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Comprehensive Analysis of the Implementation of Solid Medical Waste Management Systems in the Community Health Centers (Puskesmas) of Sungai Penuh City

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Abstract
Introduction: *The management of solid medical waste in primary healthcare facilities remains a critical issue, particularly in Sungai Penuh City, which operates five inpatient health centers serving nearly 100,000 residents. A nearly tenfold increase in waste volume from 2020 to 2023 driven by the surge in single-use PPE during the pandemic, limited availability of autoclaves, licensed incinerators, and cold storage, as well as open burning practices and delayed handover exceeding 48–72 hours high lights the need for a comprehensive assessment.* ***Objective:*** *This study aims to evaluate the current condition of solid medical waste management in the five major health centers and identify gaps in regulatory compliance.* ***Method:*** *A qualitative mixed-method approach was applied through field observations, structured interviews, and document review, validated using source and technique triangulation.* ***Result and Discussion:*** *Findings show that four key stages of waste management remain suboptimal: segregation scored 124 (inadequate), internal collection and transport scored 66 (highly noncompliant), and temporary storage scored 112 (highly noncompliant). In contrast, external transport and treatment scored 114 (highly compliant), though hindered by irregular scheduling.* ***Conclusion:*** *These results underscore the urgency to strengthen infrastructure, regulatory adherence, and scheduled waste transport systems. Future research should assess the effectiveness of eco-friendly technological interventions and competency-based training models to enhance safety and sustainability in medical waste management.*

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Introduction

The management of solid medical waste in primary healthcare facilities has become a critical environmental health issue, particularly in developing countries with decentralized health systems. In Indonesia, this challenge is exacerbated by the large number of Primary Health Centers (Puskesmas) operating with varying institutional and infrastructural capacities. Many facilities still lack adequate infrastructure to support proper waste management practices (Chotijah et al., 2017; Ministry of Health, 2023). National data indicate that out of more than 13,000 first-level healthcare facilities, only approximately 46.6% have implemented solid medical waste management in accordance with established technical standards (Hayana et al., 2021). These shortcomings are evident in key operational stages, including segregation, containerization, temporary storage, and final disposal. In Jambi Province, the compliance rate is even lower, at around 36.4%, highlighting significant regional disparities in implementation (Mauliana et al., 2024; Syarifuddin, 2019).

In Sungai Penuh City, five inpatient Puskesmas serve nearly 100,000 residents, underscoring the strategic role of primary healthcare services in the region (Yunisa, 2022). However, the increasing demand for healthcare has been accompanied by a substantial rise in medical waste generation. Records from the Sungai Penuh City Health Office (2024) show an almost tenfold increase in medical waste volume between 2020 and 2023, largely driven by intensified use of disposable personal protective equipment during and after the COVID-19 pandemic (Singh et al., 2022; Yanto et al., 2020). This situation places considerable strain on waste management systems, particularly in Puskesmas that lack essential treatment facilities such as autoclaves, licensed incinerators, or cold storage units (Pasai et al., 2021). As a result, unsafe practicesincluding open burning and delayed waste transportation exceeding the 48 to 72 hour storage limit stipulated in Ministry of Environment and Forestry Regulation No. P.56/2015 are still observed, posing risks to healthcare workers, communities, and the environment (Raharja, 2018).

Similar challenges have been documented globally in primary healthcare settings. Studies in Nigeria and Bangladesh report persistent problems related to inadequate infrastructure, poor segregation practices, and limited technical capacity among healthcare workers, leading to increased risks of infection and environmental contamination (Raji & Adeogun, 2024). These findings suggest that ineffective medical waste management in primary healthcare facilities is a widespread issue requiring context-specific assessment.

Indonesia has established comprehensive regulations governing medical waste management, including Ministry of Environment and Forestry Regulation No. P.56/2015 and Ministry of Health Regulation No. 2/2023, which emphasize standardized procedures for segregation, containerization, storage, transportation, and treatment of solid medical waste (Irianti, 2012; Riyanto et al., 2021). Nevertheless, empirical studies indicate a persistent gap between regulatory provisions and field implementation, primarily due to limited budgets, insufficient infrastructure, inadequate technical skills, and weak monitoring mechanisms (Irianti, 2013).

From an environmental health perspective, improperly managed solid medical waste poses multiple ecological and public health threats. Several studies have shown that open burning or substandard storage conditions can release hazardous substances such as dioxins, furans, and heavy metals, contributing to air, soil, and groundwater pollution

(Prata et al., 2021). The World Health Organization (WHO, 2023) and the United Nations Environment Programme (UNEP, 2022) also emphasize that sustainable medical waste management systems must be built on three main principles: minimizing health risks, promoting efficient resource use within a circular economy, and ensuring long-term environmental protection (Syafhira et al., 2024). Therefore, medical waste management should not only aim for regulatory compliance but also serve as a strategic effort to prevent environmental degradation and protect community health (dini Faghfirlia et al., 2022).

Despite growing attention to medical waste management in hospital settings, studies focusing on Puskesmas particularly in regions with geographical and infrastructural constraints remain limited (Firdaus & Febrianto, 2025). Existing research often emphasizes isolated technical aspects rather than evaluating the full waste management cycle against national indicators. Therefore, a systematic assessment of solid medical waste management practices in inpatient Puskesmas in Sungai Penuh City is urgently needed.

Accordingly, this study aims to evaluate solid medical waste management practices across four key stages: segregation and containerization, internal collection and transportation, temporary storage, and external transportation and treatment. Using national standard indicators and field observations, the study seeks to determine compliance levels and identify factors contributing to implementation gaps, thereby providing evidence-based input for improving environmental health management in Indonesia's primary healthcare system.

Method

This study employed a qualitative approach with an analytic mixed-method design, integrating direct field observation, structured interviews, and document analysis to obtain a comprehensive understanding of solid medical waste management practices in five inpatient Community Health Centers (Puskesmas) in Sungai Penuh City, Jambi Province. The mixed-method approach was selected because it allows the combination of empirical field data with administrative and policy information, thereby enhancing the depth of analysis (Creswell & Poth, 2016). Data collection was carried out from October to November 2025.

Primary data were gathered through in-depth interviews with key stakeholders, including healthcare workers, environmental sanitation officers, and logistics or administrative personnel involved in the medical waste management chain. Interview guides and observation checklists were developed based on the technical standards outlined in the Regulation of the Indonesian Ministry of Health No. 2 of 2023 concerning medical waste management in healthcare facilities. Field observations were conducted across all stages of waste management, including segregation, containerization, internal collection, temporary storage, and the handover process to third-party service providers(Ahmad et al., 2021).

Secondary data were obtained through the analysis of official documents from the health facilities, including daily waste volume logs, environmental compliance reports, transportation schedules, and waste management licensing documents from the Sungai Penuh City Health Office. The document review strengthened the primary data and allowed the identification of gaps between regulatory requirements and actual practices (Lkhagvasuren et al., 2025).

To ensure the validity of the findings, the study applied triangulation of sources and methods. Observational data were compared with interview statements, while administrative information was verified through official documentation. This triangulated approach was employed to enhance the credibility, dependability, and confirmability of the data, as recommended in contemporary qualitative research (Nowell et al., 2017). All data were analyzed thematically by identifying patterns, discrepancies, and contributing factors that influence the quality of medical waste management in each Puskesmas.

Result and Discussion

1. Result

The findings of this study reveal that the flow of solid medical waste management in healthcare facilities is organized into four principal stages, each serving as a foundation for evaluating the system as a whole. These stages consist of: **(a)** the segregation and containerization process, which ensures that each type of waste is placed in a container appropriate to its hazard characteristics; **(b)** the internal collection and transportation, which safely moves waste from the point of generation to the temporary storage area; **(c)** the temporary storage phase, designed to maintain the stability and safety of the waste before it is transported outside the facility; and **(d)** external transportation and treatment, which involves transferring the waste to licensed units for processing in accordance with regulatory standards.

These four stages not only describe operational procedures but also function as indicators of how the management system operates as an interconnected sequence of processes. By mapping these stages, this study highlights critical points within the waste management flow that determine the overall effectiveness of the system and its alignment with environmental and public health standards. Informants' response scores on segregation and containerization, internal collection and transportation, temporary storage and external transportation and treatment presented in Tables 1, 2, 3, and 4.

Table 1
Informants' Response Scores on Segregation and Containerization

Informant	Scores								Total	Mean
	1	2	3	4	5	6	7	8		
1	2	3	4	2	3	5	3	4	26	3.25
2	2	3	2	2	2	5	3	4	23	2.88
3	2	1	3	2	3	5	3	4	23	2.88
4	2	3	4	3	5	5	4	4	30	3.75
5	1	3	3	2	3	5	1	4	22	2.75
∑**Scores**									124	3.1
Assessment Classification = Less Appropriate (LA)										

Table 2
Informants' Response Scores on internal collection and transportation

Informant	Scores									Total	Mean
	1	2	3	4	5	6	7	8	9		
1	1	1	1	1	1	3	2	3	2	13	1.44
2	1	1	1	1	1	3	2	3	2	13	1.44
3	1	1	1	1	1	3	2	3	2	13	1.44
4	1	1	1	1	1	3	2	3	2	13	1.44
5	1	1	2	1	1	3	2	3	2	14	1.56
∑Scores										66	1.47
Assessment Classification = Very Inappropriate (VI)											

Table 3
Informants' Response Scores on temporary storage

Informant	Scores															Total	Mean
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
1	2	2	3	1	1	1	1	4	3	1	2	1	4	1	1	28	1.87
2	4	1	3	1	1	1	1	3	1	1	2	3	1	2	3	28	1.87
3	2	1	2	1	1	1	1	1	1	1	2	1	1	1	1	18	1.20
4	2	1	2	1	1	1	1	3	1	1	3	1	2	1	1	22	1.47
5	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	16	1.07
∑Scores																112	1.49
Assessment Classification = Very Inappropriate (VI)																	

Table 4
Informants' Response Scores on external transportation and treatment

Informant	Scores					Total	Mean
	1	2	3	4	5	19	3.8
1	5	4	4	1	5	19	3.8
2	5	4	4	1	5	19	3.8
3	5	4	4	1	5	19	3.8
4	5	4	4	1	5	19	3.8
5	5	4	4	1	5	19	3.8
∑Scores						114	4.56
Assessment Classification = Very Appropriate (VA)							

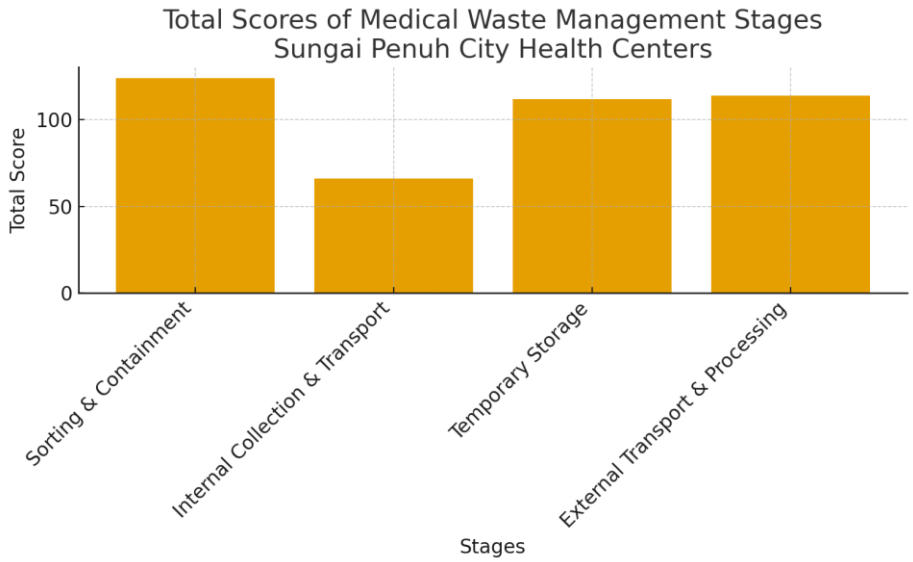
Description:
1 = Very Inappropriate (VI)
2 = Inappropriate (I)
3 = Less Appropriate (LA)
4 = Appropriate (A)
5 = Very Appropriate (VA)

2. Discussion

The findings of this study indicate that there are four key stages in solid medical waste management, which together form a systematic assessment process of the entire waste management flow: (a) Segregation and Containerization; (b) Internal Collection and Transportation; (c) Temporary Storage; and (d) External Transportation and Treatment (Mmereki et al., 2017). The general overview of these stages is summarized in Table 5 and illustrated in Picture 1.

Table 5
Categories of Solid Medical Waste Management Stages

Stage	Score	Mean	Category
Segregation & Containerization	124	3.10	Partially Compliant
Internal Collection & Transportation	66	1.47	Highly Non-Compliant
Temporary Storage	112	–	Highly Non-Compliant
External Transportation & Treatment	114	–	Highly Compliant



Picture 1. Solid Medical Waste Management Stages

Based on the evaluation of the four stages of solid medical waste management in inpatient Community Health Centers (Puskesmas) in Sungai Penuh City, the following scores were obtained: the Segregation & Containerization stage scored 124 (Partially Compliant), Internal Collection & Transportation scored 66 (Highly Non-Compliant), Temporary Storage scored 112 (Highly Non-Compliant), and External Transportation & Treatment scored 114 (Highly Compliant). These results highlight a clear disparity in performance: the internal stages (collection and temporary storage) demonstrate significant weaknesses, whereas the external stages (transportation and treatment) show relatively better compliance. This finding is consistent in the Merauke District Health Center, which reported that waste segregation in many health centers is still not carried out consistently despite the availability of facilities (Akter, 2000; Sabteka et al., 2024) .

The Segregation & Containerization stage, although partially implemented, has not fully met operational standards, indicating inconsistencies in applying established procedures (Mmereki et al., 2017). Internal Collection & Transportation and Temporary Storage reflect highly inadequate conditions, far below regulatory requirements, which may pose risks to healthcare workers, patients, and the surrounding environment. Conversely, the External Transportation & Treatment stage demonstrates that most waste has been successfully transferred to licensed third-party facilities, although administrative issues such as irregular transportation schedules persist (Kenny & Priyadarshini, 2021).

The significant difference between internal and external stage scores illustrates that the most critical challenges in medical waste management occur in the early internal phases—segregation, collection, and temporary storage. These phases depend heavily on daily operational practices within the Puskesmas: staff discipline, availability of proper containers, and access to SOPs and training. These findings align with systematic reviews demonstrating that many healthcare facilities in developing countries experience poor waste management primarily due to limited resources, inadequate infrastructure, and insufficient staff capacity (Chartier, 2014; Dinas Kesehatan Kota Sungai Penuh, 2024).

Studies conducted in Puskesmas and hospitals across Indonesia show a similar pattern: although some stages meet regulatory requirements, improper mixing of medical and non-medical waste and prolonged storage remain common issues(Andrayani et al., 2022; Arlinda et al., 2022). This underlines the importance of segregation and containerization as the first and most influential steps toward the success of the entire waste management system (Chotijah et al., 2017). When the initial stage fails, the burden on subsequent stages increases, raising contamination and infection risks.

Temporary Storage and Environmental Risks

The "Highly Non-Compliant" score for Temporary Storage indicates that storage facilities in the Puskesmas of Sungai Penuh do not meet technical and regulatory standards. This may lead to the accumulation of hazardous waste, organic decomposition, environmental contamination, and potential exposure risks for workers and surrounding communities. A similar situation was reported in a study conducted in hospitals in Palu, in which medical waste was sometimes stored for up to one month due to delays in third-party collection significantly increasing environmental and public health risks (Peng et al., 2020).

These findings reflect broader structural challenges: many primary healthcare facilities (including Puskesmas) lack essential infrastructure such as cold storage, secure containers, dedicated waste transport routes, or adequate storage SOPs. Policy analyses on post-COVID-19 medical waste in Indonesia have also emphasized that these infrastructural limitations contribute to long-term ecological problems, including marine pollution from plastics and hazardous materials (Luhar et al., 2022; Vanapalli et al., 2021).

External Transportation & Treatment: Better, but Not Optimal

The high score obtained for External Transportation & Treatment suggests that once waste is transferred to licensed service providers, processing generally adheres to standards (Williams, 2013). This indicates effective collaboration between health facilities and third-party waste operators, as well as the efficiency of centralized waste treatment systems. A study in Puskesmas in Bangli District similarly found that

cooperation with third-party providers is a key factor in achieving compliance in medical waste management (G. K. Singh et al., 2014).

However, a major concern is the lack of a fixed transportation schedule. This uncertainty can lead to fluctuations in accumulated waste volumes, forcing facilities to store waste for extended durations an issue that, as noted, carries substantial risks. This concern is especially relevant in primary healthcare settings where waste volume can rise suddenly (e.g., during pandemics) while storage capacity remains limited (Okot-Okumu, 2012).

Contributing Factors: Regulations, Infrastructure, and Human Resources

The global literature indicates that developing countries face common challenges: the absence of effective waste management plans, inadequate budgets and technical facilities, and low staff awareness and monitoring are major contributors to medical waste management failures. In Indonesia, recent studies in Puskesmas reveal similar patterns: despite the presence of national regulations (such as those issued by the Ministry of Health), implementation is frequently hindered by insufficient staff training, inadequate facilities, and weak internal supervision (Suryanto et al., 2017). Therefore, improving medical waste management requires multipronged interventions: adequate containerization and storage infrastructure, regular staff training, stricter enforcement of regulations, and strengthened collaboration with waste-processing service providers (Nurcahyo & Bachtiar, 2020).

Conclusion

This study concludes that solid medical waste management in Puskesmas across Sungai Penuh City has not yet complied with national standards and environmental health regulations. Although most Puskesmas demonstrate institutional awareness and possess written standard operating procedures, their implementation remains ineffective. Key constraints include inadequate facilities, limited budgets, and insufficient technical training for healthcare workers, which negatively affect waste segregation, storage, and handling practices. Non-compliance at the point of waste generation continues to pose environmental and occupational health risks. These findings align with previous studies emphasizing that human resource capacity and infrastructure availability are critical determinants of compliance in healthcare waste management systems. Based on these findings, three priority recommendations are proposed. First, standardized waste containers with clear labeling should be provided to ensure proper segregation. Second, compliant temporary storage facilities (TPS) must be established as a standard component of Puskesmas infrastructure. Third, a fixed and regulated waste transportation schedule should be implemented to minimize on-site accumulation. Evidence shows that these basic infrastructural and operational measures significantly improve compliance and system performance.

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