ORIGINAL ARTICLES

Status of medical solid waste management at Phu Yen General Hospital in 2025 and several influencing factors

Nguyen Thuy Quynh[1], Ho Thi Manh Quoc[2], Tran Thi Thu Thuy[1*]

ABSTRACT

Objectives: The study aimed to assess the status of medical solid waste (MSW) management at Phu Yen General Hospital in 2025 and to identify key influencing factors to propose solutions for MSW management improvement.

Methods: A mixed-method study incorporating quantitative and qualitative components was conducted from December 2024 to October 2025. MSW management practices were directly observed across clinical departments, wards, and storage areas. In addition, nine in-depth interviews (IDIs) and two focus group discussions (FGDs) were conducted with healthcare workers and environmental management staff.

Results: MSW management at the hospital demonstrated high overall performance, with compliance rates ranging from 91.2% to 100%. Compliance rates were over 96.2% for collection, 90.4% for transportation, 94.4% for storage, and 91.2% for handover. Key influencing factors included the availability of comprehensive regulations and guidelines, reliance on manual supervision, uneven and limited training modalities, insufficient human resources and weak interdepartmental coordination, constrained funding, aging equipment, and suboptimal recycling practices which limited opportunities for cost reduction.

Conclusion: MSW management at the hospital complies with current regulations and demonstrates high effectiveness; however, gaps in infrastructure, supervision, staff capacity, and financial resources remain, particularly affecting hazardous waste segregation, transportation, and recycling. Strengthening human resources, applying information technology to monitoring and reporting, and enhancing regular inspections and targeted training are needed to improve efficiency, safety, and compliance.

Keywords: *Medical solid waste, waste management, hospital, infection control.*

INTRODUCTION

Medical solid waste (MSW) refers to waste generated during medical examination, diagnosis, treatment, and care activities, and includes both non-hazardous waste and hazardous waste with infectious, toxic, or sharp characteristics (1). In Viet Nam, the volume of MSW has increased steadily in parallel with the expansion of healthcare services and rising patient utilization. In 2023, the average amount of MSW generated nationwide was approximately 440.7 tons per day, of which hazardous waste accounted for 71.5 tons per day. The overall treatment rate reached about 95%, reflecting substantial efforts by the health sector to improve waste management systems (1).

Despite these achievements, the growing scale and intensity of medical services have resulted in an increasing burden of MSW generation. Inadequate management of MSW poses

Corresponding author: Tran Thi Thu Thuy
Email: tttt@huph.edu.vn
[1]Hanoi University of Public Health
[2]Phu Yen General Hospital

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significant risks to both public health and the environment. Improper segregation, collection, and handling of MSW can lead to occupational exposure among healthcare workers, increase the risk of infections and injuries from sharps, and contribute to environmental contamination of soil, water, and air. In particular, incidents involving sharp objects, improper storage, or illegal reuse of MSW significantly elevate the risk of disease transmission and environmental pollution (1). Therefore, strengthening MSW management remains an urgent and essential requirement for healthcare facilities, especially large hospitals with high patient volumes.

To address these risks, the Vietnamese Ministry of Health issued Circular No. 20/2021/TT-BYT, which provides comprehensive technical and procedural guidance for MSW management, including waste classification, collection, transportation, storage, and treatment (2). This regulation serves as a key legal framework to standardize MSW management practices across healthcare facilities and ensure compliance with safety and environmental protection requirements. Subsequent studies have shown that compliance with source segregation of municipal solid waste (MSW) was very high, ranging from 91% to 100% (3-5). The collection, transportation, storage, and treatment activities generally complied with regulations; however, in some hospitals, some mixing of waste categories was still observed, and there was no designated route for MSW transportation (3, 5). Positive factors in MSW include strong commitment from hospital leadership; a supportive policy and regulatory environment; well-invested infrastructure and adequately equipped facilities; and effective training, capacity-building, inspection, and supervision activities (3, 4).

Phu Yen General Hospital, a provincial Grade I hospital, generates approximately 996 kg of solid waste per day, including about 158.8 kg of hazardous waste. Although MSW management at the hospital has been implemented in accordance with Circular No. 20/2021/TT-BYT—covering segregation, collection, transportation, and treatment—implementation gaps remain in routine practice, particularly in timely and correct waste segregation and collection. These gaps may increase occupational exposure risks for healthcare workers and lead to avoidable inefficiencies and higher waste treatment costs. Despite the regulatory framework and the scale of waste generation, evidence on the real-world performance of MSW management systems at provincial hospitals in Viet Nam remains limited. To address this evidence gap, the study entitled *"Current Status of Medical Solid Waste Management at Phu Yen General Hospital in 2025 and Some Influencing Factors"* was conducted to assess the status of medical solid waste management at Phu Yen General Hospital in 2025 and to analyze selected factors influencing its implementation. By providing context-specific evidence from a high-volume provincial hospital, the study aims to inform targeted interventions to strengthen medical solid waste management, enhance occupational safety for healthcare workers, and improve the efficiency of hospital waste management systems.

METHODS

Study design

This study employed a mixed-methods design, integrating a cross-sectional quantitative component with qualitative inquiry. The quantitative phase was conducted first to assess the status of MSW management, followed by a qualitative phase to explore factors influencing its performance.

Study setting and period

The study was conducted from December 2024 to October 2025 at Phu Yen General

Hospital. Data collection took place from May to October 2025 across clinical and paraclinical departments, as well as at the centralized MSW storage and record-keeping areas of the hospital.

Study subjects and data collection

Quantitative component

The quantitative component was implemented through guided direct observation using standardized checklists to assess the hospital's MSW management activities. Observations focused on key stages of the waste management process, including waste segregation, collection, transportation, storage, and handover. The units of observation included healthcare workers responsible for each MSW management activities, waste containers and bags, equipment, facilities, waste storage areas, and relevant records and documentation related to MSW management practices within the hospital.

Qualitative component

The qualitative component involved purposively selected participants, including hospital leaders, head nurses, technicians, and staff responsible for MSW management. Data were collected through nine in-depth interviews and two focus group discussions using semi-structured interview guides. This approach enabled an in-depth exploration of perceived influencing factors, strengths, challenges, and proposed solutions for improving the effectiveness of MSW management at the hospital.

Sample size and sampling method

Quantitative research

Sample size

The quantitative component was conducted using direct observation in clinical and paraclinical departments and MSW storage areas, covering five activities of MSW management. Therefore, sample of each activity was determined as follows:

- MSW classification**:** The sample size for observing waste classification practices was calculated using the formula for estimating a proportion:

$$n = Z^2_{(1-\alpha/2)} \frac{p(1-p)}{d^2}$$

with Z = 1.96; p = 0.949; d = 0.05. The p value was derived from a study conducted by Pham Hoa Loi at An Giang Central Hospital (2014), which reported a correct MSW classification rate of 94.7% (4). Based on this calculation, the minimum required sample size was calculated as 76.8 observation. In the present study, all MSW bags and containers in the selected departments during the study period were included, resulting in a total of 341 observed units.

- MSW collection: A total of fifty-two collection events were observed, representing two collection rounds per department across twenty-six departments.

- MSW transportation: Fifty-two transportation trips were observed, corresponding to internal waste movement from departments to storage areas, two observations for each of twenty-six departments.

- MSW storage: Fifty-four storage observations were conducted, covering twenty-six temporary storage points and one central storage facility, with observations conducted twice daily.

- MSW Handover: A total of fifty-seven handover events were observed, comprising fifty-two internal handovers and five external handovers with licensed medical waste treatment contractors.

Qualitative research

Sample size and participants

The qualitative component included twenty-three participants (9 in-depth interviews

(IDI) and two focus group discussions (FGD) with fourteen participants) selected through purposive sampling. The in-depth interviews were conducted with infection control officers and head nurses or technicians from relevant departments. One focus group discussion involved seven nurses or technicians selected from seven departments, while the second focus group discussion included six orderlies, medical assistants, and waste collection staff directly involved in waste collection and transportation, along with one staff member from the centralized MSW storage facility.

Study variables

Quantitative component:

The quantitative study examined items related to five key stages of MSW management, including: waste segregation (8 items), collection (7 items), transportation (6 items), storage (7 items), and handover (5 items). All items were assessed as compliance or non-compliance.

Qualitative component:

The qualitative study explored factors influencing MSW management, focusing on three main domains: (1) management and governance, including the issuance of hospital policies and guidelines, inspection and supervision activities, and training for healthcare workers; (2) human resources, encompassing healthcare workers' knowledge of MSW management, attitudes and work practices, and inter-staff coordination; and (3) financial factors, including funding for waste treatment and investment in equipment and facilities supporting MSW management.

Data collection tools and methods

Quantitative data collection

Five standardized observation checklists were developed based on the requirements of Circular 20/2021/TT-BYT (2) and previous studies (3, 4), corresponding to the following stages: waste classification, collection, transportation, storage, and handover. Data were collected through direct observation at 26 departments and the centralized storage area. Waste segregation was observed at points of generation, including injection trolleys, procedure rooms, inpatient wards, and dressing stations, to assess compliance with regulations on color coding and waste categories. Observations were conducted twice daily during working hours when containers were near full capacity. Waste collection was observed from points of generation to temporary departmental storage areas, focusing on collection frequency and container conditions. Subsequently, internal transportation from departments to the central storage area was assessed with respect to timing, transport equipment, use of personal protective equipment, transport routes, and container safety. Storage practices at the central facility were evaluated based on location, hygiene, signage, waste segregation, and storage conditions. Finally, the handover process to licensed waste treatment contractors was observed, including documentation, record-keeping, and consistency between reported and actual waste quantities and composition at the time of scheduled collection. Participants were informed about the period of data collection but unaware of the time they were observed. Data collectors (infection control staff) integrated observation checklist administration with other of their routine tasks.

Qualitative data collection

Semi-structured IDI guides and FGD guides were used to collect qualitative data. These tools facilitated exploration of perceived strengths, challenges, influencing factors, and proposed solutions for improving MSW management.

Data processing and analysis

Quantitative analysis

Quantitative data were entered using EpiData version 3.1 and subsequently processed and analyzed using SPSS version 22.0. Descriptive statistical methods were applied to summarize compliance rates of MSW management practices following Circular 20/2021/TT-BYT (2).

Qualitative analysis

Qualitative data were transcribed, coded, and analyzed using thematic analysis. Content relevant to the study objectives was identified, categorized, and interpreted to complement and contextualize the quantitative findings.

Research ethics

The study was conducted in full compliance with ethical principles for research involving human participants. The research protocol was approved by the Ethics Committee of Hanoi University of Public Health under Decision No. 168/2025/YTCC-HD3 dated May 6, 2025. Approval for study implementation was also obtained from the Board of Directors of Phu Yen General Hospital.

RESULTS

Current status of medical solid waste segregation

MSW segregation

Table 1. Current status of MSW classification at Phu Yen General Hospital

No	Criteria	Total (N)	Compliance	
			n	%
1	MSW classification at the point of generation	341	331	97.1
2	Non-recyclable general waste is placed in blue bags or bins	159	151	95
3	Infectious waste without sharps is placed in yellow bags or bins that are properly lined and do not contain sharp objects	74	68	94.9
4	High-risk infectious waste is stored in containers lined with yellow bags and clearly designated for this waste category	4	4	100
5	Recyclable waste is segregated into white bags or bins	28	27	96.4
6	Non-infectious hazardous waste in solid form is collected in black bags or bins with appropriate lining	31	30	96.8
7	Anatomical waste is packaged in double yellow bags or placed in bins lined with yellow bags and clearly labeled “anatomical waste”	10	10	100
8	Infectious sharps waste is collected in puncture-resistant containers or boxes that are yellow in color to ensure safety during handling and disposal	35	34	97.1

Table 1 shows that the compliance rate for MSW classification at the point of generation ranged from 95% to 100%. Most departments adhered correctly to the color-coded segregation regulations. Compliance was highest for high-risk infectious waste and anatomical waste, both achieving 100%, while lower compliance rates were observed for general waste and non-sharp infectious waste (94.9%).

MSW collection

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Table 2. MSW collection activities (N = 52)

No.	Criteria	Compliance	
		n	%
1	Different types of MSW were collected separately and not mixed	51	98.1
2	MSW bins were color-coded, labeled, and have proper sorting instructions.	52	100
3	MSW containers were cleaned daily, are in good condition, leak-free, and undamaged.	52	100
4	The volume of MSW should not exceed the capacity of the bag, and the bag must be securely sealed to prevent leakage or spillage.	51	98.1
5	MSW were collected using specialized, clean, and intact equipment or vehicles that are dedicated exclusively to MSW handling	50	96.2
6	Waste collection should be conducted in accordance with designated routes, procedures, and locations within the hospital	51	98.1
7	The frequency of waste collection must comply with regulatory requirements, with a minimum of two collections per day	52	100

Table 2 indicates that MSW collection at the hospital was well implemented, with compliance rates ranging from 96.2% to 100%. Most criteria achieved full compliance; however, the availability and use of specialized collection equipment and vehicles recorded the lowest compliance rate (96.2%).

MSW transportation

Table 3. MSW transportation activities (N = 52)

No.	Criteria	Compliance	
		n	%
1	MSW was transported to the centralized storage area at least once per day	52	100
2	Transportation followed designated routes and avoided clean or patient-care areas	51	98.1
3	Waste was transported within the prescribed timeframe to prevent prolonged accumulation in departments	52	100
4	Transport vehicles or containers are equipped with tightly sealed lids to ensure safety and prevent leakage	50	96.2
5	Waste is transported without spillage, overfilling, or overflow from bins or containers	50	96.2
6	Transport vehicles are color-coded and clearly labeled according to waste type (e.g., yellow for infectious waste, black for non-infectious hazardous waste, and green for general waste)	47	90.4

Table 3 shows that MSW transportation at the hospital was well implemented, with compliance rates ranging from 90.4% to 100%. Most criteria achieved compliance levels of 96.2% or higher; however, correct color-coding and labeling of transport vehicles remained limited, with the lowest compliance rate observed for this criterion (90.4%).

MSW Storage

Table 4. MSW storage activities (N = 54)

No.	Criteria	Compliance	
		n	%
1	General MSW was stored separately from other waste categories	53	98.1
2	Infectious MSW was stored in a separate, designated area	54	100
3	Non-infectious hazardous MSW was stored separately in accordance with regulations	54	100
4	General MSW intended for recycling was stored separately	54	100
5	Waste storage bins were equipped with lids, were not overfilled, and prevented leakage or spillage, in compliance with regulations	53	98.1
6	MSW was stored within the prescribed time limits and under appropriate conditions as regulated	53	98.1
7	Storage areas were kept clean and well maintained, and regular cleaning and disinfection were performed to eliminate microorganisms and prevent contamination	51	94.4

Table 4 shows that MSW storage practices at the hospital were well maintained, with compliance rates ranging from 94.4% to 100%. Most criteria achieved compliance levels of 98.1% or higher; however, hygiene and disinfection of storage equipment recorded the lowest compliance rate (94.4%).

Handover of MSW

Table 5. Medical solid waste handover activities (N = 57)

No.	Criteria	Compliance	
		n	%
1	The quantity of each type of MSW was weighed and handed over in accordance with regulations	52	91.2
2	Handover records were fully completed and signed by all relevant parties as required	54	94.7
3	MSW was transferred to a licensed waste treatment unit with appropriate legal authorization	55	96.5
4	General MSW is handed over to licensed entities in compliance with regulatory requirements	56	98.2
5	All handover documentation is properly recorded and archived	55	96.5

Table 5 indicates that MSW handover activities at the hospital were implemented effectively. Most criteria demonstrated elevated levels of compliance with compliance rates ranging from 91.2% to 98.2%. However, the weighing and handover of each type of MSW recorded the lowest compliance rate (91.2%).

Several factors influencing the management of medical solid waste

Management and policy factors

Policy factors

Regulatory frameworks and strong leadership commitment emerged as key facilitators of MSW management at the hospital. National regulations provided a clear legal basis for implementation. In response, hospital leadership directed systematic implementation across departments, established and strengthened MSW management committees and infection control networks, and issued internal regulations and operational plans. The regulatory framework enabled the development of detailed procedures for MSW management as well as annual training and periodic inspections *"having clear legal documents allows us to conduct regular supervision and provide on-site guidance when non-compliance is identified"* (IDI_2).

Clinical and paraclinical staff consistently reported that national and hospital-level guidelines helped standardize daily practices, clarify staff responsibilities, and reduce operational errors. Participants highlighted that *"staff are able to follow each step from collection to reporting, which improves safety and minimizes mistakes"* (IDI_3), and that internal communication systems facilitated timely dissemination of guidance and feedback (IDI_5).

Nevertheless, several barriers were identified. Limited financial resources constrained training activities, monitoring, and improvements to storage infrastructure (PVS_4). In addition, participants noted that *"without regular supervision, compliance may decline, particularly among newly recruited staff who are not yet familiar with procedures"* (PVS_6).

Monitoring and supervision

Regular and supportive supervision was identified as a key mechanism for improving compliance with MSW management procedures. The hospital implemented systematic and routine supervision, primarily led by the Infection Control Department (ICD). Daily inspections across clinical departments and hospital premises, in coordination with the Nursing Department and the Administrative Office were organized, covering not only MSW management but also environmental hygiene, patient care, and infection prevention and control practices.

Supervision was described as constructive and educational rather than punitive. When non-compliance was identified, staff were guided on-site through a "hands-on" approach to correct errors in waste segregation, collection, transportation, and storage. *"We conduct daily inspections, and when departments do not comply, we provide immediate, hands-on guidance. Persistent non-compliance is formally reported for monthly performance classification"* (IDI_2). In parallel, transparent reward and penalty mechanisms were applied to reinforce accountability and motivation.

Nurses and orderlies acknowledged that frequent supervision created pressure but also promoted adherence. "*Daily inspections make us feel pressured, but they push us to follow procedures correctly. When mistakes happen during busy periods, on-site guidance helps us adjust immediately*" (FGD_1_6), "*continuous reminders force us to memorize and follow each step; although stressful, this prevents negligence*" (TLN_2_4).

Despite these strengths, several challenges were reported. High workload, particularly during night shifts and weekends, increased the likelihood of procedural lapses (TLN_1_2). In addition, supervision records were largely paper-based, limiting efficiency in data aggregation and long-term monitoring: "*The lack of a unified digital system makes supervision tracking time-consuming and manual*" (PVS_2).

Training

Regular training and refresher sessions were reported to help staff master procedures for sorting, collecting, and transporting MSW, thereby reducing occupational accidents and infection risks. As one participant noted, *"we received thorough training, so waste collection is safer"* (FGD_2). However, work pressure and time constraints sometimes limited staff participation and concentration, resulting in uneven training outcomes across departments.

Human resources

Human resource constraints, particularly shortages of nursing staff, combined with heavy workloads and limited incentives, directly affected the quality of MSW management. Participants reported that work overload can lead to misclassification, increasing the risk of injury for waste handlers. One waste collector shared, *"with so many patients… needles are often thrown into regular garbage bags, and we only discover them during collection, which is very dangerous"* (FGD_2). These findings highlight the critical role of adequate staffing and effective task allocation in ensuring safe waste management practices.

Financial and equipment factors

Limited funding under the hospital's financial autonomy mechanism was identified as a major barrier to investing in infrastructure, upgrading equipment, and sustaining MSW management activities. Hospital leaders noted that *"the annual cost of* MSW *treatment ranges from 1–2 billion VND, so we face many difficulties"* (IDI_1). Outdated collection equipment, inconsistent transport vehicles, and the large volume of heavy waste such as glass bottles further increase operational costs and labor demands.

Observations of 341 MSW bins and bags showed notable disparities and shortages in the availability of containers across departments and waste categories. While non-hazardous waste containers predominated, bins for infectious, hazardous, sharp, and recyclable waste were comparatively limited and unevenly distributed. This imbalance suggests inadequate infrastructure for effective waste segregation, which may undermine compliance with MSW management procedures.

DISCUSSION

The current management of medical solid waste in Phu Yen hospital

The study findings indicated that MSW management at the hospital achieved a high level of compliance across all stages of the management process. The high compliance rates for waste segregation reached over 95% was comparable to the findings of Pham Thi Loi (4) and substantially higher than those reported in several other studies (3, 5), although still lower than the 100% compliance observed by Pham Thi Kim Hue (6). Notably, high-risk waste groups, including highly infectious waste and anatomical waste, achieved 100% compliance. This result exceeds the levels reported in the WHO (2017) assessment for low- and middle-income countries (7) and is consistent with findings from several domestic studies (3-5), indicating strong institutional attention to waste categories posing the greatest health risks.

Collection and transportation activities also

demonstrated high compliance rates (≥96%), comparable to or markedly higher than those reported in previous studies (3-5). These results reflect effective organization and adherence to prescribed procedures. However, certain limitations persist, particularly regarding the adequacy and condition of collection vehicles, work overload among staff, and the occasional sharing of transport vehicles between waste types. These challenges are similar to those identified by Ly Vinh Trung (8), suggesting that resource constraints remain a common issue across facilities.

Waste storage practices were generally well implemented, with hazardous waste storage achieving full compliance (100%), in line with findings from other domestic studies (3, 4). Nevertheless, the study identified shortcomings in the routine cleaning and disinfection of storage containers, indicating an area requiring further attention to minimizing secondary contamination risks.

At the handover stage, overall compliance remained high; however, the weighing and recording of waste quantities were not consistently performed, resulting in lower compliance compared with the findings reported by Nguyen Tri Tue (9).

Overall, the results demonstrate that the hospital has achieved a higher level of compliance with MSW management than many other healthcare facilities. Nevertheless, further improvements in labor organization, equipment investment, and supervisory mechanisms are necessary to move toward full and sustainable compliance across all stages of MSW management.

Several factors influencing the management of medical solid waste

The study results indicate that MSW management is influenced by multiple groups of factors, most notably management and policy frameworks, human resources, and financial capacity. From a management perspective, the timely promulgation and effective implementation of Circular 20/2021/TT-BYT, together with a comprehensive system of internal regulations and clear assignment of responsibilities, have played a critical role in improving compliance. This finding is consistent with the results reported by Nguyen Tri Tue (2021) and Pham Thi Loi (2025) (4, 9). Regular inspection and supervision, particularly when combined with on-site guidance and immediate feedback, were found to be more effective in maintaining high and sustainable compliance than supervision models relying primarily on punitive measures (4, 9). In addition, regular training and refresher workshops that are closely linked to practical implementation have a direct and positive impact on improving waste classification and handling practices, in line with findings from other domestic studies (3, 4, 9).

Despite these strengths, human resource constraints remain a significant challenge. Overcrowding, high workload, staff performing dual or multiple responsibilities, and limited coordination between departments increase the likelihood of errors in waste segregation and handling. These challenges mirror those reported in previous studies (3, 9), suggesting that human resource shortages are a persistent systemic issue in hospital waste management.

From a financial perspective, although the hospital proactively allocated a substantial budget for MSW management (VND 3.66 billion in 2025), the financial autonomy mechanism and continuously rising waste treatment costs have placed considerable pressure on resource allocation. This finding is consistent with the assessments of Nguyen Tri Tue, Lam Thai Hung, and the World Health Organization, all of whom emphasize the critical role of sustainable and stable financing in ensuring effective and long-term MSW management systems (3, 7, 9).

Limitations of the study

Several limitations of this study should be considered when interpreting the findings. First, the investigators responsible for quantitative and qualitative data collection were infection control officers and hospital staff, which might introduce potential bias due to existing professional relationships with participants, as well as the possibility of altered behavior when healthcare workers were aware that they were being observed (Hawthorne Effect). Second, the study was conducted over a relatively short data collection period, reflecting the status of MSW management at the hospital at a specific point in time. Consequently, the findings may not fully capture variations in practices across different periods or workloads, and longer-term studies are needed to provide a more comprehensive assessment of MSW management dynamics.

CONCLUSION AND RECOMMENDATIONS

MSW management at the hospital generally complies with current regulations and demonstrates high overall effectiveness. However, persistent gaps in infrastructure, supervision systems, staff capacity, and financial resources continue to constrain optimal performance, particularly for hazardous waste segregation, transportation, and recycling.

To further improve MSW management efficiency, it is necessary to increase human resources, particularly nursing and support staff, and to apply information technology in monitoring, supervision, and reporting systems. Regular inspections and targeted training should be strengthened to enhance staff competencies and compliance awareness. In addition, all healthcare workers must strictly adhere requirements of waste segregation, handover, cleaning, and disinfection to ensure safety and sanitary.

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