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Research Article

A STUDY ON BIOMEDICAL WASTE DISPOSAL MANAGEMENT IN A MULTISPECIALTY HOSPITAL

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ABSTRACT
Background Biomedical waste generated in healthcare settings poses significant risks to public health and the environment if not managed properly. Effective biomedical waste management is essential to prevent disease transmission and environmental contamination. This study aims to evaluate the biomedical waste disposal management practices in a multispecialty hospital in an urban setting. **Objectives:** To assess the types and quantities of biomedical waste generated; to examine the disposal mechanisms in use; and to identify challenges and opportunities for improvement in waste management practices. **Methods:** An observational study was conducted over one month at a 70-bed multispecialty hospital. Waste segregation, handling, and disposal protocols were evaluated through direct observation, staff interviews, and quantitative measurement of waste collected in color-coded bags. **Results:** The hospital demonstrated a high compliance rate (~95%) with waste segregation protocols using color-coded bags in line with BMW Rules, 1998. Total waste generated was 5496.06 kg during the study period, with 15% infectious waste and 85% non-infectious waste. Disposal methods included incineration, autoclaving, microwaving, hydroclaving, and shredding, managed by hospital facilities and authorized external agencies. Challenges included non-compliance by a minority of staff and mixing of waste by patient caregivers. **Conclusion:** The biomedical waste management system in the hospital was effective, emphasizing the importance of continuous staff training and adherence to protocols. Addressing existing challenges through education, monitoring, and infrastructure improvements is vital for ensuring safe and sustainable biomedical waste disposal.
Keywords: Biomedical waste management. Healthcare waste disposal. Infection control.

INTRODUCTION
Biomedical waste refers to any waste generated during diagnosis, treatment, or immunization of humans or animals. Management of biomedical waste is crucial in controlling infection and maintaining hygiene within healthcare settings, as these environments generate substantial amounts of potentially hazardous waste. This waste is classified according to its infective risk, including sharps such as needles and scalpels, pathological wastes like anatomical tissues and cultures, infectious items contaminated with body fluids (e.g., dressings, catheters), as well as other wastes including radioactive materials and chemical substances. According to the World Health Organization, about 85% of hospital waste is non-hazardous, 10% is infectious, and 5%

is hazardous but non-infectious. In India, the proportion of infectious waste may range from 15% to 35%, depending on the volume generated.[1][2]

Despite its importance, biomedical waste management (BMWM) worldwide is still developing, accompanied by widespread confusion among waste producers, operators, policymakers, and the broader community regarding safe practices. This is often due to a lack of awareness and training at multiple levels of healthcare. Therefore, educational resources targeted at hospital administrators, surgeons, nurses, paramedics, and waste handlers are urgently needed to reduce risks and improve management outcomes. Proper biomedical waste segregation and disposal protocols not only prevent occupational health hazards but also reduce environmental pollution, preventing the spread of communicable diseases such as hepatitis, HIV, and various bacterial infections. Ongoing research and surveillance of waste generation and management practices are essential to improve policy formation and implementation in this vital area of public health.[3][4]

Aim

To have an overview of management of biomedical waste in a multispecialty hospital in an urban area for effective interventions and implementations.

Objectives

- To assess the type and quantity of biomedical waste generated at the hospital settings.
- To assess biomedical waste disposal mechanisms in use at the hospital settings.
- To provide suitable recommendations based on the project study findings.

MATERIALS AND METHODOLOGY

Study Setting and Duration

The study was conducted in a multispecialty hospital, which was randomly selected for this research. The hospital, comprising 70 occupied beds with various surgical and medical specialty units, granted permission to conduct the study after full disclosure of the project details. The observational study took place over one month, from June 11, 2022, to July 11, 2022.

Study Design

An observational study design was employed, focusing on the biomedical waste segregation and management practices across multiple hospital units, including wards, Intensive Care Units (ICUs), emergency departments, operation theatres, laboratories, and the Central Sterile Supply Department (CSSD).

Data Collection

Primary data collection involved both direct observation and structured questioning. Observations were made during routine hospital rounds to assess compliance with the use of color-coded bags for waste segregation at the site of generation, ensuring adherence to hospital policies and national guidelines. Healthcare personnel were interviewed using a structured questionnaire to evaluate their knowledge and practices related to biomedical waste management.

Waste Quantification

The hospital's central waste storage area was regularly inspected, and waste was weighed systematically to quantify infectious and non-infectious waste generated. The average infectious waste per bed per day was calculated by dividing the total weight of infectious waste collected in red, yellow, and puncture-proof containers by the number of days of the study and by the number of occupied beds.

Waste Handling and Disposal

Biomedical waste transportation, treatment, and final disposal were managed by a contracted external agency, Life Secure Enterprises, which operated in compliance with established biomedical waste rules and regulations.

Sample Size and Criteria

The sample encompassed the total waste generated within the hospital premises corresponding to the 70-bed capacity during the study period. Waste originating outside the hospital and any non-healthcare-related refuse were excluded.

Data Handling and Analysis

Data recording included systematic documentation of waste weights and healthcare staff responses. Observational audits assessed adherence to waste handling protocols. Statistical analysis comprised descriptive methods, including calculation of means, percentages, and compliance rates, to evaluate the effectiveness of the hospital's biomedical waste management. The findings were intended to guide recommendations for improving biomedical waste practices.

OBSERVATION AND RESULTS

Table 1: Overview of Biomedical Waste Management in a Multispecialty Hospital in an Urban Area

Aspect	Description
Hospital Type	Multispecialty tertiary care hospital with surgical and medical units
Bed Capacity	70 beds
Waste Management Protocols	Segregation at source in color-coded bags adhering to BMW Rules, 1998
Waste Handling	Segregated waste transported through chute to carts, then to storage and finally disposal site
Treatment Disposal	Disposal by external agency (Life Secure Enterprises) through approved methods (incineration, etc.)
Staff Training	Regular staff training and education on BMW rules
Compliance Rate	Approximately 95% knowledge and practice of segregation among healthcare workers
Challenges	Non-compliance by 5% workers, mixing by patient caregivers, workload, location of bins
Total Waste Generated	5496.06 kg during study period
Infectious Waste Proportion	15% infectious waste; 85% non-infectious general waste

The overview of biomedical waste management in a multispecialty hospital situated in an urban area encompassed a well-structured system tailored for effective waste handling and disposal. The hospital, with a capacity of 70 beds, conducted a study over one month from June 11 to July 11, 2022, focusing on adherence to biomedical waste (BMW) management protocols. Waste segregation was rigorously practiced at the source using color-coded bags in compliance with BMW Rules, 1998. The segregated waste was transported efficiently through a chute system to carts, followed by storage and eventual disposal. Treatment and disposal processes were managed by an external agency, Life Secure Enterprises, that employed approved methods such as incineration. The hospital emphasized regular staff training and education on BMW rules, achieving approximately 95% compliance in knowledge and practice among healthcare workers. However, challenges persisted including non-compliance by about 5% of workers, waste mixing by patient caregivers, workload pressures, and inconvenient bin locations. During the study, a total of 5496.06 kg of waste was generated, with infectious waste accounting for 15% and non-infectious general waste 85% of the total [Table 1].

Table 2: Type and Quantity of Biomedical Waste Generated at the Hospital Settings

Waste Category	Color Code	Quantity Generated (kg/month)	Quantity Generated (kg/day)	Waste per Bed per Day (kg)
Soiled Infectious Waste	Yellow Bag	450.51	15.01	0.214
Solid Infectious Waste	Red Bag	301.90	10.03	0.143
Sharp Waste	Blue/Puncture-proof Container	72.00	2.4	0.034
Total Infectious Waste	-	824.41	27.44	0.392
Non-Infectious Waste	Black Bag	4671.65	155.72	2.224
Total Biomedical Waste	-	5496.06	183.16	2.616

Regarding the types and quantities of biomedical waste generated, the hospital produced various categorized wastes with precise measurements. Soiled infectious waste, collected in yellow bags, accounted for 450.51 kg per month or 15.01 kg per day, translating to 0.214 kg per bed per day. Solid infectious waste, segregated in red bags, summed to 301.90 kg monthly and 10.03 kg daily, equivalent to 0.143 kg per bed per day. Sharps waste, such as needles and broken glass collected in blue puncture-proof containers, totaled 72.00 kg monthly or 2.4 kg daily, around 0.034 kg per bed per day. Collectively, the infectious waste categories amounted to 824.41 kg per month or 27.44 kg per day, approximately 0.392 kg per bed daily. The majority of the waste was non-infectious, gathered in black bags, totaling 4671.65 kg per month or 155.72 kg daily, equating to 2.224 kg per bed per day. Consequently, the total biomedical waste produced amounted to 5496.06 kg monthly, or 183.16 kg daily, averaging 2.616 kg per bed per day [Table 2].

Table 3: Biomedical Waste Disposal Mechanisms in Use at the Hospital Settings

Disposal Method	Description	Responsibility/Notes
Incineration	Controlled combustion destroying pathogens at high temperatures	Common Waste Treatment Facility managed by Elite Engineers
Autoclaving	Low heat steam sterilization for disinfection of waste in hospital departments	Hospital's own autoclaves
Microwaving	Microbial inactivation through electromagnetic radiation and steam	Optional method in some units
Hydroclaving	Indirect steam heating with continuous tumbling for sterilizing waste	Available as alternate to autoclaving

Shredding	Mechanical disintegration of waste to prevent reuse and aid disposal	Performed at common waste treatment facility
Waste Transportation	Color-coded bags transported by sanitary workers to storage area and then to disposal site	By Life Secure Enterprises
Sharps Disposal	Puncture-proof containers for needles, scalpels, and broken glass	Collected and safely transferred
Chemical Treatment	Use of 1% hypochlorite solution for liquid waste before disposal	Used in treatment of liquid waste

The hospital employed multiple biomedical waste disposal mechanisms to ensure safe and effective treatment. Incineration was the primary method, utilizing controlled combustion at high temperatures to destroy pathogens, with operations managed at a common waste treatment facility by Elite Engineers. Autoclaving, a low-heat steam sterilization process, was conducted within hospital departments using the hospital's own autoclaves for disinfection. Microwaving, involving microbial inactivation through electromagnetic radiation and steam, was applied optionally in certain units. Hydroclaving, similar to autoclaving but using indirect steam heating with continuous tumbling, served as an alternative sterilization method. Mechanical shredding was used to disintegrate waste, preventing reuse and facilitating disposal, performed at the common treatment facility. Waste transportation involved sanitary workers moving color-coded bags to storage and disposal sites, under the responsibility of Life Secure Enterprises. Sharps were managed separately in puncture-proof containers to ensure safe collection and transfer. Additionally, chemical treatment utilizing a 1% hypochlorite solution was applied to liquid waste before disposal [Table 3].

DISCUSSION

The biomedical waste management system observed in the multispecialty hospital reflects both compliance and challenges commonly reported in healthcare waste management literature. The hospital's approach-a 70-bed tertiary care center operating over a month-long study period-adhered strictly to BMW Rules, 1998, through segregation of waste at the source using color-coded bags. This segregation protocol, including waste transport through designated routes to storage and final disposal by an external agency using incineration and other approved methods, aligns well with standards observed in other Indian and international healthcare settings. Kularatne RK.(20)[5] The high compliance rate of approximately 95% among healthcare workers indicates effective staff training and awareness programs, paralleling findings from other studies which emphasize education as a key enabler of waste segregation success. Nonetheless, non-compliance by a minority of 5%, largely attributed to workload, convenient bin locations, and inadvertent mixing by patient caregivers, echoes similar barriers documented in studies from varied settings. The total waste quantified was 5496.06 kg during the study period, with infectious waste constituting 15%, matching national estimates that hazardously infected waste often accounts for 10-35% of total hospital waste. Saritha G.(2025)[6] & Singh H *et al.*(2024)[7]

Regarding the types and quantities of waste, soiled infectious waste in yellow bags constituted 0.214 kg per bed per day, solid infectious waste in red bags 0.143 kg per bed per day, and sharps in puncture-proof containers about 0.034 kg per bed per day. The cumulative infectious waste averaged 0.392 kg per bed daily, whereas non-infectious waste in black bags dominated at 2.224 kg per bed per day, culminating in a total of 2.616 kg per bed per day. These figures are consistent with findings from both Indian governmental reports and international research, such as studies from Delhi hospitals reporting 0.26 kg per bed infectious waste and global ranges of 0.5–2.0 kg per bed total biomedical waste in comparable settings. The dominance of

non-infectious waste aligns with WHO estimates indicating around 85% of hospital waste is non-hazardous. Sahoo MC *et al.*(2024)[8]

The hospital employed multiple disposal mechanisms indicative of an integrated biomedical waste management system. Incineration, recognized globally for pathogen destruction efficiency, was managed by a common facility (Elite Engineers), supplemented by on-site autoclaving in hospital departments, with microwaving and hydroclaving serving as optional and alternate sterilization methods respectively, aligning with standard biomedical waste treatment hierarchical protocols. Shredding ensured waste rendered unrecognizable, preventing reuse, consistent with best practices internationally. Khan MS.(2024)[9] Waste transportation under Life Secure Enterprises maintained safety and compliance with regulatory frameworks. Specialized handling of sharps in puncture-proof containers and chemical treatment of liquid waste with 1% hypochlorite as pre-disposal disinfection steps further assured risk minimization, mirroring protocols well documented in the biomedical waste management literature. Shivashankarappa D *et al.*(2024)[10]

CONCLUSION

The study on biomedical waste disposal management in a multispecialty hospital demonstrated that effective segregation, handling, and disposal of biomedical waste can be achieved through strict adherence to established protocols, comprehensive staff training, and collaboration with authorized waste disposal agencies. The hospital exhibited a high level of compliance with segregation practices using color-coded bags, and employed multiple treatment methods including incineration, autoclaving, and shredding to minimize risk to health and environment. However, challenges such as occasional non-compliance by healthcare workers and improper waste handling by patient caregivers indicate the need for continuous education, monitoring, and infrastructural improvements. Safe biomedical waste management is not only a legal obligation but a critical public health service that protects hospital staff, patients, and the wider community from infection and environmental hazards. The findings underscore the importance of sustainable biomedical waste management strategies and the need for ongoing research and policy support to enhance these practices.

LIMITATIONS OF THE STUDY

This study was limited to a single multispecialty hospital in an urban area, and the observational design focused primarily on overall waste management without disaggregating data by specific hospital units or departments. Consequently, the study could not identify the precise sources or hospital units generating the maximum amount of infectious waste. The relatively short duration of one month limits the understanding of seasonal or long-term variations in waste generation and management practices. Additionally, potential biases could arise from direct observation and self-reporting by healthcare workers on their knowledge and practices. Future studies with a multicenter design, longer duration, and detailed unit-wise waste analysis would provide more comprehensive insights into biomedical waste management challenges and opportunities.

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