

ORIGINAL ARTICLES

## Status of Medical Waste Segregation and Influencing Factors at Buon Ma Thuot City General Hospital, Dak Lak Province, in 2024

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### ABSTRACT

**Objective:** To assess the status of medical solid waste (MSW) segregation and identify influencing factors at Buon Ma Thuot City General Hospital, Dak Lak Province, in 2024.

**Methods:** A mixed-methods study was conducted, including quantitative direct observation of 190 waste bins across 14 departments and qualitative interviews with hospital leadership and healthcare personnel in 2024. Compliance was evaluated against 7 standard segregation criteria.

**Results:** Overall compliance with segregation at source was 92.11%. Full compliance (100%) was achieved for high-risk infectious waste and anatomical waste, while sharp waste segregation showed the lowest rate (64.52%). Key facilitators included the availability of formal procedures and internal training. Barriers involved lack of dedicated personnel, multitasking among staff, limited funding for equipment, degraded infrastructure, and nonspecific supervisory activities.

**Conclusions:** MSW segregation compliance at the hospital were generally adequate, especially for high-risk waste. However, low compliance in sharp waste handling and operational limitations highlight the need for targeted investments in infrastructure, staff training, and dedicated monitoring systems.

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

### INTRODUCTION

Medical solid waste (MSW) is generated from healthcare activities and includes general, hazardous non-infectious, and hazardous infectious waste (1). In 2023, hospitals in Vietnam generated about 440.7 tons/day of MSW, of which 71.5 tons were hazardous; approximately 95% was properly treated (1).

If inadequately managed, MSW poses severe health risks. Reuse of untreated waste may cause widespread infections, while handlers face injuries from sharps with exposure to HBV, HCV, HIV, and other pathogens. Improper burial can contaminate water sources, and

poorly managed disinfectants may transform into toxic chemicals harmful to humans and ecosystems (2–3).

MSW management includes segregation, collection, transport, storage, and treatment, with source segregation being the most critical step. Waste must be separated at the point of generation using safe, accessible containers. Typically, MSW is sorted into 4–6 groups: (i) infectious sharps (yellow puncture-proof); (ii) highly infectious waste (yellow liner bags); (iii) anatomical waste (double yellow liner bags); (iv) hazardous non-infectious waste (black-lined); (v) general non-recyclable waste (green-lined); and (vi) recyclable waste (white-lined) (3).



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Improper source segregation of MSW can cause hazardous waste to be mixed with general waste, disrupting downstream management and increasing treatment costs. More critically, untreated hazardous waste endangers community health. In Vietnam, MSW classification remains inadequate due to limited staff knowledge, insufficient facilities, and weak administrative oversight (4).

Buon Ma Thuot City General Hospital, a level II public hospital in a densely populated area, was originally designed for 150 beds but now operates 280. Each month, the hospital generates approximately 3,056 kg infectious waste, 1,200 kg recyclable waste, and 10,253 kg general waste (5). Overcrowding, rising waste volumes, and limited resources challenge effective management. Proper segregation is therefore essential to ensure compliance, reduce treatment costs, and optimize resource use. This study analyzes the status of MSW segregation and factors influencing practices at Buon Ma Thuot City General Hospital, Dak Lak Province, in 2024.

## METHODS

**Study Design:** This study employed a mixed-method design, integrating both quantitative and qualitative components. The quantitative research adopted a cross-sectional design, while the qualitative research utilized a phenomenological approach.

**Study site and time:** The study was conducted data in Buon Ma Thuot City General Hospital, Dak Lak Province from February and October 2024, with data collected from June to October 2024.

### Study Subjects

*Quantitative research:* Medical waste bins/bags were collected from all 14 clinical and paraclinical departments of the hospital, thereby representing the entire range of such departments within the facility

*Qualitative research:* Representatives of the

Board of Directors, heads of Infection Control, Surgery, Internal Medicine–Infectious Diseases, and Laboratory Departments, along with relevant clinical and paraclinical staff. Exclusion applied to those absent during data collection.

### Sample size and sampling method

*Quantitative research:* The sample size was calculated using the following formula:

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

In there: n: total required sample size;  $Z_{1-\alpha/2}$ : standard normal deviate for a 95% confidence level ( $Z = 1.96$ ); P: estimated compliance proportion as the percentage of waste bins/bags meeting the segregation criteria. The proportion of 0.667 from the study of Trung (6) was used; d: desired absolute precision = 0.07. According to this calculation, the required sample size was  $n = 174$ .

A total sampling method was applied, targeting all waste bins/bags in 11 clinical and 3 paraclinical departments of the hospital. In total, 190 waste bins were including: general medical waste, sharps infectious waste, non-sharp infectious waste—each stored in 4 to 6 types of color-coded bins/bags.

*Qualitative research:* A purposive sampling approach was employed to explore factors influencing MSW segregation practices among healthcare staff. The qualitative component included 4 in-depth interviews (IDIs) (Hospital leadership, Head of the Infection Control Department, Head of the Surgery Department, and Head of the Laboratory Department) and 3 focus group discussions (FGDs) (each involving six participants, including representatives from paraclinical departments, internal medicine departments, and other clinical units).

### Study variables and qualitative research topics

*Quantitative research:* MSW Segregation Indicators based on Circular No. 20/2021/TT-BYT, dated November, 2021 (3) : A total of 7 criteria were used to assess segregation

practices: (i) MSW segregated at the point of generation; (ii) Sharps infectious waste disposed into puncture-resistant yellow bins; (iii) High-risk infectious waste segregated into bins lined with yellow bags; (iv) AW disposed of in double yellow bags or bins with yellow liners; (v) Non-infectious hazardous waste segregated into black bags or bins with black liners; (vi) Non-recyclable general waste segregated into green bags or bins with green liners; (vii) Recyclable general waste segregated into white bags or bins with white liners. Each department was classified as “compliant” if all bins/bags observed during the survey met all seven criteria.

*Qualitative research:* The impact of following factors to the practice of MSW segregation, including: Policies, regulations, and standard operating procedures; Human resources (knowledge, attitude, and practice regarding MSW segregation; staff numbers; training and refresher courses); Infrastructure and financial resources; Monitoring, supervision, and waste management oversight.

### Tools and methods of data collection

*Quantitative research:* Waste bins/bags in clinical departments were observed both directly and via installed surveillance cameras at observation sites. The observation period was pre-scheduled and communicated to relevant departments in advance. Observations were conducted at the end of each work session (morning and afternoon, Monday to Friday), just before waste collection time, when the bins were expected to be full. In each observation, investigators examined all bins/bags in the department of seven criteria. Each was rated “compliant” or “non-compliant” with segregation standards. The checklist was developed based on the guidelines provided in Circular No. 20/2021/TT-BYT dated November 26, 2021 by the Ministry of Health, which regulates medical waste management within hospital premises (3).

*Qualitative research:* In-depth interviews (IDIs) were conducted by the research team in private offices of the participants, with each

session lasting between 30 to 40 minutes and three FGDs, each lasting approximately 40 to 50 minutes, following the FGD guide. IDI and FGD guides were developed to explore factors influencing MSW management.

**Processing and analyzing data:** Each completed checklist was cleaned, coded, and entered into Microsoft Excel for data management and analysis. IDIs and FGDs were audio-recorded and transcribed verbatim. The transcribed content was analyzed using thematic analysis. Representative quotes were selected to illustrate each key theme.

**Research ethics:** The study protocol was approved by the ethics committee of the University of Public Health under Decision No. 249/2024/YTCC-HD3, dated May 28, 2024.

## RESULTS

### Status of MSW Segregation

Among the 190 waste bins/bags observed in clinical and paraclinical departments, the distribution by color code was as follows: 52 yellow bins/bags, 52 green bins/bags, 32 white bags, 12 black bags, 11 containers lined with double yellow biohazard bags, and 31 puncture-proof bins. Yellow and green bins/bags were distributed relatively evenly across departments, with the highest numbers in Obstetrics (7 yellow, 7 green) and the Emergency Intensive Care Unit (6 yellow, 5 green). White bags were mainly found in Obstetrics (4), Outpatient (3), and other clinical departments (2–3 each). Black bags were fewer, with Radiology contributing the highest proportion (5, >40%). Containers lined with double yellow biohazard bags for infectious waste were concentrated in high-risk departments such as Obstetrics (3), Anesthesiology (2), Surgery (2), and Emergency (2). Puncture-proof sharps containers were present in most departments, with the highest counts in Laboratory (5), Surgery (4), and other procedure-intensive units

**Table 1. Compliance with Medical Waste Segregation: Equipment and Tools**

No.	Criteria	Assessment
1	Yellow plastic bags compliant with regulations	Compliant
2	Green plastic bags compliant with regulations	Compliant
3	Black plastic bags compliant with regulations	Compliant
4	White plastic bags compliant with regulations	Compliant
5	Yellow MSW bins compliant with regulations	Compliant
6	Green MSW bins compliant with regulations	Compliant
7	Black MSW bins compliant with regulations	Compliant
8	White MSW bins compliant with regulations	Compliant
9	Puncture-proof containers for sharps waste	Compliant
10	Color of puncture-proof containers compliant with regulations	Non-compliant

Table 1 indicates that all types of bags and bins used in the hospital met regulatory standards for MSW segregation, except

for the color compliance of puncture-proof sharps containers, which does not meet the specified requirement.

**Table 2. Compliance with MSW Segregation**

No Segregation Activity	Compliant	
	n	%
1 Yellow puncture-proof containers – Sharps only (n = 31)	20	64.52
2 Yellow containers (non-puncture-proof) – High-risk infectious waste only (n = 52)	52	100
3 Double yellow bags with proper labeling – Anatomical waste only (n = 11)	11	100
4 Green bins/bags – Non-recyclable general waste only (n = 52)	45	86.54
5 Black bins/bags – Non-infectious hazardous waste only (n = 12)	10	83.33
6 White bins/bags – Recyclable general waste only (n = 32)	25	78.13
7 All containers/bags observed – Waste correctly segregated at the point of generation (n = 190)	175	92.11

According to Table 2, the segregation of high-risk infectious waste and AW was fully compliant (100%). Overall compliance with correct segregation at the time of generation was high (92.11%). Lower compliance rates were observed for the segregation of non-recyclable general waste (86.54%), non-infectious hazardous waste (83.33%), and recyclable general waste (78.13%). The lowest compliance rate was the classification for sharps disposed in puncture-proof yellow containers (64.52%).

## Factors Affecting the Implementation of MSW Segregation

### *Policy, Regulation, and Procedure*

Based on governmental and Ministry of Health regulations, Buon Ma Thuot City General Hospital issued the Medical Solid Waste Management Procedure under Decision No. 1394/QĐ-BVTP dated December 13, 2022. The hospital also established an infection control network consisting of the Board of Directors,



department heads, and head nurses. Training sessions and implementation guidelines were developed, emphasizing the obligation of all healthcare workers to segregate medical solid waste (MSW). Clear regulations, supervision plans, and defined criteria enhanced leadership awareness, clarified responsibilities, supported regular training, financial allocation, and investment in waste management equipment. As one leader noted: *“Each year, our department develops a training plan... helping individuals and teams better understand their responsibilities in MSW management”* (IDI - 2).

### **Training Activities**

Training on MSW management is conducted annually, either by the provincial health department or the hospital’s Infection Control Department. Most staff reported post-training improved understanding and behaviors. However, errors such as misclassification between general and recyclable waste still occur. IDIs and FGDs revealed that training often prioritized clinical staff (doctors, nurses, midwives), while auxiliary staff (nursing aides, orderlies) – who are directly responsible for waste segregation and transport – received less attention. This gap negatively impacts overall MSW management: *“Every year, we send our head nurse and other staff to attend MSW management training sessions held externally or in-house”* (IDI - 3); *“Nursing aides directly handle key MSW processes but have received little training, leading to misclassification and inadequate compliance... They need focused training”* (IDI - 4).

### **Healthcare Workers**

While most healthcare workers (HCWs) demonstrated good knowledge and compliance with MSW segregation, a few showed inadequate awareness or failed to follow established protocols. Although training has been provided, improper segregation practices still occur. Additionally, MSW management is often an extra responsibility; most staff juggle clinical

duties alongside waste management. This multitasking affects both HCWs’ and patients’ adherence to segregation procedures

One participant shared:

*“We work all day on clinical tasks, receive patients, administer medications, and also have to constantly remind patients and caregivers to dispose of waste correctly”* (FGD – 3).

### **Facility and Financial Resources**

The Infection Control Department provided essential equipment, such as waste bins/bags, instructional signage, color-coded containers, gloves, and masks. However, equipment procurement was slow and bureaucratic, delaying replacements. One leader reported: *“Some large bins are old and cracked, but replacement is delayed due to the purchasing process”* (IDI – 2); *“At times, we ran out of supplies like garbage bags... even after submitting early requisitions, we had to pay out-of-pocket money to bridge the gap while waiting for procurement”* (IDI – 2).

Regarding funding, the hospital operates under autonomy level 2, and revenue primarily covers salaries. Other costs, such as costs for infrastructure upgrades, waste processing machines, and puncture-resistant containers, were provided by the Provincial Department of Health. Routine funding was only sufficient for basic consumables. This financial constraint affected MSW management: *“To save costs, we use hard plastic bins for sharps instead of puncture-proof paper containers. While they prevent injuries, they do not meet required color and labeling standards”* (FGD – 3).

Despite this, several challenges persist, such as deteriorated infrastructure and a substantial discrepancy between the original design capacity (150 beds) and current usage (280 beds). The increasing volume of waste requires significant infrastructure investments. However, the hospital operates under financial autonomy level 2, resources remain limited and primarily cover salaries and allowances.

## Monitoring and Supervision

Monitoring was conducted periodically, following the hospital's annual plan. This helped raise staff awareness; however, supervision was often integrated with broader internal inspections, rather than solely for MSW management. As a result, strengths and weaknesses at the department level were not clearly identified. One leader commented:

*“During inspections, we answer questions about both clinical work and waste management. We are too busy with clinical duties to fully present the difficulties we face in MSW management”* (IDI – 3).

Additionally, patient noncompliance remained an issue:

*“Patients often dispose waste at their convenience, ignoring our instructions or posted signs. Even after we explain proper segregation upon room admission, many still don't follow the guidelines”* (FGD – 3).

## DISCUSSION

### Status of MSW Segregation

In this study, the segregation rate was 92.11%, comparable to findings by Pham Ngoc Khanh (97.8%) (7), and Pham Thi Kim Hue (8) who reported 100% compliance, and higher than results from Ly Vinh Trung (66.67%) (6) and To Minh Hung (72.6%) (9). Proper segregation facilitates collection, transport, storage, and treatment, enhancing safety and cost-effectiveness. At this hospital, segregation is reinforced through training and supervision but full compliance has not been achieved, partly due to patient and caregiver behaviors and overcrowding. Lower compliance in inpatient wards further underscores their influence on segregation outcomes..

In this study, two criteria achieved 100% compliance: (i) infectious waste disposed of in

yellow-coded bags/containers and (ii) anatomical waste (AW) placed in double-layered yellow bags with appropriate labeling. These findings align with Pham Ngoc Khanh (2022) at the Military-Civilian Hospital of the Eastern Region, where AW disposal reached 100% and infectious waste segregation 98.3% (7), and with Nguyen Tri Tue at Ha Long General Hospital reporting 100% for both (10). Our compliance for infectious waste exceeded Pham Thi Kim Hue's result (84%) (8). These outcomes reflect institutional emphasis on safe management of high-risk waste, given its infection risks to staff, patients, and caregivers. However, the cost of processing such waste at this hospital is high (~24,913 VND/kg).

The lowest compliance was for sharps disposal into yellow puncture-resistant containers (64.52%), comparable to Pham Thi Kim Hue (66.6%) (8) but much lower than Pham Ngoc Khanh (98.9%) (7). Noncompliance often involved replacing standard containers with plastic jerry cans or makeshift bins to reduce costs. While these substitutes provide puncture protection, they fail to meet regulatory standards for color coding and labeling.

Regarding the segregation of recyclable general waste into white-coded containers, our compliance rate was 78.13%, similar to that reported by Ly Vinh Trung (6), Pham Thi Kim Hue (86%) (8). For non-recyclable general waste, our compliance rate was 86.54% though slightly lower than those reported by Pham Thi Kim Hue (94.1%) (8). The segregation of these two categories of general waste: recyclable and non-recyclable, was often overlooked. The two waste types were occasionally mixed, particularly in inpatient departments with higher volume of these types of waste, generated by patients and their caregivers. Hence, the effectiveness of MSW segregation also depends on patients' and caregivers' awareness and cooperation.

### Factors Affecting the Implementation of MSW Segregation

At Buon Ma Thuot City General Hospital,

regulations from the Board of Directors were promptly disseminated, facilitating staff awareness and improving MSW management. Nevertheless, full implementation of Circular No. 20 remains difficult, as some requirements are more suited to higher-tier hospitals; compliance with infrastructure and equipment standards is limited by financial and logistical constraints. Similar challenges were reported by Pham Thi Kim Hue (8). Healthcare personnel are central to all MSW management stages, with segregation at source being critical. However, effectiveness depends on staff knowledge, awareness, and coordination; gaps in these areas, coupled with heavy workload or weak accountability, can undermine outcomes. These findings are consistent with Vo Tuan Ngoc (11) and Pham Ngoc Khanh (7).

Infrastructure is another critical factor influencing waste segregation. The hospital was constructed over 20 years ago and has operated for 14 years, originally designed for 150 beds. Now, the hospital now accommodates 280 beds, leading to a significant rise in waste volume and greater demands on segregation points, bins, and bags. The limited space and insufficient number of appropriately placed containers increase the risk of waste being disposed into the wrong bins when existing ones are full.

The hospital's infrastructure is now severely outdated. There is no dedicated route for transporting MSW; staff must wait until after working hours or low-traffic periods to move waste, which can delay segregation or cause temporary mixing of waste types. Similar issues were reported by Pham Ngoc Khanh (7).

Financial constraints are a major obstacle. As a level-2 autonomous hospital, its primary income is from national health insurance services, which barely covers personnel salaries and allowances. Requests for additional segregation facilities, such as appropriately colored bins, bags, and designated segregation areas, must be submitted to the Department of Health. Limited funding restricts the hospital's ability to proactively

maintain and improve waste segregation practices. This challenge is echoed in studies by Ly Vinh Trung at Buon Ho General Hospital (6), Ho Thi Thanh Tu at Dong Thap Traditional Medicine Hospital (12), and the Ministry of Natural Resources and Environment (13).

At this hospital, inspections followed Circular No. 20 of the Ministry of Health (3), with oversight led by the Infection Control Department in coordination with Nursing and General Planning. However, limited staff meant supervision was integrated into general clinical oversight, reducing effectiveness; departmental strengths and weaknesses were not assessed, and compliance remained inconsistent. Similar issues were reported by Dinh Ngoc Bao Nam (2019) in Lam Dong (14), highlighting the need for more specific and ad-hoc inspections to promptly address non-compliance.

*Limitations of the research:* The observation schedule was pre-announced to departments, which may have triggered the Observer Effect and led to higher compliance rates than in routine practice. The qualitative findings may be influenced by social desirability bias, as some participants could have provided favorable responses to align with perceived expectations of hospital leadership. The single-hospital design limits the generalizability of the results to other settings with different resources, staffing, or waste management systems. The five-month data collection period may not fully capture seasonal or operational variations. Inspections during peak waste periods also limited the ability to assess segregation accuracy for waste at the bottom of containers. To reduce these impacts, the study incorporated surveillance camera review, minimized observer interference, and encouraged honest, practice-based responses during interviews.

## CONCLUSION

At Buon Ma Thuot City General Hospital, MSW was correctly segregated in 92.11% of cases,

with 100% compliance for highly infectious and anatomical waste. However, sharps segregation showed only 64.52% compliance, posing serious occupational and public health risks. Despite official guidelines, limited training, multitasking staff, outdated infrastructure, insufficient equipment, and non-targeted supervision reduced effectiveness. Sharps management requires priority attention alongside broader system improvements to ensure staff safety and regulatory compliance.

**Recommendation:** The hospital should establish a dedicated MSW transport route and ensure timely provision and maintenance of segregation supplies. Monitoring should include random weekly spot-checks, while auxiliary staff undergo mandatory annual recertification with practical skills testing. The Infection Control Department must advise leadership, conduct targeted supervision, and coordinate with clinical units to ensure compliance. Healthcare staff should engage in training, clarify unclear steps, and maintain accountability. In parallel, awareness campaigns for patients and caregivers are needed to support proper segregation.

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