Challenges in Handling Biomedical Waste at a Tertiary Care Hospital in Chennai: A Mixed Method Study

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ABSTRACT

Introduction: Biomedical waste (BMW) management is a critical aspect of hospital hygiene and infection control. Inadequate handling of such waste poses serious health risks to healthcare workers, patients, and the community. This study aimed to assess the compliance and challenges in biomedical waste management practices in a tertiary care hospital in Chennai.

Methods: A mixed-method study was conducted over six weeks using direct observation and key informant interviews. A structured checklist was used across 34 units, including ICUs, general wards, emergency, and labour wards. In-depth interviews were conducted with biomedical waste handlers, nursing officers, and hospital administrators, and thematic analysis was applied to qualitative data.

Results: Quantitative analysis revealed that 64.7% of the wards demonstrated good BMW management practices (score ≥25), 17.6% were average (score 20–24), and 17.6% were poor (score <20). Good compliance was observed in ICUs, while general wards, especially orthopaedics and paediatrics, had lower scores. Qualitative findings identified gaps such as lack of regular training, inadequate bin colour coding, and poor supervision as key challenges.

Discussion: Despite overall satisfactory compliance, inconsistencies in practices across departments highlight the need for standardized training, regular monitoring, and better infrastructure. Strengthening these areas can ensure safer and more efficient waste management aligned with national guidelines.

Keywords: Outpatient Services, Delay, Qualitative Observations, Patient Flow, Healthcare Delivery.

Introduction

Understanding and addressing the challenges in handling the bio medical waste in a health care setting a prime mandate for improving healthcare delivery. Biomedical waste (BMW), which is referred to as healthcare or clinical waste, comprises of all forms of waste that are generated during the diagnosis, treatment, or immunization of humans and animals. This also includes waste that are generated during the process of research activities and the production or testing of biologicals.[1] This waste may include infectious materials, sharps, pharmaceuticals, chemicals, and radioactive substances. The waste produced by the health facilities in the course of healthcare activities has a greater potential and probability to cause injury and infection to people than other type of waste. Of the total amount of waste generated by health-care activities, about 85% is general, non-hazardous waste.[2] The remaining 15% is considered hazardous material that may be infectious, toxic or radioactive.[2,3] Biomedical waste can be classified into several types based on its origin, composition, and potential risk. Infectious waste includes materials contaminated with blood, bodily fluids, or other infectious agents, such as used bandages, gloves, and swabs. Sharps refer to objects like needles, scalpels, and broken glass that can cause cuts or puncture wounds and pose a high risk of infection.[3] Pathological waste consists of human or animal tissues, organs, and body parts removed during surgery or autopsy. Pharmaceutical waste includes expired, unused, or contaminated medicines and vaccines, while chemical waste comprises discarded disinfectants, laboratory reagents, and solvents. Genotoxic waste, including cytotoxic drugs used in cancer treatment, is highly hazardous and requires special handling. Radioactive waste originates from medical procedures involving radioactive substances, such as nuclear medicine and radiotherapy.[4] lastly, non-hazardous general waste, though produced in healthcare settings, is similar to domestic waste and poses minimal risk if properly separated. Each type requires specific handling and disposal methods to minimize health and environmental risks.[5]

Thus, due to its hazardous nature, improper handling and disposal of biomedical waste can pose higher risks to public health, environmental safety, and the wellbeing of healthcare workers and waste handlers. Despite global guidelines and national regulations, challenges still persist in effective biomedical waste management. These include inadequate segregation at the source, lack of awareness and training among healthcare personnel, insufficient infrastructure, non-compliance with legal frameworks, and financial constraints.[6,7] The COVID-19 pandemic further amplified these challenges, highlighting vulnerabilities in waste management systems due to the surge in disposable protective gear and medical supplies. Addressing these issues requires coordinated efforts in policy enforcement, technology adoption, capacity building, and public education to ensure safe and sustainable biomedical waste management practices.[8,9] The present study aims to describe the current situation of infectious waste management practices among healthcare workers through direct observation in a tertiary care hospital in

Chennai district. In addition, it seeks to identify the underlying issues and barriers affecting effective infectious waste handling by conducting in-depth interviews with healthcare professionals and biomedical waste handlers.

Methodology

Study design:
A Mixed method study – An observational study coupled with a qualitative approach was employed in this study.

Study setting:
Tertiary care hospital in Chennai district, Tamil Nadu, India
Study population:
1. Healthcare workers (HCWs) involved in the generation, handling, and disposal of infectious waste (e.g., doctors, nurses, laboratory staff, housekeeping staff) in a tertiary care hospital in Chennai district.
2. Biomedical waste handlers working in the same hospital.
3. Hospital administrators and staffs involved in waste collection, storage and transport for in-depth interviews.

Inclusion criteria:
1. Healthcare workers and biomedical waste handlers with at least 6 months of work experience in the hospital.
2. Those directly involved in the generation, segregation, transportation, or disposal of infectious waste.
3. Professionals and waste handlers who consent to participate in observation or interviews.
4. For interviews: staff involved in administration, monitoring, or supervision of biomedical waste management.

Exclusion criteria:
1. Interns, trainees, or temporary staff with less than 6 months of experience.
2. Healthcare workers not involved in waste handling (e.g., administrative staff not part of waste management systems).
3. Individuals who refuse or are unavailable to participate during the study period.

Sampling method:
Purposive sampling technique
Study duration:
Six weeks of observation was done**.**
Study tool:
This study adopted a mixed-method approach to explore the challenges in handling biomedical waste at a tertiary care hospital in Chennai. The quantitative component involved direct, non-participant observations using a structured observation checklist to assess biomedical waste management practices across various hospital departments, including wards, laboratories, operation theatres, and waste storage areas. Direct observation and physical verification will be carried out, using WHO validated checklist for the processes of segregation, collection, storage and disposal of infectious waste.[2,3,10] Wards and ICUs of all departments in the hospital will be included for the study. The qualitative component employed the key informant interview method to gain deeper insights into the systemic, operational, and behavioral challenges faced in waste handling. Interviews were conducted with purposively selected staff including biomedical waste handlers, nursing officers, infection control personnel, and hospital administrators. Thematic analysis was used to identify recurrent patterns and perspectives regarding knowledge gaps, compliance issues, and institutional barriers. Ethical approval was obtained from the institution with an ethical clearance number 06/NOVEMBER/2023
Data collection:
Data were collected through non-participant direct observations using a structured checklist. Observations were carried out across various functional areas of the hospital, including general wards, ICUs, laboratories, operation theatres, and waste storage rooms. Each location was observed during peak activity hours to ensure reliability. Several observational sessions were conducted. Qualitative Component Key informants were purposively selected based on their roles and involvement in biomedical waste management. Participants included housekeeping and sanitation staff, nursing personnel, hospital administrators.

Data entry and analysis:
Quantitative Data:
The data collected through the direct observation checklist were entered into Microsoft Excel and exported to SPSS version 23 for analysis. Descriptive statistics such as frequencies, percentages, and means were used to summarize the compliance levels across various components of biomedical waste management, including segregation practices, colour coding, PPE usage, and storage protocols. Cross-tabulations were also performed to identify any patterns or departmental variations in compliance.
Scoring methodology:
To evaluate biomedical waste management practices across various hospital wards, a structured questionnaire consisting of 30 key parameters was utilized. These parameters spanned four main domains: the condition of waste receptacles, segregation of wastes, mutilation of recyclable waste, and disinfection of plastics and sharps. Each question was answered with a simple “Yes” or “No,” where a “Yes” response was awarded 1 point, indicating compliance with best practices, and a “No” response was given 0 points. Consequently, the highest possible score for any ward was 30, representing full adherence to all assessed criteria. The scores were then grouped into three categories to reflect the overall performance level of each ward in managing biomedical waste:

- Good: Score equal to or greater than 25
- Average: Score between 20 and 24
- Poor: Score below 20

This scoring system allowed for a straightforward and standardized comparison of waste management efficiency across different ward types.

Qualitative Data:
Interview transcripts from the key informant interviews were transcribed verbatim and analysed using thematic analysis. Key themes included lack of awareness, inadequate training, infrastructure limitations, and compliance challenge
After assessing the data from direct observation, staffs were interviewed to gain their perspectives on the above results. A total of five key informants were interviewed, representing the major ward categories: ICU staff, labor ward staff, emergency ward staff, general medicine ward staff, and general surgery ward staff. The interviews highlighted several important themes that helped explain the observed variations in biomedical waste management across different wards.

Results

Table 1: Distribution of Rooms across Wards

Category	**ard Type**	**o. of Rooms**
ICU	U	
Labor Ward	bor Room	
Emergency	nergency Ward	
General Wards	ale General Medicine	
	male General Medicine	
	Male Surgery	3
	Female Surgery	3
	Orthopaedics	2
	Paediatrics	2
	Trauma Ward	2
	Post-Operative Ward	2
Total		**34**

A total of 34 rooms from different ward types were evaluated. The labor ward had one room and the intensive care unit had six. Five rooms were given by the emergency ward. The majority of the rooms came from general wards, which included three rooms each for male and female surgery and four rooms each for male and female general medicine. Other general wards that donated two rooms each were Orthopaedics, pediatrics, trauma, and post-operative wards.

Table 2: Level of compliance to bio medical waste management practices among various wards

Ward Type	**Total Score**	**Category**
ICU	26	Good
Labor Ward	25	Good
Emergency	25	Good
Male General Med	26	Good
Female General Med	25	Good
Male Surgery	25	Good
Female Surgery	25	Good
Orthopaedics	21	Average
Paediatrics	23	Average
Trauma Ward	19	Poor
Post-Operative	18	Poor

The majority of wards had good compliance levels, according to the study. Labor, Emergency, Female General Medicine, and both surgical wards received scores of 25, all of which were classified as "Good," while the ICU and Male General Medicine received the highest scores (26). Pediatrics (23) and Orthopaedics (21) were categorized as "Average." Trauma Ward (19) and Post-Operative Ward (18), on the other hand, were classified as "Poor." Overall, the findings show that most wards have high compliance, with trauma and post-operative regions performing rather poorly.

Table 3: Key observations of the study

Ward type	Challenges noted	Recommendations
Labour Ward	Incomplete segregation of waste; lack of posters	Improve waste segregation practices; display guiding posters near bins
Emergency Ward	Limited availability of blue bins; poor mutilation of needles	Provide adequate blue bins; emphasize safe needle mutilation
Male General Med	Poor bin coverage; improper bag fitting; inadequate mutilation	Ensure bin covers and secure bag fitting; enforce safe mutilation protocols
Female General Med	Inadequate segregation; insufficient biohazard symbols	Strengthen segregation training; use clear biohazard labeling
Male Surgery	Lack of foot-operated covers; used needles often recapped	Increase foot-operated bins; reinforce needle safety practices
Female Surgery	Inconsistent use of disinfectant; improper mutilation	Regular disinfectant use; improve mutilation procedures
Orthopaedics	Low compliance in mutilation and segregation	Focus on training and supervision of waste handling
Paediatrics	Poor mutilation practices; lack of posters	Enhance awareness and display educational materials
Trauma Ward	Poor needle mutilation; lack of general waste bins	Improve needle mutilation and general waste segregation
Labour Ward	Incomplete segregation of waste; lack of posters	Improve waste segregation practices; display guiding posters near bins
Emergency Ward	Limited availability of blue bins; poor mutilation of needles	Provide adequate blue bins; emphasize safe needle mutilation

Many key informants from the ICU and Labor Ward emphasized that regular training sessions have played a crucial role in maintaining high standards of waste segregation and disposal. One staff member noted, “Most of our staff in the ICU and Labor ward have undergone regular training on biomedical waste segregation, which reflects in our good compliance scores.” This commitment to education was seen as a key factor behind the good category scores in these critical areas.

Resource availability was another commonly discussed point. Respondents from the Emergency and ICU wards reported consistent availability of color-coded bins and bags, which facilitated proper segregation. As one nurse mentioned, **“**We have all the required color-coded bins and bags available in the ICU and Emergency wards, which helps us maintain proper segregation**.”**

Regarding the physical conditions of waste receptacles, key informants highlighted that Labor Ward bins were often covered and foot-operated, minimizing contamination risks. **“**The bins in our labor room are always covered and foot-operated, reducing contamination risks,” remarked one staff nurse. Conversely, some general wards lacked such features, with bins sometimes uncovered or without foot pedals, which posed hygiene challenges.

When discussing waste segregation practices, informants from the Emergency Ward reported strict adherence, with proper placement of sharps and infectious waste. **“**In the Emergency ward, waste segregation is taken seriously. Sharps are always placed in the white bins, and infectious waste is properly handled,” stated an emergency room technician. On the other hand, wards such as Trauma and Post-Operative sometimes fell short, especially concerning mutilation of plastic waste like bottles and tubing. Staffs also candidly spoke about challenges they face. High patient loads and staff shortages were cited as major obstacles, particularly in general wards, affecting the consistent application of waste management protocols. One nurse shared, “Staff shortage and high patient load in general wards make strict adherence to waste protocols challenging.” Unsafe practices such as needle recapping were also mentioned as areas needing improvement: “Sometimes, lack of supervision leads to improper disposal of needles, like needles being recapped, which is unsafe,” explained a senior nurse.

Finally, informants offered recommendations to enhance biomedical waste management hospital-wide. Increased frequency of training sessions and stronger supervisory measures were frequently suggested. “We recommend increasing the frequency of training and providing more supervision to improve compliance, especially in general wards,” stated an in-charge nurse.

Discussion

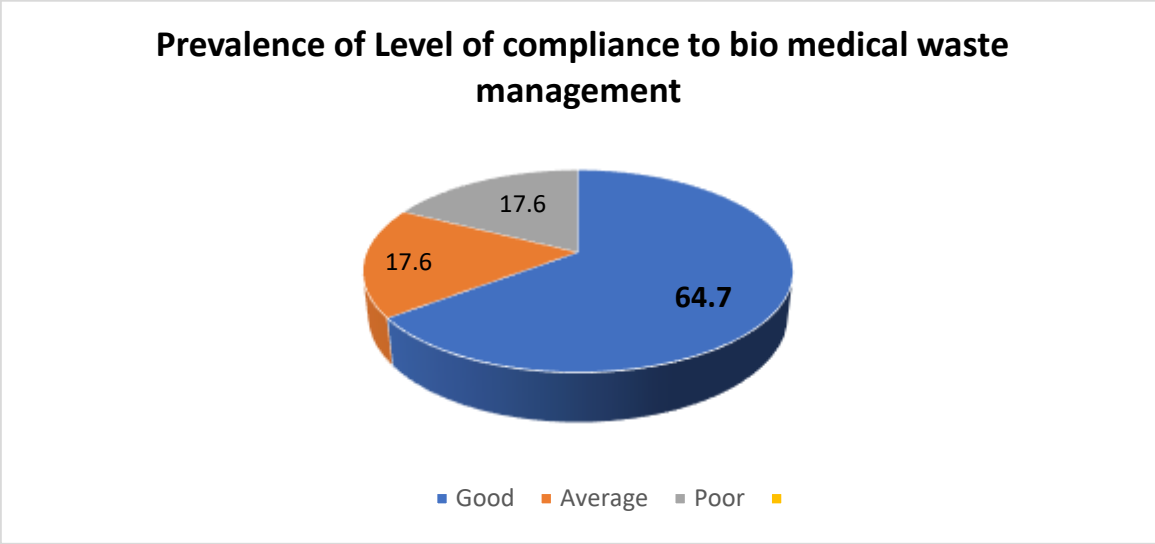
Quantitative:

The results obtained from the present study reveal that there is a relatively high degree of compliance among various departments regarding the handling of biomedical waste. However, there are some variations in

compliance between the different departments. For example, it was observed that departments like the ICU and the Male General Medicine were highly compliant, and this is attributable to their effective adherence to the existing guidelines, which may be associated with greater supervision and high levels of awareness within these departments.[11,12,17]

On the other hand, the poor compliance observed within Trauma and Post-Operative wards reflects problems that need to be addressed. For example, these wards frequently have high rates of patient turnover and are driven by emergencies, and these situations may result in difficulties in ensuring proper BMW segregation and disposal. The existing literature points to such factors as workload stress, staffing inadequacy, and lack of training as major contributors to BMW management deficiencies.[13,18]

Fig 1: Prevalence of Level of compliance to bio medical waste management practices among various wards



Qualitative:

1. Condition of Waste Receptacles

The availability and condition of waste receptacles varied by ward ICU and Labor wards consistently had white, yellow, and red color-coded bins, while blue bins were less common. Proper lining with matching colored bags was frequent in ICU and Labor but inconsistent in general wards. Secure bag fitting was typical in ICU but lacking elsewhere, risking leaks and contamination. Most bins were covered, but foot-operated covers were rare, raising infection control concerns. Biohazard symbols were usually on bags in ICU and general wards, but educational posters near bins were limited, indicating a lack of visual guidance for staff.[14,15]

2. Segregation of Wastes

Different wards used different waste sorting techniques. Good adherence was demonstrated by the ICU and labor units, which used the proper color-coded bins for the various waste categories. On the other hand, even though separate bins were available, general wards had inadequate waste segregation and frequently mixed garbage.[16] Inadequate segregation makes waste management more difficult and raises the risk of virus transmission, underscoring the need for focused interventions and training.[19]

3. Mutilation of Recyclable Waste

Major inconsistencies in the safe disposal and processing of recyclable garbage, particularly sharps, were found by the study. Unsafe behaviors including needle recapping and bending continued in multiple wards, increasing the danger to healthcare workers and waste handlers, even if ICU and labor wards demonstrated some compliance.Similarly, there was variable adherence to the correct cutting of spent plastic bottles and tubing, especially in general wards.[20] This emphasizes the necessity of enforcing mutilation procedures more strictly in order to guarantee biosafety.

4. Disinfection of Plastics and Sharps

ICU and labor wards had superior plastic and sharp object disinfection procedures than other wards. Blue containers were used infrequently, while red containers were used more frequently in the intensive care unit but less frequently in emergency and regular wards. Syringe barrel and plunger separation prior to disinfection was more common in emergency rooms and intensive care units,[21] but it wasn't always the case elsewhere. Disinfection procedures were inconsistent overall and require improvement.

5. Overall Compliance and Scoring

The evaluation showed that different wards handled biomedical waste differently. ICUs demonstrated "Good" compliance (≥25), indicating a high level of procedure adherence. The "Average" range (20–24) for labor and emergency wards indicated a reasonable level of compliance. The majority of general wards, on the other hand, received a score of less than 20 and was classified as "Poor." In total, 65% of wards had good compliance, 18% had average compliance, and 17.6% had low compliance. These results highlight the necessity of targeted enhancements in general wards.

6. Challenges Identified

Several challenges emerged from the study observations and key informant interviews:

- Foot-operated bins are not widely available or used, which raises the danger of contamination.

- Inadequate compliance with trash segregation procedures
- unsafe methods for disposing of sharp objects (recapping, bending, incomplete destruction)
- Absence of instructional signs or visual aids next to trash cans
- Problems with maintenance that result in broken or inadequate containers and bags

7. Recommendations

Based on the findings, several practical recommendations can improve biomedical waste management:

- Make sure all wards have a sufficient supply and utilize foot-operated bins.
- Provide frequent instruction on disposal, mutilation, and segregation procedures.
- Conduct regular supervisory audits and monitoring with comments.
- Put up legible educational posters next to waste pickup locations.
- Boost the upkeep and availability of bins, bags, and disinfectants
- Promote a culture of safety by offering rewards and removing obstacles for employees.

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