	Result
	Efficient	Not Efficient			
Implementing Reverse logistics	14	0	0,0001	20,498	Significant
Not Implementing Reverse logistics	5	17			

5. CONCLUSION

This study concludes that the implementation of reverse logistics significantly improves cost efficiency in medical waste management at health clinics in Padang City. Clinics applying reverse logistics benefit from reduced waste disposal costs, greater sustainability compliance, and improved resource utilization. Key findings include: (1) 21 out of 36 clinics have adopted reverse logistics, albeit at a basic stage (2) Main barriers among clinics not implementing reverse logistics include lack of infrastructure, budget constraints, and low staff awareness (3) Employee involvement and organizational commitment play a critical role in ensuring successful implementation.

These findings have practical implications for clinic managers and policymakers in strengthening waste management strategies. Future studies should expand the sample size and include additional variables, such as the environmental impact of reverse logistics, to provide a more comprehensive understanding of its benefits.

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