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Evaluating Solid Medical Waste Management through SOP Compliance in HNGV Hospital Timor-Leste

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ABSTRACT

Solid medical waste management in hospitals is essential for protecting public health and ensuring environmental safety, as improper handling of infectious and hazardous waste can lead to disease transmission and environmental contamination. As the national referral hospital in Timor-Leste, Hospital Nacional Guido Valadares (HNGV) has a critical responsibility to comply with established Standard Operating Procedures (SOPs) and national regulations. This study aimed to evaluate the level of compliance with SOPs in solid medical waste management at HNGV across four dimensions: policy, human resources, technical aspects, and operational processes, including containment, segregation, transportation, and disposal. A quantitative descriptive design with a survey approach was employed. Data were collected from cleaning staff and sanitation officers 60 using structured questionnaires and analyzed using descriptive statistical techniques, particularly percentage distribution, to measure SOP compliance levels. The results indicate a high level of compliance in several key indicators, including waste segregation (>90%), use of autoclave and incinerator systems (approximately 90–95%), and adherence to personal protective equipment (PPE) protocols (>90%). However, lower compliance was observed in temporary waste storage adequacy (<80%) and consistent use of specific protective equipment. Overall, HNGV's solid medical waste management system generally meets established standards, although gaps remain in infrastructure and operational consistency. This study contributes to the existing literature by providing empirical evidence on SOP-based compliance in hospital waste management within a developing country context and highlights the need for strengthening infrastructure, equipment provision, and continuous monitoring systems to enhance sustainable medical waste management practices.

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INTRODUCTION

Waste is the residue of human activities that is no longer useful and tends to be discarded in solid, liquid, gaseous, or other forms (Al-Taai, 2022). Medical waste refers to waste containing infectious materials or having the potential to transmit disease (Janik-Karpinska et al., 2023). Generated from health facilities such as hospitals, clinics, and laboratories, medical waste poses significant risks to public health if not properly managed (Singh et al., 2022). This issue is particularly critical in developing countries, including Timor-Leste, where regulatory frameworks and waste management infrastructure remain limited.

In Timor-Leste, medical waste management is formally regulated through Decreto-Lei No.26/2012 and Ministerial Diploma No.75/2021, which define hazardous waste classifications and outline hospital responsibilities for environmental sanitation. Although these regulations demonstrate institutional awareness, their implementation often faces practical challenges. In many low-income settings, medical waste is not adequately segregated from general waste, increasing the volume of hazardous materials (Shewaye & Terefe, 2025). Similarly, studies in Southeast Asia indicate that hospitals frequently lack adequate waste management planning (Raj et al., 2024). These findings suggest a persistent gap between regulatory frameworks and actual practices.

Hospitals play a crucial role in maintaining environmental safety and preventing infection transmission. Improperly managed medical waste can contribute to nosocomial infections and environmental contamination, posing risks to patients, healthcare workers, and surrounding communities (Ibáñez-Cruz et al., 2025; Nosheen et al., 2022;

Wei et al., 2021; Ghali et al., 2023). Despite the recognized importance of systematic waste management, existing studies largely emphasize general risks and challenges, with limited empirical evaluation of compliance with Standard Operating Procedures (SOPs), particularly in resource-constrained hospital settings.

The medical waste management system typically involves three stages: inputs (policies, human resources, and infrastructure), processes (segregation, storage, transportation, and treatment), and outputs (environmental safety and reduced infection risk) (Yang et al., 2024; Nadi et al., 2024; Wen & Ding, 2020). However, in practice, many hospitals in developing countries continue to face challenges across these stages due to limited equipment, insufficient technical guidance, and low staff awareness. This indicates a lack of systematic evaluation linking regulatory compliance with operational performance.

At Hospital Nacional Guido Valadares (HNGV), the national referral hospital in Timor-Leste, several operational challenges have been observed, including suboptimal incinerator performance, inadequate waste recording systems, limited availability of personal protective equipment, and insufficient trained personnel. These conditions reflect a substantial discrepancy between regulatory expectations and field implementation.

Although previous studies have highlighted the risks and general challenges of medical waste management, there is still a lack of empirical, compliance-based assessment of SOP implementation at the hospital level, particularly in developing country contexts such as Timor-Leste. This study addresses this gap by systematically evaluating SOP compliance across policy, human resources, technical aspects, and operational processes in a national referral hospital setting.

Based on the identified research gap, this study aims to assess the level of compliance of solid medical waste management at HNGV with established SOPs and regulatory standards. It further investigates the key challenges that hinder effective implementation and examines the role of policy, human resources, and technical factors in shaping the overall effectiveness of waste management practices.

Accordingly, this study aims to evaluate the implementation of SOP-based solid medical waste management at Hospital Nacional Guido Valadares (HNGV) in Dili, Timor-Leste. The findings are expected to provide empirical evidence to support improvements in hospital waste management systems and contribute to the development of more effective policies and practices in similar developing country contexts.

METHOD

Type of Research

This study employed a quantitative descriptive method, which is appropriate for evaluating the level of compliance with Standard Operating Procedures (SOPs) in solid medical waste management (Ghanad, 2023). The main objective of this approach was to describe the distribution, frequency, and percentage of each indicator related to SOP implementation at Hospital Nacional Guido Valadares (HNGV) Dili, Timor-Leste. This design was selected because it allows for systematic assessment of existing conditions without manipulating variables.

Research Location

The research was conducted at the solid medical waste management unit of Hospital Nacional Guido Valadares, located in Kuluhun Village, Cristo Rei District, Dili, Timor-Leste. This site was selected due to its role as the national referral hospital, making it representative of medical waste management practices in the country.

Population and Sample

The research population consisted of all employees and cleaners involved in solid medical waste management at HNGV, totaling 152 individuals. The sample size was determined using the Slovin formula with a 10% margin of error, resulting in 60 respondents. The selection of a 10% error rate was considered acceptable for exploratory descriptive studies with limited resources, including time, funding, and manpower (Anugraheni et al., 2023). Respondents were selected proportionally to represent different work units involved in waste management.

Inclusion and Exclusion Criteria

The inclusion criteria included hospital employees who had direct involvement in solid medical waste management at HNGV, were actively working during the study period, and consented to participate in the study. Exclusion criteria included employees who were absent due to illness or leave during data collection, as well as those who declined participation.

Research Variables

This study used independent and dependent variables based on SOP indicators for solid medical waste management at HNGV (Herdian et al., 2022). The independent variables included policy, human resources, technical aspects, and operational processes, while the dependent variable was the level of compliance with SOP implementation.

Operational Definition
The operational definitions were developed based on 14 SOP indicators for solid medical waste management, including definition, objectives, policies, hygiene practices, equipment availability, medical waste handling, training, non-medical waste, biological residues, waste coding, waste management procedures, equipment safety, sharp waste handling, and sanitation facilities. Each indicator was measured using a structured questionnaire with binary response categories: "appropriate" (score 1) and "not appropriate" (score 0), allowing for quantitative assessment of compliance levels.

Research Instruments
The research instruments consisted of structured questionnaires and observation checklists. The questionnaire included 14 SOP indicators with a total of 30 statements designed to assess knowledge, attitudes, and practices related to waste management. Observation checklists were used to validate actual practices in the field and to minimize response bias. To ensure data quality, the instrument underwent content validity assessment through expert review in the field of environmental health and hospital waste management. In addition, a pilot test was conducted on a small group of respondents outside the study sample to evaluate clarity and consistency. Reliability testing was performed using internal consistency measures (e.g., Cronbach's alpha), indicating that the instrument was sufficiently reliable for data collection.

Data Collection Techniques
The study utilized both primary and secondary data. Primary data were obtained through structured questionnaires and direct observation of waste management practices at HNGV. Secondary data were collected from hospital documents and relevant literature, including employee records, work unit distribution, and institutional reports.

Data Collection Procedure
Data collection was conducted in several stages to ensure procedural clarity and replicability. First, preliminary observations were carried out to understand the waste management workflow. Second, questionnaires were distributed directly to respondents and completed under supervision to ensure accuracy. Third, structured observations were conducted using checklists to compare reported practices with actual conditions. Finally, document analysis was performed to support and triangulate findings from primary data sources.

Data Analysis Techniques
Data analysis was performed using Microsoft Excel to calculate frequencies and percentages of respondents' answers (Remenyi et al., 2022). Responses categorized as "appropriate" were scored as 1, while "not appropriate" responses were scored as 0. The results were then converted into percentages to determine the level of compliance with SOP implementation. Indicators were ranked from highest to lowest percentage to describe the overall compliance level. An indicator was classified as "compliant" when the proportion of "appropriate" responses exceeded that of "not appropriate" responses. Although this study primarily applied descriptive statistical analysis, this approach was considered appropriate for the study's objective of evaluating compliance levels rather than testing causal relationships. However, the limitation of this method is the absence of inferential statistical analysis, which may restrict deeper generalization of findings.

RESULTS AND DISCUSSION

Definition of Nosocomial Infection and Management Goals
The results indicate that 97% of respondents considered the definition of nosocomial infection in the SOP for solid medical waste management at HNGV to be compliant with applicable standards, while 92% reported that the objectives of SOP implementation had been achieved. This high level of compliance suggests strong conceptual understanding among staff regarding infection prevention as a core component of waste management. However, the remaining 8% gap indicates partial inconsistency in translating SOP objectives into operational outcomes.

Compared to previous studies, this finding is consistent with Lemiech-Mirowska et al. (2021) and Batra et al. (2024), which emphasize that clear understanding of infection control concepts significantly reduces hospital-acquired infection risks. Similarly, Sholehah & Holifah (2024) and Khairil et al. (2024) highlight that proper alignment between SOP definitions and practice contributes to improved hygiene outcomes.

From a theoretical perspective, this result supports the infection control framework, where knowledge acts as a precursor to compliance behavior. However, the persistence of a small non-compliant proportion suggests that knowledge alone is insufficient without reinforcement mechanisms such as monitoring and evaluation systems.

Table 1. Suitability of the Definition of Nosocomial Infection and the Purpose of SOP in HNGV

Indicator	Compliant	Inappropriate	Information
Definition of nosocomial infection	97 %	3 %	Understanding is good
Objectives of SOP management	92 %	8 %	It's appropriate, it needs regular reinforcement

A high level of compliance in both conceptual understanding and SOP objectives reflects strong awareness among staff regarding infection prevention as a core component of waste management. However, the 5% gap between these indicators suggests that, despite strong knowledge, its translation into achieving SOP objectives is not fully optimal. This discrepancy may reflect limitations in operational implementation or insufficient reinforcement mechanisms, highlighting the need for continuous supervision and practical application of SOP principles.

Policy, Politics, and Oversight

The study found that 97% of respondents perceived hospital policies related to safety, comfort, and supervision as compliant, while 90% reported adequate understanding of policy content. This indicates that institutional governance at HNGV is relatively strong, particularly in establishing formal regulatory structures. However, the 10% gap in policy understanding reflects limitations in policy dissemination and internal communication.

This finding aligns with Hussein et al. (2021), who argue that policy effectiveness depends not only on formulation but also on clarity and dissemination. From a governance perspective, this suggests that HNGV has achieved administrative compliance but still faces challenges in achieving full behavioral compliance. In practical terms, this gap may lead to inconsistent SOP implementation across units, highlighting the need for continuous policy socialization and training programs.

Table 2. Respondents' Perception of Policies and Supervision at HNGV

Policy Indicators	Compliant	Inappropriate	Information
Safety and convenience policy	97 %	3 %	Up to standard
Understanding the content of the policy	90 %	10 %	There is a need for further socialization.

High compliance in institutional policies reflects strong administrative governance within HNGV. However, the lower level of staff understanding indicates that policy effectiveness is partially constrained by gaps in internal communication and dissemination. This suggests that formal regulations alone are insufficient to ensure consistent implementation, highlighting the need for continuous policy socialization and reinforcement mechanisms across all operational units.

Task Execution and Tool Availability

Compliance with operational tasks ranged between 85% and 97%, indicating that routine waste management activities are generally performed according to SOPs. However, a critical discrepancy emerges in the availability and use of PPE. While general compliance is high, specific PPE usage remains significantly low, with only 17% using work uniforms, 8% using goggles and hats, and 25% using boots.

This contrast reveals a structural gap between procedural compliance and resource availability. According to occupational safety theory (Oh et al., 2022), PPE functions as a primary barrier against hazardous exposure. Therefore, low PPE usage not only reflects behavioral non-compliance but also indicates systemic limitations such as inadequate supply or weak enforcement. This finding suggests that high compliance percentages in general indicators may mask critical vulnerabilities in specific safety practices, emphasizing the need for disaggregated analysis rather than relying solely on aggregate compliance rates.

Table 3. Availability and Use of PPE by HNGV Officers

Types of Personal Protective Equipment	Compliant (%)	Inappropriate (%)	Information
Work uniform	17	83	Very low
Glasses & Hats	8	92	Very low
Big shoes	25	75	Needs to be improved
Masks & Gloves	70	30	Quite available

A clear disparity emerges between general procedural compliance and the actual use of specific PPE. While routine tasks appear to be implemented according to SOPs, the low utilization of critical protective equipment

indicates underlying structural issues, such as limited availability and weak enforcement. This imbalance suggests that high overall compliance may obscure significant risks in occupational safety, emphasizing the importance of evaluating compliance at a more detailed operational level.

Waste Containers and Biological Residue Management

The study shows high compliance in the management of sharp waste and biological residues, with 97% adherence to SOP standards. This indicates effective implementation of high-risk waste handling procedures, particularly in the use of safety boxes and standardized disposal systems.

However, only 20% compliance was observed in temporary waste storage facilities, indicating a major structural weakness in the waste management chain. This imbalance suggests that while upstream processes (segregation and containment) are well implemented, downstream processes (storage and infrastructure) remain inadequate.

Consistent with Arumdani (2021), the use of standardized containers significantly reduces contamination risk. However, without adequate temporary storage facilities, the overall system effectiveness is compromised. This finding highlights the importance of system integration, where failure in one stage can undermine the entire waste management process.

Table 4. Suitability of Waste and Biological Residue Containers at HNGV

Indicator	Compliant	Inappropriate	Information
Sharp waste container (safety box)	97 %	3 %	Complies with WHO standards
Biological residue management	97 %	3 %	Appropriate, need continuous monitoring
Temporary landfill (TPS)	20 %	80 %	Still not up to standard

High compliance in the handling of sharp waste and biological residues reflects effective implementation of critical safety procedures. However, the substantially lower compliance in temporary storage facilities reveals a major structural weakness within the waste management system. This imbalance indicates that while upstream processes are well managed, downstream infrastructure remains inadequate, potentially undermining the overall effectiveness of waste management practices.

Officer Training and Work Discipline

A total of 97% of respondents reported having participated in PPE training, indicating strong institutional commitment to capacity building. However, the exclusion of 3% of workers, particularly temporary staff, introduces inconsistency in operational practices.

This finding supports Haque et al. (2024), who emphasize the role of continuous training in improving safety compliance. Additionally, Shaban et al. (2021) demonstrate that disparities in training access between permanent and contract workers reduce overall system consistency. From a human resource management perspective, this indicates that training programs at HNGV are effective but not yet inclusive. Ensuring universal training coverage is essential to achieving uniform SOP compliance.

Table 5. Officers' Participation in PPE Training at HNGV

Training Participation Status	Respondents (%)	Information
Attend training	97	The majority, according to WHO standards
Not attending training	3	Dominated by daily contract workers

Training participation is generally high, indicating strong institutional commitment to human resource development. However, the exclusion of a small proportion of workers suggests that training programs are not yet fully inclusive. This gap may lead to inconsistencies in SOP implementation, particularly among contract or temporary staff, highlighting the importance of ensuring equal access to training for all personnel.

Color Coding and Medical Waste Management

The compliance level for color coding reached 98%, indicating near-perfect adherence to waste segregation standards. This suggests that visual-based SOP systems are highly effective in guiding staff behavior. However, the remaining 2% non-compliance still poses a risk, particularly in high-risk waste categories. Ahmad et al. (2025) highlight that even minor deviations in waste segregation can significantly increase contamination risk. This finding reinforces the importance of continuous supervision, as high compliance rates do not eliminate the need for monitoring in critical safety procedures.

Table 6. Compliance Level of Color Code Use in HNGV

Waste Container Color	Types of Waste Collected	Compliance (%)	Non-Compliant (%)
Green	General garbage	98	2
Yellow	Infectious medical waste	98	2
Red	Cytotoxic waste	98	2
Orange	Sharp waste (syringes, needles)	98	2

The near-perfect compliance in color coding reflects the effectiveness of visual management systems in supporting proper waste segregation practices. However, even minimal non-compliance remains critical, as small deviations in waste classification can increase the risk of contamination. This finding underscores the importance of maintaining strict supervision and consistency, even in areas with high overall performance.

Temporary Disposal Sites (TPS) and Personal Equipment

The most critical weakness identified in this study is the extremely low compliance of temporary disposal site (TPS) standards, with only 3% meeting SOP requirements. This indicates a severe infrastructural deficiency that directly affects the overall effectiveness of waste management.

In addition, only 33% of respondents reported consistent use of complete PPE, indicating weak enforcement of safety protocols. These findings are consistent with Munadi et al. (2021), who identify inadequate waste storage facilities as a major contributor to environmental contamination risks. From a policy perspective, this reflects a gap between regulatory compliance and resource allocation. As emphasized by Graham (2022), providing PPE is a fundamental institutional responsibility. However, provision alone is insufficient without enforcement and behavioral compliance mechanisms.

Table 7. Suitability of TPS and Use of Individual PPE at HNGV

Indicator	Compliant	Inappropriate	Information
Medical waste TPS according to SOP	3 %	97 %	Very low, does not meet standards
Officers use complete PPE	33 %	67 %	The majority of them are undisciplined

The most critical weaknesses are observed in infrastructure and PPE compliance. The extremely low compliance in temporary disposal site standards, combined with limited use of complete PPE, indicates a significant gap between policy requirements and operational implementation. This suggests that the challenges are not only technical but also managerial, involving insufficient resource allocation and weak enforcement mechanisms, which may increase environmental and occupational health risks.

Synthesis and Implications

Overall, the findings reveal a dual pattern of compliance, characterized by high adherence to procedural and knowledge-based indicators alongside significant weaknesses in infrastructure and enforcement-related aspects. This suggests that SOP implementation at HNGV is administratively strong but operationally uneven. From a theoretical perspective, this study contributes to the understanding of SOP compliance by demonstrating that compliance is multidimensional, involving not only knowledge and policy but also infrastructure readiness and behavioral enforcement. From a practical perspective, the results highlight several key priorities, including the need to strengthen waste management infrastructure, particularly temporary storage facilities, improve the availability and enforcement of personal protective equipment (PPE), and enhance continuous monitoring and inclusive training systems. These findings provide empirical evidence for improving hospital waste management systems, particularly in developing country contexts where resource constraints and institutional gaps remain significant.

CONCLUSION

The results of this study indicate that the implementation of solid medical waste management at Hospital Nacional Guido Valadares (HNGV) generally complies with established standard operating procedures (SOPs), with most indicators demonstrating high levels of adherence (above 90%). This reflects a strong institutional commitment to environmental health and infection control practices. However, critical gaps remain in infrastructure and operational enforcement, particularly in the availability of standard-compliant Temporary Disposal Sites (TPS) and the consistent use of complete personal protective equipment (PPE).

From a scientific perspective, this study contributes to the literature by demonstrating that SOP compliance in hospital waste management is multidimensional, involving not only knowledge and procedural adherence but also infrastructure readiness and behavioral enforcement. These findings highlight that high compliance in administrative

and technical indicators does not necessarily guarantee overall system effectiveness when structural and supervisory components are weak.

From a policy perspective, the study underscores the need for integrated strategies that go beyond regulatory compliance, including strengthening infrastructure provision, improving enforcement of PPE usage, and enhancing continuous training and monitoring systems. These results provide empirical evidence to support more targeted and context-specific policy development for hospital waste management in developing countries, particularly in resource-constrained settings such as Timor-Leste.

Future research is recommended to expand the scope by conducting comparative studies across multiple hospitals, incorporating more advanced analytical approaches, and examining the relationship between compliance levels and health or environmental outcomes. Such efforts would contribute to the development of more comprehensive and evidence-based national policies for sustainable medical waste management.

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AUTHOR CONTRIBUTION STATEMENT

Ivo Da Costa Soares and Rima Semiarty contributed to the conceptualization, research design, data collection, data analysis, and manuscript preparation. Both authors have read and approved the final version of the manuscript.

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