Section: Hospital Management

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# IMPACT OF HOSPITAL ACCREDITATION ON BIO MEDICAL WASTE MANAGEMENT: COMPLIANCE, OCCUPATIONAL SAFETY, AND ENVIRONMENTAL PERFORMANCE IN A TERTIARY CARE HOSPITAL

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## ABSTRACT

**Background:** Biomedical waste poses direct risks to patient safety, healthcare workers, and the environment. While the Bio-Medical Waste Management Rules 2016 strengthened regulations in India, compliance gaps remain. Accreditation is promoted as a quality driver, yet evidence on its impact on waste management and environmental safety is limited. The aim is to assess how accreditation-driven quality assurance systems influence biomedical waste management practices, occupational safety, and regulatory compliance in a tertiary care hospital. The objective is to assess compliance with biomedical waste segregation practices at the point of waste generation and adherence to color coded BMW protocols. To assess staff training coverage and competency in biomedical waste management practice. To evaluate the effectiveness of internal audits and the implementation of corrective and preventive actions.

**Material and Methods:** A hospital-based cross-sectional study was conducted over six months in a 500-bed accredited teaching hospital. We included 325 healthcare workers involved in waste handling. Compliance with segregation, color-coding, training, PPE use, waste generation, and regulatory standards was measured through direct observation, audits, and record review. Chi-square tests compared observed rates with 90% benchmark standards.

**Results:** Among the 325 Healthcare workers, 319 (98.15%) Healthcare workers were covered in the training and 297 (91.38%) were covered in refresher training. Segregation compliance was observed in 313 (96.30%), color-coding in 308 (94.76%), and bin labelling in 304 (93.53%). PPE compliance was observed in 303 (93.23%) and Hepatitis-B vaccination in 310 (95.4%). Mean waste generation was 1.82 kg/bed/day. Collection within 24 hours occurred for 317 (97.5%) of waste and disposal within 48 hours for 100%. Needle-stick injuries were low at 2.1 per 100 workers/year with 100% investigation. SOP compliance was 95.2% and regulatory compliance 97.3%. All indicators significantly exceeded benchmark levels and were higher than previously reported studies.

**Conclusion:** Accreditation-driven quality systems were associated with high compliance across biomedical waste management domains. Strong training, audit, and safety practices likely underpin these outcomes. The findings support integrating structured quality assurance into routine waste management to improve environmental safety and regulatory adherence.

**Keywords:** Biomedical Waste Management, Medical Waste Disposal, Healthcare Waste Management, Hospital Accreditation, Quality Assurance, and Health Care.

# INTRODUCTION

Biomedical waste management (BMWM) is an essential component of modern healthcare systems because of its significant impact on patient safety, occupational health, environmental sustainability, and regulatory compliance. Healthcare facilities generate a wide range of hazardous and non-hazardous wastes, including infectious materials, pathological waste, sharps, pharmaceutical residues, microbiological waste, and chemical by-products. Improper segregation, handling, transportation, treatment, and disposal of biomedical waste can lead to the spread of infectious diseases, environmental contamination, and increased healthcare costs. Consequently, effective biomedical waste management is recognized as a fundamental element of quality healthcare delivery and public health protection.[1]

The World Health Organization has highlighted the risks associated with healthcare waste when it is not managed appropriately. Exposure to contaminated sharps and infectious waste can result in the transmission of blood-borne pathogens such as hepatitis B virus, hepatitis C virus, and human immunodeficiency virus. In addition, improper disposal practices contribute to soil, water, and air pollution, posing long-term threats to environmental and public health.[2]

In India, biomedical waste management has undergone substantial improvement following the implementation of the Bio-Medical Waste Management Rules, 2016. These regulations introduced stringent requirements related to waste segregation, color-coding, barcoding, transportation, treatment, disposal, and occupational safety. The objective of these rules is to ensure environmentally sound waste management practices while promoting accountability and regulatory compliance among healthcare institutions.[3,4]

Effective biomedical waste management is increasingly regarded as a key indicator of healthcare quality. Accreditation and quality assurance frameworks incorporate biomedical waste management standards because of their close association with infection prevention, patient safety, risk management, and environmental stewardship. Healthcare institutions are expected to establish written policies, standard operating procedures (SOPs), staff training programs, monitoring indicators, audit mechanisms, and corrective and preventive action (CAPA) systems to facilitate continuous quality improvement.[3,4]

The success of biomedical waste management programs depends largely on the knowledge, attitude, and practices of healthcare workers. Studies have shown that inadequate awareness regarding waste categories, segregation procedures, color-coding systems, and disposal protocols contributes significantly to non-compliance. Regular educational interventions and structured training programs have been demonstrated to improve staff competency and adherence to biomedical waste management guidelines.[1,5,6]

Segregation of biomedical waste at the point of generation remains the cornerstone of effective waste management. Proper segregation minimizes the volume of hazardous waste requiring specialized treatment, reduces environmental burden, and lowers operational costs. Research has consistently shown that staff sensitization, periodic monitoring, and institutional quality initiatives significantly enhance segregation compliance and overall waste management performance.[7,8]

Occupational safety is another critical aspect of biomedical waste management. Healthcare workers involved in waste handling are exposed to risks such as sharps injuries, infectious materials, and chemical hazards. The use of personal protective equipment (PPE), hepatitis B vaccination, safe waste-handling practices, and incident reporting systems are essential measures for protecting healthcare personnel. Quality assurance and accreditation programs reinforce these practices through regular assessments and compliance monitoring.[2,5,9]

Clinical audits and internal quality assessments have emerged as valuable tools for evaluating biomedical waste management practices. These assessments help identify deficiencies in segregation, documentation, staff compliance, and adherence to regulatory requirements, enabling timely corrective actions. Hospitals implementing structured audit programs generally demonstrate higher compliance rates and better waste management outcomes than institutions lacking systematic monitoring mechanisms.[10,11]

Recent studies conducted in tertiary care hospitals have reported that accreditation-driven quality initiatives contribute to improved staff awareness, better segregation practices, enhanced regulatory compliance, and stronger documentation systems. Continuous quality improvement strategies, including competency-based training, internal audits, performance monitoring, and CAPA implementation, have been associated with measurable improvements in environmental safety and occupational health outcomes.[12,13]

Despite considerable progress in biomedical waste management, several challenges remain. Segregation errors, inconsistent staff training, documentation deficiencies, occupational injuries, and variability in compliance continue to be reported across healthcare settings. Furthermore, limited evidence is available regarding the long-term effectiveness of accreditation-driven quality assurance systems in achieving sustained environmental safety and regulatory compliance. Understanding the contribution of these systems is essential for strengthening institutional quality frameworks and optimizing biomedical waste management practices.[13,14]

Therefore, the present study was undertaken to assess the effectiveness of accreditation-driven quality assurance systems in biomedical waste management

and to evaluate their impact on environmental safety and regulatory compliance in a tertiary care hospital.

## MATERIAL AND METHODS

**Study Design:** Hospital-based cross-sectional observational study.
**Setting:** 500-bed tertiary care teaching hospital with an established biomedical waste management and quality assurance system.
**Duration:** December 2025 to May 2026.
**Participants:** 325 healthcare workers involved in waste generation, segregation, handling, and disposal. Nurses formed the largest group at 43.7%.
**Inclusion**
Staff employed >6 months and involved in biomedical waste activities.
**Exclusion**
New recruits <6 months, those on long leave, or unwilling to participate.
**Variables:** We measured segregation compliance, color-coding adherence, waste generation rate, training coverage, PPE use, needle-stick injuries, SOP compliance, internal audits, regulatory compliance, and CAPA closure.
**Data Collection**
Direct observation using structured audit checklists, review of waste registers, training records, incident reports, and accreditation documents.
**Analysis**
Data entered in Excel and analyzed with SPSS v26. Frequencies, percentages, means, SDs reported. Chi-square test compared observed rates with 90% benchmark. $p<0.05$ was significant.

## RESULTS

Segregation compliance was 96.4%, color-coding 94.8%, and bin labelling 93.5%. All exceeded the 90% benchmark. Training coverage was 98.1% and refresher training 91.4%. PPE compliance reached 93.7% and Hepatitis-B vaccination 95.4%. Waste generation averaged 1.82 kg/bed/day. Collection within 24 hours was 97.5% and disposal within 48 hours was 100%. Needle-stick injuries were low at 2.1 per 100 workers/year, with 100% of incidents investigated. SOP compliance was 95.2% and regulatory compliance 97.3%. Compared with prior studies, this hospital showed higher compliance across segregation, training, PPE, and regulatory indicators.

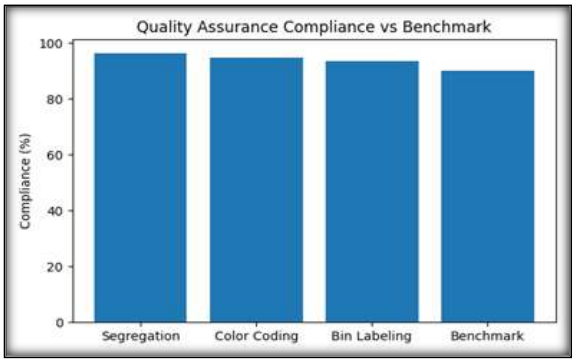


**Figure 1: Quality Assurance Compliance Compared with Benchmark Standards**

The chart demonstrates that segregation compliance (96.4%), color-coding compliance (94.8%), and bin-labelling compliance (93.5%) were all higher than the benchmark standard of 90%. These findings indicate excellent adherence to biomedical waste management protocols and reflect the effectiveness of the institution's quality assurance and accreditation-driven monitoring systems.

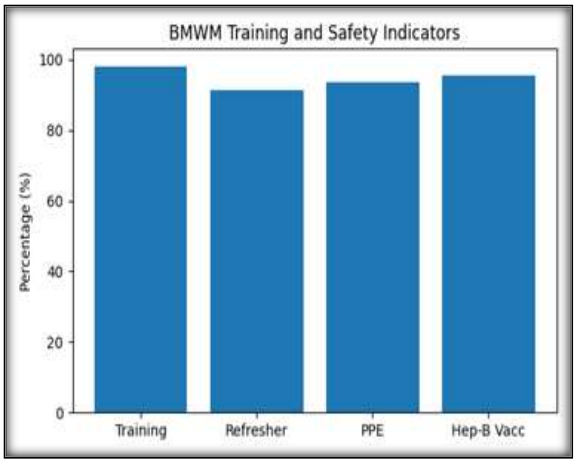


**Figure 2. Training and Occupational Safety Indicators in Biomedical Waste Management**

The chart shows that training coverage (98.1%), refresher training attendance (91.4%), PPE compliance (93.7%), and Hepatitis-B vaccination coverage (95.4%) were consistently high among healthcare workers. These results suggest that regular training programs and occupational safety initiatives have significantly contributed to strengthening biomedical waste management practices.

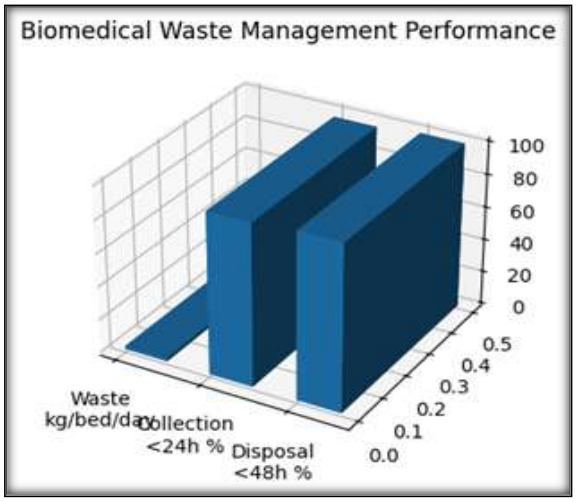


**Figure 3. Biomedical Waste Collection and Disposal Compliance**

The chart illustrates that 97.5% of biomedical waste was collected within 24 hours and 100% was disposed of within 48 hours as per regulatory requirements. These findings reflect efficient waste handling processes and demonstrate compliance with prescribed biomedical waste management standards.

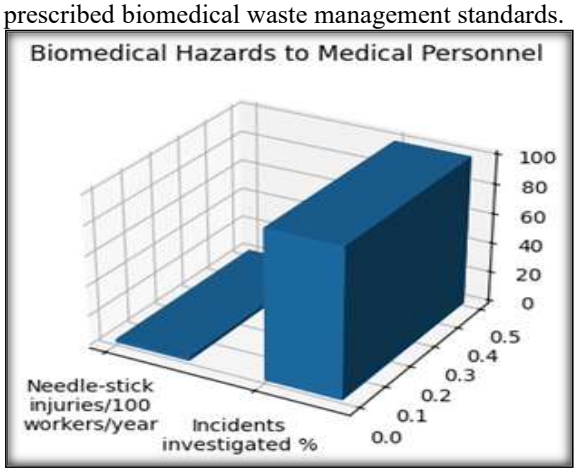


**Figure 4: Occupational Safety Outcomes and Incident Investigation**

The chart highlights a low needle-stick injury rate of 2.1 per 100 healthcare workers per year, while all reported incidents were investigated. This indicates an effective occupational safety program with robust incident reporting, surveillance, and corrective action mechanisms.

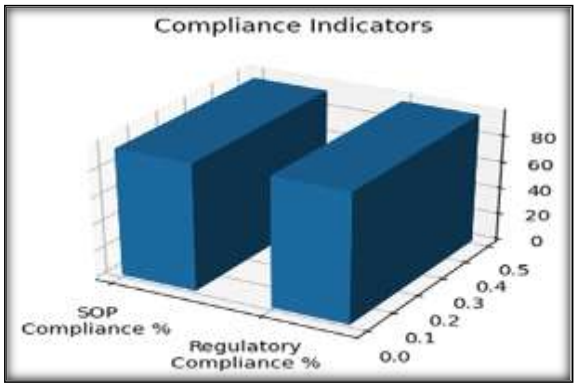


**Figure 5: SOP and Regulatory Compliance Indicators**

The chart demonstrates high levels of SOP compliance (95.2%) and regulatory compliance (97.3%) within the institution. These findings indicate successful implementation of standardized procedures and strong adherence to statutory biomedical waste management requirements, contributing to continuous quality improvement.

These explanations are suitable as figure legends or result descriptions in a manuscript, thesis, dissertation, or conference presentation.

## DISCUSSION

Biomedical waste management protects people and the environment, yet hospitals worldwide still face segregation errors and inconsistent training. This study shows that an accreditation-driven quality system can address several of these gaps. Segregation at source is the foundation of safe waste management. We found 96.4% compliance, higher than the 89.6% reported by Dutta et al. and 91.8% by Jalaja et al,[11] The difference likely reflects continuous training and internal audits embedded in accreditation processes. When staff understand why segregation matters for infection control and environmental protection, compliance improves.

Training and safety outcomes were also strong. With 98.1% staff trained and 93.7% PPE compliance, the hospital exceeded both national benchmarks and earlier studies. Hepatitis-B vaccination at 95.4% further reduced occupational risk. These results align with the idea that accreditation shifts focus from one-time training to ongoing competency and monitoring.

Waste generation and disposal met regulatory timelines. 1.82 kg/bed/day is within expected limits for a tertiary hospital, and 100% disposal within 48 hours shows operational discipline. The low needle-stick injury rate of 2.1 per 100 workers/year, with full incident investigation, indicates that safety systems are functioning, not just documented. The demographic profile of the study participants revealed that nurses constituted the largest professional group (43.7%), followed by doctors (17.8%), housekeeping staff (17.2%), laboratory personnel (10.8%), waste handlers (5.5%), and administrative staff (4.9%). Similar observations have been reported in previous studies, where nursing personnel formed the primary workforce responsible for waste segregation and monitoring due to their continuous involvement in patient care activities.[15] Their central role in waste generation and disposal practices makes them key stakeholders in ensuring compliance with BMWM protocols. The predominance of nurses in the present study underscores their contribution to maintaining effective waste management systems.

Segregation of biomedical waste at the point of generation remains the cornerstone of effective waste management. Incorrect segregation increases the volume of hazardous waste, treatment costs, and environmental risks while reducing the efficiency of

waste treatment processes.[16,17] Dutta et al. reported segregation compliance of 89.6%, whereas Jalaja et al. observed compliance of 91.8% following audit-based interventions.[10,11] In comparison, the present study demonstrated segregation compliance of 96.4%, color-coding compliance of 94.8%, and bin-labelling compliance of 93.5%, all exceeding the benchmark standard of 90%. These findings suggest that regular monitoring, accreditation-based assessments, and structured quality initiatives contribute substantially to improved segregation practices and regulatory adherence.

Training and education are essential determinants of successful biomedical waste management programs. Several studies have shown that periodic educational interventions significantly enhance healthcare workers' knowledge, attitudes, and practices related to biomedical waste management.[18] Mukherjee et al. reported that structured training programs improved awareness and compliance among healthcare trainees.[12] Similarly, Sharma et al. documented training coverage of 87.9% and emphasized the importance of regular refresher sessions in sustaining compliance.[15] In the present study, 98.1% of healthcare workers had received formal BMWM training, and 91.4% had attended refresher training programs. These rates are higher than those reported in many previous studies and reflect the effectiveness of accreditation-driven educational strategies in promoting staff competency and compliance.

Occupational safety is another important dimension of biomedical waste management. Healthcare workers involved in waste handling are at risk of sharps injuries, exposure to infectious materials, and chemical hazards. Patel et al. reported that consistent use of personal protective equipment (PPE) significantly reduces occupational exposure among healthcare personnel handling biomedical waste.[19] Previous studies have documented PPE compliance rates ranging from 79% to 88% (18,19). In contrast, the present study recorded PPE compliance of 93.7% and Hepatitis-B vaccination coverage of 95.4%. These findings indicate that accreditation-driven occupational safety initiatives, including mandatory training, vaccination programs, and compliance monitoring, contribute significantly to reducing workplace hazards and improving staff safety.

Biomedical waste generation rates provide useful indicators of operational efficiency and resource utilization. Regulatory agencies have reported that tertiary care hospitals generally generate between 1.5 and 2.5 kg of biomedical waste per bed per day, depending on patient load and service complexity (20). Proper collection, transportation, treatment, and disposal within prescribed timelines are essential for minimizing environmental contamination and maintaining regulatory compliance.[21] In the present study, the average waste generation rate was 1.82 kg/bed/day, with 97.5% of waste collected within 24 hours and 100% disposed of within 48 hours. These findings demonstrate efficient waste handling practices and effective implementation of regulatory requirements.

Needle-stick injuries remain among the most important occupational hazards associated with biomedical waste handling. Dhole et al. highlighted that underreporting of sharps injuries continues to be a significant challenge in healthcare institutions, potentially compromising occupational safety programs.[9] The World Health Organization has identified needle-stick injuries as a major source of transmission of hepatitis B, hepatitis C, and HIV among healthcare workers.[2] In the present study, the needle-stick injury rate was only 2.1 per 100 healthcare workers per year.

The implementation of standard operating procedures (SOPs), documentation systems, and internal audits is fundamental to effective biomedical waste management. Regulatory authorities consistently emphasize the importance of SOP-based practices, periodic audits, and corrective actions in maintaining compliance.[21] Jalaja et al. demonstrated that clinical audits improve compliance by identifying gaps requiring corrective intervention.[11] Kumar et al. and Verma et al. similarly reported higher compliance levels in institutions conducting regular audits and quality reviews (13,20). In the present study, SOP availability was 100%, SOP compliance reached 95.2%, internal audit performance was 92.6%, and CAPA closure rates were 89.4%. These findings highlight the effectiveness of structured monitoring systems in sustaining high standards of biomedical waste management.

Environmental safety and regulatory compliance represent the ultimate goals of biomedical waste management programs. National regulations require healthcare institutions to maintain proper segregation, transportation, treatment, disposal, documentation, and environmental monitoring systems. Khan et al. reported that environmental safety indicators improve significantly when healthcare facilities adopt structured waste management programs and continuous compliance monitoring.[21] Thomas et al. observed that accredited healthcare institutions generally achieve better regulatory compliance and environmental performance than non-accredited facilities.[22] Consistent with these findings, the present study recorded BMW Rules compliance of 97.3%, Pollution Control Board compliance of 96.8%, documentation compliance of 98.5%, and an environmental safety score of 94.2%.

Overall, the study demonstrated that accreditation-driven quality assurance systems contribute substantially to improved biomedical waste management practices. High levels of compliance in waste segregation, staff training, occupational safety, audit performance, documentation, and regulatory adherence were observed across all evaluated indicators.

**Limitations:** Single-centre design limits generalizability. We measured compliance at one-

time point, so long-term sustainability needs follow-up. Future multicenter studies can test if these results hold across hospital types.

**Implication:** For hospitals aiming to improve biomedical waste management, accreditation provides a practical framework. It links training, audits, and compliance into daily practice. Policy makers can consider strengthening accreditation requirements as a way to raise environmental safety.

## CONCLUSION

Accreditation-driven quality systems were linked to strong compliance across biomedical waste management domains. Segregation and color-coding exceeded benchmarks, while training and PPE use reflected effective safety programs. Low injury rates and timely waste disposal suggest robust operational control. Overall, accreditation appears to strengthen waste management, occupational safety, and regulatory adherence. These findings support wider adoption of structured quality assurance.

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