Journal of Civil Engineering, Science and Technology
Volume 17, No.2, September 2026, 168-176

RISK IDENTIFICATION PRACTICES IN CLINICAL WASTE MANAGEMENT: KEY PRACTICES IN MALAYSIAN PUBLIC HOSPITALS

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Date received: 06/02/2025 **Date revised:** 13/08/2025 **Date accepted:** 23/07/2026 **Date published:** 30/09/2026
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DOI: 10.33736/jcest.9001.2026

Abstract — Risk identification provides a comprehensive understanding that supports stakeholder engagement and informed project decision-making. In clinical waste management, effective risk identification is essential for achieving hospital objectives while preventing health hazards and environmental pollution associated with improper waste handling. Inappropriate risk identification practices may increase the risk of secondary disease transmission through exposure to infectious agents. This study investigates risk identification practices for clinical waste management in Malaysian public healthcare facilities. A qualitative approach was adopted using semi-structured interviews with facility managers responsible for risk identification. Four (4) public healthcare facilities were selected from each region of Malaysia, and the data were analysed using cross-case analysis and pattern matching. The study identified eight (8) key risk identification practices: understanding the regulatory framework, waste classification, emergency response planning, segregation and packaging, personal protective equipment (PPE), audits and inspections, training, awareness and education, and technology and innovation. The findings revealed that these practices were consistently implemented across the participating healthcare facilities, although differences were observed in respondents' understanding of the regulatory framework. Furthermore, the adoption of technology and innovation enhanced risk visualization and supported more effective risk identification. Effective risk identification also enables healthcare facilities to allocate resources more efficiently by prioritising high-risk areas requiring immediate attention. The novelty of this research lies not in identifying new individual risk identification practices but in integrating facilities management practices, regulatory requirements, and technology-based risk visualization to provide a comprehensive understanding of clinical waste risk identification in public healthcare facilities. This integrated perspective offers a more systematic approach to risk identification and serves as the empirical foundation for the subsequent development of an integrated risk identification framework. The study contributes to both theory and practice by extending the current understanding of clinical waste risk identification and providing practical guidance for facility managers to improve risk identification practices, strengthen regulatory compliance, and support efficient resource allocation. Future research should validate these findings across different healthcare settings and project contexts to support the development of a comprehensive risk identification framework.

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***Keywords*:** clinical waste management, facilities management, public healthcare facility, hospital risk management, risk identification

1.0 INTRODUCTION

The healthcare sector encompasses businesses that provide medical services, manufacture medical equipment or drugs, offer medical insurance, or otherwise facilitate the provision of healthcare to patients [1]. Good healthcare improves life quality and helps prevent diseases. The goals of Healthy People 2030 are to ensure that everyone has access to healthcare services and to enhance the quality of healthcare [2]. As a result, it has been established that risk identification plays a crucial role in helping organizations create plans and reduce harm [3].

The healthcare sector has a significant impact on the global population and is closely tied to the development of all countries [3]. Awareness of the Sustainable Development Goals (SDGs) varies widely. SDG 3 not only aims for measurable improvements in people's well-being, national economies, and the global environment, but also focuses on the means of achieving these improvements. It also seeks to create an environment of peace, security, and the

rule of law, as well as circumstances that promote inclusion and participation [4]. An effective approach to realizing SDG 3 is through the identification of risks in clinical waste management, which can provide a strong incentive for achieving multiple targeted goals [2].

Improper handling of clinical waste can lead to the spread of infectious diseases, harm to the environment (contaminating soil and water with dangerous substances), and potential injury to individuals through the improper disposal of sharp objects [5]. In response to public health and environmental concerns, the government of Malaysia has developed guidelines for the handling and management of clinical waste. It wasn't until 1980, following the emergence of HIV and AIDS, that a proper clinical waste management system was established in Malaysia [6]. The Ministry of Health of Malaysia (MOH) collaborated with the Department of Environment Malaysia (DOE) to revise policies and guidelines for controlling infectious diseases and handling clinical waste [7].

Varley et al. [7] emphasize the importance of managing clinical waste thoroughly and in a coordinated manner. Clinical waste management is an underfunded and underrecognized field, with serious consequences for employees, patients, and the community [8]. Resolving this issue could eliminate health risks for over half of the world's population. While there are variations in clinical waste management among hospitals, the areas of concern are common across all Facilities Management (FM) phases, including segregation, collection, packaging, storage, transport, treatment, and disposal [9]. FM plays a crucial role in identifying risks and must be well-versed in healthcare procedures due to the complex and regulated nature of the healthcare industry [10]. Efficient clinical waste management is essential to lower the risk of incidents, and it should be implemented across all sources of clinical waste production, regardless of size [8].

The failure to identify these risks poses indirect health hazards through the release of pathogens and toxic air pollutants into the environment. Department of Statistics Malaysia [11], suggested that the project team should thoroughly review program scope, cost estimates, schedule (including critical path evaluation), technical maturity, key performance parameters, performance challenges, supply-chain vulnerabilities, integration, interoperability, supportability, external and internal dependencies, implementation challenges, ability to handle threats, cost deviations, test event expectations, safety, security, and other factors to identify risks effectively. The greater the number of risks a project carries, the more diverse the approaches needed to address them [12]. To address this issue, many hospitals are enhancing their methods for identifying risks. FM is evolving beyond reliance solely on clinical champions for risk identification. FM professionals must possess the knowledge and skills needed to engage stakeholders and navigate the complexities of the process.

Risk identification in clinical waste management is one of the systems that can contribute to achieving SDG 3; it can act as a strong driver for achieving a wide range of specific targets of the goal. So, this study aims to investigate risk identification practices for clinical waste management at hospital facilities. The potential exists, therefore, to improve the risk identification process by identifying the areas that need improvement within current risk identification practices. To accomplish the government’s aspirations in moving towards more efficient clinical waste management and to support SDG 3 to ensure healthy lives and promote well-being for all ages and a better environment, there is an urgent need to improve the risk identification for clinical waste through the establishment of a good framework.

2.0 LITERATURE REVIEW

2.1 Clinical Waste Management

Clinical waste management processes need to adhere to the policy and legislation outlined in the Environmental Quality Act (Schedule Waste) 2005, as well as the standard operating procedure prepared by the Ministry of Health (MOH). In Malaysia, clinical waste generation has been reported to be up to 33,000 tonnes per year [13]. The rate of clinical waste generation varies for each healthcare facility, depending on factors such as the number of patients in care, the size, and the type of medical institution [14]. On average, Malaysia produces 1.9 kg of healthcare waste per bed per day, which is higher than the reported rates in Thailand, India, and China, but lower than in South America and Western Europe. Effective management of hospital material waste requires careful consideration of details such as generation and minimization, source separation and segregation, identification and labeling, handling and storage, safe transportation, treatment, and disposal of residues (including emissions).

Improper management can result in inadequate segregation and disposal of infectious waste, putting healthcare workers, waste handlers, and the public at risk of harmful pathogens. This increases the likelihood of diseases such as HIV, hepatitis, and other infections [14]. Mishandling of sharps, such as needles, blades, and other instruments, can cause injuries, leading to direct exposure to bloodborne pathogens. These incidents are common when sharps are improperly disposed of in regular waste bins or left in inaccessible areas. A common issue is the failure to properly segregate hazardous clinical waste from non-hazardous waste, resulting in all waste being treated as hazardous [15]. This increases disposal costs and the risks of exposure to infectious materials.

Poor management of clinical waste can lead to risks associated with environmental contamination. Improper incineration or burning of clinical waste can release toxic gases, such as dioxins, mercury, and other pollutants, contributing to air pollution and posing serious health risks to nearby populations [15]. Improper disposal methods, such as burying untreated waste or dumping it in open areas, can lead to the leaching of contaminants into soil and groundwater. This not only affects local ecosystems but also poses long-term risks to human health by contaminating drinking water sources. Poor clinical waste management practices can erode public trust in healthcare providers, as patients and communities expect healthcare facilities to maintain high standards of hygiene and safety [16]. This poses significant health risks to marginalized communities engaged in waste picking. Poor clinical waste management can contribute to the spread of infectious diseases within surrounding communities, especially in areas with inadequate clinical waste treatment and disposal infrastructure.

The lack of commitment from healthcare leadership to prioritize clinical waste management can lead to insufficient policy enforcement and resource allocation. When there is no accountability for failures in clinical waste management, mistakes are not properly addressed, leading to repeated errors and ongoing risks. FM plays a crucial role in identifying potential hazards in clinical waste management, particularly in healthcare environments where the safe handling, storage, and disposal of such waste are essential for ensuring safety and compliance [11]. Figure 1 shows the total and growth rate of clinical waste generation from 2020 to 2024. According to the Department of Statistics Malaysia [11], the quantity of clinical waste increased by 11.8 per cent in 2024 after two consecutive years of decline. It rose to 46.7 thousand metric tonnes from 41.8 thousand metric tonnes in 2023. The three states that generated the largest amount of clinical waste were Selangor (11.8 thousand metric tonnes), W.P. Kuala Lumpur (5.1 thousand metric tonnes), and Sarawak (5.0 thousand metric tonnes).

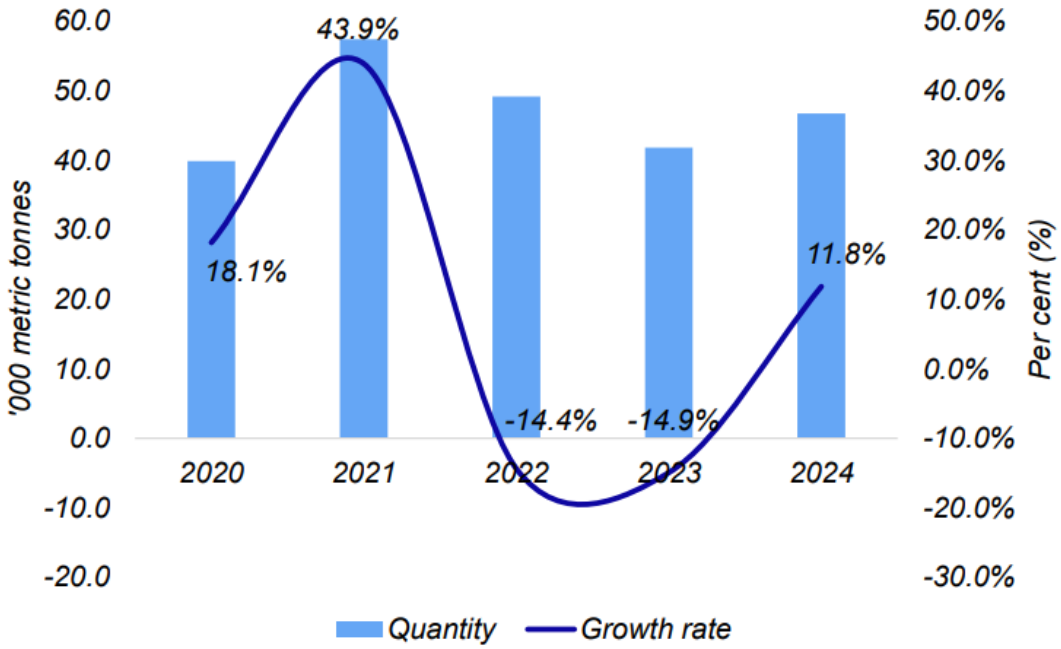


Figure 1 Total and growth rate of clinical waste, Malaysia 2020-2024 [11]

2.2 The Importance of Facilities Management in Managing Clinical Waste

In accordance with ISO 41001:2018, Facility Management is an organizational function that integrates people, places, and processes within the built environment. Its purpose is to improve the quality of life for people and the

productivity of the core business. In other words, FM is a tool used by individuals or building managers to ensure that buildings, people, and facilities work effectively to create a peaceful coexistence [10]. FM priorities encompass cleanliness, cost savings, employee safety, improved productivity, and customer satisfaction [10]. In the healthcare industry, FM plays a crucial role in ensuring the smooth and safe operation of the organization while maintaining a healthy environment [17]. FM is responsible for ensuring that clinical waste management practices comply with local, national, and international regulations, including those related to clinical waste segregation, treatment, and disposal. Miamiliotis and Talias [18] acknowledged that managing healthcare facilities is considered one of the most complex and challenging tasks due to the need for consistent delivery of effective service. Even the smallest mistake could lead to fatal consequences in the long term.

According to Amos et al. [10], proper clinical waste management practices can reduce the risk of accidents and injuries associated with handling sharps, chemicals, and other hazardous waste components. FM ensures that clinical waste is disposed of using safe and effective methods, such as autoclaving, incineration, or chemical treatment, depending on the type of waste [19]. By employing appropriate disposal methods, FM can develop and implement efficient clinical waste management processes that improve operational workflows and reduce waste handling time and costs. Effective management ensures that resources, including personnel, equipment, and budget, are allocated efficiently to support clinical waste management activities. The complexities of resource management, such as treating FM and properties as cost centers, have led to the neglect of this aspect of healthcare provision in many parts of the developing world [10]. These issues have resulted in an ineffective healthcare environment, leading to hospital-acquired illnesses [19]. Implementation of robust clinical waste management practices by FM can help protect health, minimize environmental impact, and manage costs, ultimately contributing to a safer and more sustainable healthcare environment.

2.3 The Importance of Risk Identification by Facilities Management

The goal of risk management is to proactively identify potential issues and take advantage of opportunities for the benefit of the business. By implementing risk identification practices and considering various potential risks and events beforehand, a business can save money and secure its future [20]. Effective risk identification allows a company to establish procedures to prevent potential threats, minimize their impact if they occur, and deal with the consequences [21]. When organizations can understand and manage risk, they are better equipped to make confident business decisions. Furthermore, adherence to strong corporate governance principles that emphasize risk identification and management can help organizations achieve their objectives. Identifying risks allows for a comprehensive understanding that can be used to influence stakeholders and improve project decisions. Good risk identification leads to effective project communication, which in turn leads to sound decisions [22].

Effective risk identification is crucial for any facility management team as it serves as the primary defense against unforeseen emergencies. Emergencies are inevitable, and organizations that plan effectively will recover more quickly and at a lower cost [1]. Key elements to include in risk identification for clinical waste management are commitment from all organizational levels, clearly defined policies and procedures for all staff, well-defined roles, responsibilities, and accountability for all staff, allocation of adequate resources and tools, ongoing training, testing, and monitoring in risk identification [1]. The benefits of effective risk identification include saving valuable resources such as time, income, assets, people, and property. It allows FM to prepare for unexpected events, mitigate risks, and associated costs before they occur [23]. Additionally, it creates a safe and secure environment for staff, visitors, and customers, reduces legal liability, increases operational stability, protects people and assets from harm, protects the environment, and reduces the threat of possible litigation [24].

2.4 The Practices of Risk Identification by Facilities Management

In Malaysia, regulations and guidelines govern the procedures for managing clinical waste in both private and public healthcare facilities. The Ministry of Health (MOH) and the Department of Environment (DOE) in Malaysia are responsible for creating and implementing these regulations. Identifying risks specific to clinical waste management involves understanding the regulatory framework. According to Hignett et al. [25], it is crucial to understand the regulatory framework for identifying risks in various industries, including clinical waste management. The regulatory framework provides the legal framework and rules for carrying out certain activities and is essential for recognizing and controlling the risks associated with those activities.

According to Hignett et al. [25], regulations often require FM to continuously monitor clinical waste management practices and identify emerging risks, adjusting their procedures accordingly. As noted by Amos et al. [10], the literature emphasizes the importance of proper waste classification and segregation at the source, highlighting the risks associated with improper segregation and the need for clear guidelines to categorize different types of clinical waste. Waste classification is crucial for effective risk identification in clinical waste management because it helps in systematically identifying, assessing, and mitigating the risks associated with different types of waste [10]. Healthcare workers are exposed to various dangers when handling clinical waste. Clear classification helps workers quickly identify high-risk materials, such as sharps or infectious waste, ensuring the workers use appropriate protective gear and follow safety protocols. By systematically identifying risks through waste classification, FM can create safer, more efficient, and more sustainable clinical waste management.

Kudoma [26] emphasized the importance of emergency response plans in FM. These plans are essential for handling incidents related to clinical waste management and for identifying potential hazards. In the event of a clinical waste emergency (e.g., exposure to infectious materials, chemical leaks, or radioactive contamination), response plans enable facilities to quickly identify risks to healthcare workers, patients, and the public. Kudoma [26] also highlighted the need to establish protocols to minimize harm to both people and the environment. In the case of an accidental release of hazardous waste, such as cytotoxic drugs or radioactive materials, emergency response plans ensure that the materials are contained and neutralized swiftly to reduce environmental impact. Additionally, Nazeer et al. [8] discussed the importance of using the right tools, such as personal protective equipment (PPE), to identify and mitigate risks associated with clinical waste management. PPE helps workers maintain a cautious approach when handling hazardous waste. It encourages proper segregation, safe handling, and disposal of waste, which is critical for identifying and mitigating risks such as contamination or injury.

Training in workplace settings has proven to be effective in improving workers' adherence to hepatitis B vaccinations and the use of personal protective equipment when handling clinical waste. This has led to a decrease in injuries from clinical waste [27]. Education programs help workers quickly identify high-risk materials, such as sharps, chemicals, or infectious waste, which require special handling and disposal methods. Early identification of these materials helps to mitigate potential risks before they escalate. Proper education on clinical waste handling reduces the risk of occupational hazards like needlestick injuries, chemical burns, or infections [27]. According to the Department of Statistics Malaysia [11], regular audits and inspections can help identify processes that expose employees to hazardous materials, settings that pose physical risks, or equipment that has been installed or maintained illegally. Regular audits and inspections allow FM to detect emerging risks in clinical waste management processes before leading to incidents. Audits provide a way to track whether a facility is consistently complying with clinical waste management protocols. Department of Statistics Malaysia [11] also highlighted that by comparing results from multiple inspections, facilities management can identify patterns of non-compliance or recurring risks that need to be addressed. The use of state-of-the-art technologies can lead to significant improvements and breakthroughs in various project risk management areas. It is also recognized that effective risk identification can be achieved through automated risk identification tools and sentiment analysis techniques to recognize potential risks and emerging trends. Haifete et al. [27] emphasized that technologies like Radio Frequency Identification (RFID) and barcoding systems enable real-time tracking of clinical waste from generation to disposal. This allows workers to monitor the movement and handling of clinical waste, ensuring that clinical waste is properly categorized, stored, and disposed of, reducing the risk of lost or improperly handled clinical waste [7]. By integrating modern tools and systems, FM can better identify and mitigate risks, ensuring safer waste management and reducing environmental impact.

3.0 METHODOLOGY

3.1 Data Collection

The methodology was based on a qualitative approach using semi-structured interviews conducted with facilities managers (FMs) to obtain in-depth information on risk identification practices for clinical waste management in public healthcare facilities. Qualitative research is a type of research that explores and offers deeper insights into real-world problems. The interview had three main sections. Section A determines the respondents' demographics; Section B focuses on general information on selected public healthcare facilities; and Section C examines respondents' opinions on risk identification practices for clinical waste management at the hospital. The targeted respondents are from FM organizations with risk management expertise. All interviewees were selected for their experience in risk identification of clinical waste in Malaysia and have more than seven (7) years of experience.

The analysis is based on cross-case analysis and pattern matching. According to Felo et al. [28], these methods can offer a better understanding of how selected public healthcare facilities address similar issues. This helps to identify best practices by determining consistent patterns and summarizing relevant investigation details.

The selected public healthcare facilities for this research is public hospitals. The case studies are divided into regions, namely the Northern Region, Central Region, Southern Region, and East Coast, with Hospital A, Hospital B, Hospital C, and Hospital D. The choice of public healthcare facilities is based on size and capacity, specialization, infrastructure complexity, and waste management practices. Hospitals of different sizes have been used to understand how risk identification practices might vary with facility size and capacity. The size and capacity of public healthcare facilities are significant factors contributing to challenges in identifying and managing clinical waste risks for facilities management (FM) teams. Larger hospitals with higher capacities tend to generate more complex waste streams, making it difficult to identify and assess the risks associated with hazardous materials. The increased volume and diversity of clinical waste types, along with the need for effective segregation and disposal processes, complicate risk identification. This requires enhanced monitoring and specialized procedures to maintain safety and compliance. The specialization of public healthcare facilities is also a key factor contributing to the challenges FM faces in identifying risks in clinical waste management. Specialized departments, such as oncology, surgery, or infectious diseases, generate specific and often hazardous waste that requires careful handling and disposal. This diversity of waste types, especially for clinical waste, makes it more difficult for FM to identify all potential risks, particularly in ensuring regulatory compliance, preventing contamination, and safeguarding healthcare workers and the public. Considering the infrastructure complexity in public healthcare facilities is another important factor. Older buildings may pose different challenges than newer ones. Complex infrastructure, including the layout, specialized clinical waste systems, and interconnected departments, can hinder efficient waste flow, increase the risk of mismanagement, and complicate the identification of potential hazards.

4.0 ANALYSIS AND DISCUSSION

This research adds to the existing body of knowledge on the subject. Skilled facilities managers collaborated on developing questions that would be used to collect the essential data for the study.

4.1 Respondents' Demographics

The sample characteristics of the interviewees can be shown in Table 1 below. The level of work experience for all respondents exceeds seven (7) years, and they are experts in risk identification in healthcare fields. All the respondents were involved in managing government and private hospitals. All of them had been involved in supervising risk identification, especially for clinical waste.

Table 1 Comparison of Case Studies

Practices of Risk Identification	Case Study 1 (Respondent 1)	Case Study 2 (Respondent 2)	Case Study 3 (Respondent 3)	Case Study 4 (Respondent 4)
Understanding Regulatory Framework	/	/	/	-
Waste Classification	/	/	/	/
Emergency Response Plans	/	/	/	/
Segregation and Packaging	/	/	/	/
Personal Protective Equipment (PPE)	/	/	/	/
Audits and Inspections	/	/	/	/
Training, Awareness & Education	/	/	/	/
Technology and Innovation	/	/	/	/

The respondents mentioned that larger hospitals produce large quantities of clinical waste on a daily basis, which includes infectious, chemical, and pharmaceutical waste. Proper segregation and packaging are essential to ensure that the waste is sorted correctly at the source, reducing the risk of mishandling and misidentification of hazardous waste. This makes it easier to identify risks because the waste is already categorized and labeled for easy monitoring. Segregated and properly packaged waste ensures that hospital infrastructure, such as waste chutes, storage areas, and transport routes, is used effectively for hospitals A, B, C, and D. According to all respondents,

complex hospitals with multiple departments can improve risk identification practices through segregation and packaging. Proper classification and labeling of waste allow for better coordination between departments and the FM team. FM can easily identify potential risks, such as overloaded storage areas or improper transport routes, and address these issues to maintain safety and efficiency. Lopatina et al.[29] also emphasized the importance of proper segregation of different types of clinical waste to identify risks related to incorrect segregation and packaging, which could lead to the spread of infections or other hazards.

All individuals surveyed agreed that implementing good practices in segregation, packaging, the use of proper personal protective equipment (PPE), and conducting audits and inspections can reduce the risk in clinical waste management for hospitals A, B, C, and D. In larger hospitals where the volume of clinical waste is high, PPE ensures that staff handling waste are protected from exposure to hazardous materials. Proper use of PPE allows for effective risk identification by ensuring that any issues related to clinical waste handling, such as spills or leaks, are promptly addressed without compromising staff safety. Additionally, proper PPE usage ensures that staff can safely handle and transport clinical waste within the hospital infrastructure. This includes managing clinical waste through designated routes, storage areas, and disposal facilities without risking exposure or contamination. In their study, Granikov et al. [30] concurred that in hospitals of varying sizes, infrastructures, and complexities, effective PPE practices help manage the diverse risks associated with clinical waste, from preventing contamination and exposure to ensuring consistent safety protocols across departments. This leads to a safer and more efficient clinical waste management system overall.

It is crucial to conduct audits and inspections as part of clinical waste management to identify and mitigate potential risks. According to the interview conducted, testees indicated that in larger hospitals, where clinical waste management operations are more extensive, regular audits and inspections help ensure that all areas of waste handling are thoroughly evaluated for hospitals A, B, C, and D. The contributors mentioned that hospitals with complex infrastructure benefit from audits and inspections by assessing the effectiveness of their waste handling systems, such as waste chutes, storage facilities, and transport routes. Effective audits help assess how well different departments coordinate their clinical waste management practices. For hospitals with multiple specialized units, inspections can reveal gaps in interdepartmental communication and collaboration, leading to improvements in how waste is handled and risks are managed across the facility. According to the Department of Statistics Malaysia [11], conducting audits and inspections as part of clinical waste management to identify and mitigate potential risks can help to ensure compliance with regulations, enhance safety protocols, and identify hazards associated with the handling, storage, and disposal of clinical waste.

The contributors mentioned that effective training, awareness, and education are crucial for improving risk identification practices in clinical waste management. In large hospitals, where diverse teams handle clinical waste across multiple departments, comprehensive training ensures that all staff understand and adhere to clinical waste management protocols. This uniformity helps in identifying risks consistently across the facility, reducing the likelihood of mishandling or non-compliance. All respondents agreed that proper training ensures that staff can effectively use and maintain clinical waste management infrastructure, such as waste disposal units, containment areas, and transport systems. This leads to better identification of risks related to infrastructure, such as malfunctions or inadequate capacity. The respondents mentioned that specialized training helps hospitals stay updated with changes in waste management regulations. Proper training enhances the ability to identify and address risks, improves compliance, and supports the efficient and safe management of clinical waste across various hospital settings. In Bernie [21] study, it is suggested to conduct regular training sessions for hospital staff involved in clinical waste management to ensure that the staff are aware of the risks associated with clinical waste and knowledgeable about the proper procedures for handling and disposal.

All survey respondents agreed that technology, such as automated waste tracking systems and waste sorting machines, can streamline clinical waste management processes in larger hospitals. The innovations help identify risks related to waste handling efficiency and reduce manual errors, improving overall safety and compliance for hospitals A, B, C, and D. Technology can enhance the design and functionality of clinical waste management infrastructure. Respondents also agreed that innovations such as smart waste bins that automatically sort and compact waste and advanced filtration systems for incinerators improve infrastructure efficiency and help identify risks associated with system malfunctions or inefficiencies. They mentioned that in hospitals with complex operations and specialized departments, technology can provide tailored solutions for different types of clinical waste. Haifete et al. [27] recognized that technology helps streamline clinical waste management processes, optimize infrastructure, and provide specialized solutions for different clinical waste types in hospitals of varying

sizes, infrastructures, and complexities. By enabling real-time monitoring, predictive analytics, and improved coordination, technology and innovation facilitate proactive risk identification and ensure a safer and more effective clinical waste management system. Exploring and adopting innovative technologies for clinical waste management and disposal in compliance with regulations is essential for identifying and managing risks associated with new technologies.

Through a combination of technology, staff training, improved infrastructure, regular audits, and sustainable practices, FM can identify and mitigate risks more effectively, ensuring safer environments for healthcare workers and the surrounding community.

5.0 CONCLUSION

Risk identification involves the systematic detection, assessment, and documentation of potential risks that may adversely affect organisational performance, quality, safety, environmental sustainability, and reputation. This study found that although facilities managers (FMs) generally adopted similar risk-identification practices for clinical waste management, there were variations in their understanding of the regulatory framework. Nevertheless, all respondents recognised that adopting new technologies and innovations could enhance risk visualization and support more effective decision-making. Regularly reviewing and updating clinical waste management policies in response to emerging risks, technological advancements, and regulatory changes can further strengthen risk identification practices and ensure compliance with industry standards and organisational requirements. The novelty of this study lies not in identifying new individual risk identification practices but in integrating facilities management practices, regulatory requirements, and technology-based risk visualization to provide a comprehensive understanding of clinical waste risk identification in public healthcare facilities. This integrated perspective offers a more systematic approach to risk identification and provides the empirical foundation for the future development of an integrated risk identification framework. This research contributes to both theory and practice by extending the current understanding of risk identification practices in facilities management for clinical waste management. The findings provide practical guidance for facilities managers to enhance risk identification practices, strengthen regulatory compliance, optimise resource allocation, and improve decision-making. Ultimately, these findings can support healthcare facilities in achieving safer, more efficient, and more sustainable clinical waste management. Future research should investigate the implementation of these risk identification practices across different healthcare settings and draw on project data to support the development and validation of a comprehensive risk identification framework.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

[1] Akpieyi, A., Tudor, T. L., & Dutra, C. (2015). The utilisation of risk-based frameworks for managing healthcare waste: A case study of the National Health Service in London. Safety Science, 72, 127-132. https://doi.org/10.1016/j.ssci.2014.08.014

[2] Hopkin, P. (2018). Fundamentals of risk management: understanding, evaluating and implementing effective risk management. Kogan Page Publishers.

[3] Lai, J., & Yuen, P. L. (2021). Identification, classification and shortlisting of performance indicators for hospital facilities management. Facilities, 39(1/2), 4-18. https://doi.org/10.1108/F-08-2019-0092

[4] Cernev, T., & Fenner, R. (2020). The importance of achieving foundational Sustainable Development Goals in reducing global risk. Futures, 115, 102492. https://doi.org/10.1016/j.futures.2019.102492

[5] Agamuthu, P., & Barasarathi, J. (2020). Clinical waste management under COVID-19 scenario in Malaysia. Waste Management & Research, 39(1_suppl), 18-26. https://doi.org/10.1177/0734242X20959701

[6] Ali, S. S., Ijaz, N., Aman, N., Nasir, A., Anjum, L., & Randhawa, I. A. (2017). Clinical waste management practices in District Faisalabad. Earth Sciences Pakistan, 1(2), 4-6. https://doi.org/10.26480/esp.02.2017.04.06

[7] Varley, P. R., Borrebach, J. D., Arya, S., Massarweh, N. N., Bilderback, A. L., Wisniewski, M. K., & Hall, D. E. (2021). Clinical utility of the risk analysis index as a prospective frailty screening tool within a multi-practice, multi-hospital integrated healthcare system. Annals of surgery, 274(6), e1230-e1237. https://doi.org/10.1097/SLA.0000000000003808

[8] Nazeer, S. F., Ramachandra, T., Gunatilake, S., & Senaratne, S. (2020). Emerging sustainable facilities management practices in health-care sector. Journal of Facilities Management, 18(1), 1-19. https://doi.org/10.1108/JFM-10-2019-0056

[9] Awodele, O., Adewoye, A. A., & Oparah, A. C. (2016). Assessment of medical waste management in seven hospitals in Lagos, Nigeria. BMC public health, 16(1), 1-11. https://doi.org/10.1186/s12889-016-2916-1

[10] Amos, D., Musa, Z. N., & Au-Yong, C. P. (2020). Modelling the performance of waste management services in Ghana's public hospitals: A facilities management perspective. Facilities, 38(9/10), 715-738. https://doi.org/10.1108/F-08-2019-0086

[11] Department of Statistics Malaysia (2025) 'Compendium of Environment Statistics', World Statistics Pocketbook (Ser. V), pp. 158–158. https://doi.org/10.18356/9789211071825c135

[12] Tabrizi, J. S., Saadati, M., Heydari, M., Rezapour, R., & Zamanpour, R. (2019). Medical waste management improvement in community health centers: an interventional study in Iran. Primary health care research & development, 20, e66. https://doi.org/10.1017/S1463423618000622

[13] Coronado, A. J., & Wong, T. L. (2014). Healthcare cybersecurity risk management: Keys to an effective plan. Biomedical instrumentation & technology, 48(s1), 26-30. https://doi.org/10.2345/0899-8205-48.s1.26

[14] Omar, D., Nazli, S. N., Subramaniam, A., & Karuppannan, L. (2012). Clinical waste management in district hospitals of Tumpat, Batu Pahat and Taiping. Procedia-Social and Behavioral Sciences, 68, 134-145. https://doi.org/10.1016/j.sbspro.2012.12.213

[15] Janik-Karpinska, E., Brancaleoni, R., Niemcewicz, M., Wojtas, W., Foco, M., Podogrocki, M., & Bijak, M. (2023). Healthcare waste—a serious problem for global health. In Healthcare, Vol. 11, No. 2, p. 242. MDPI. https://doi.org/10.3390/healthcare11020242

[16] Akkajit, P., Romin, H., & Assawadithalerd, M. (2020). Assessment of knowledge, attitude, and practice in respect of medical waste management among healthcare workers in clinics. Journal of environmental and public health, 2020(1), 8745472. https://doi.org/10.1155/2020/8745472

[17] Arampatzi, E., & Burger, M. (2020). Facility management services and employee well-being. Journal of Facilities Management, 18(2), 109-130. https://doi.org/10.1108/JFM-10-2019-0055

[18] Miamiliotis, A. S., & Talias, M. A. (2023). Healthcare workers' knowledge about the segregation process of infectious medical waste management in a hospital. In Healthcare, Vol. 12, No. 1, p. 94. MDPI. https://doi.org/10.3390/healthcare12010094

[19] Bieser, J., Kurzrock, B. M., & Batra, R. (2020). Risk management in facility management for data centres: status and deficits. Property Management, 38(2), 219-240. https://doi.org/10.1108/PM-11-2019-0068

[20] An, B., & Tang, S. (2020). Agency-level Incentives and Risk Management in Mandated Collaboration. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3627955

[21] Bernie Roseke, P. (2020). The Risk Planning Process. Project Engineer. Retrieved 21 November 2020, from https://www.projectengineer.net/the-risk-planning-process/#google_vignette.

[22] Kim, Y., Ku, M., & Oh, S. S. (2022). Public health emergency response coordination: putting the plan into practice. In COVID-19 (pp. 96-112). Routledge.

[23] Costa, M. C., Goumperis, T., Andersson, W., Badiola, J., Ooms, W., Pongolini, S., & Robinson, T. (2017). Risk identification in food safety: strategy and outcomes of the EFSA emerging risks exchange network (EREN), 2010–2014. Food Control, 73, 255- 264. https://doi.org/10.1016/j.foodcont.2016.04.045

[24] Farah, S., & Muneera, E. (2018). The Implementation of Risk Management Plan: Towards Safer Hillside Development Project. Malaysian Construction Research Journal (MCRJ), 3(Special Issue), 1-9

[25] Hignett, S., Wolf, L., Taylor, E., & Griffiths, P. (2015). Firefighting to innovation: using human factors and ergonomics to tackle slip, trip, and fall risks in hospitals. Human factors, 57(7), 1195-1207. https://doi.org/10.1177/0018720815593642

[26] Kudoma, B. (2019). An evaluation of clinical waste management in Gaborone city council healthcare facilities (Doctoral dissertation, University of South Africa).

[27] Haifete, A. N., Justus, A. H., & Iita, H. (2016). Knowledge, attitude and practice of healthcare workers on waste segregation at two public training hospitals. Eur J Pharm Med Res, 3(5), 674-689.

[28] Felo, L., Otero-Lobato, M., Geldhof, A., & Noël, W. (2019). Effectiveness of the golimumab educational program in ensuring healthcare professionals' awareness of risks described in the European risk management plan. Therapeutic Advances in Drug Safety, 10, 2042098619847420. https://doi.org/10.1177/2042098619847420

[29] Lopatina, K., Dokuchaev, V. A., & Maklachkova, V. V. (2021, October). Data Risks Identification in Healthcare Sensor Networks. In 2021 International Conference on Engineering Management of Communication and Technology (EMCTECH) (pp. 1-7). IEEE. https://doi.org/10.1109/EMCTECH53459.2021.9619178

[30] Granikov, V., Bouthillier, F., & Pluye, P. (2024). Exploring the factors and outcomes of collaborative information monitoring: Findings of a cross-case analysis. Journal of the Association for Information Science and Technology. https://doi.org/10.1002/asi.24887