# Biomedical Waste Management at Omdurman Military Hospital in Khartoum State, Sudan: Knowledge and Practices

**Asma Mohamed Tahirhamad[1], Hassan Ibrahim Ali Mofadel[1, 2*], Manal Awad Kheiry[3], Alaa Salih Hamadto[4], Tarig Elsheikh Mahmoud[3] and Mohamed Ahmed Elhabib[2]**

[1]Department of Environmental and Ecology, Faculty of Geographical and Environmental sciences, University of Khartoum, Sudan.
[2]Kenana Sugar Company, Khartoum, Sudan.
[3]Department of Biological and Environmental Sciences, School of Natural and applied Sciences, Kampala International University, Uganda.
[4]Solar Food Company, Khartoum, Sudan.
Correspondence Author Email address: hmofadel@gmail.com

**Direct Research Journal of Public Health and Environmental Technology**

Direct RESEARCH JOURNALS

Vol. 10(3), Pp. 150-156, December 2025

**Research Article**
**ISSN: 2734-2182**
https://journals.directresearchpublisher.org/index.php/drjphet; https://www.ajol.info/index.php/drjphet

Received 5 November 2025, Accepted 20 December 2025, Published 22 December 2025

**ABSTRACT**

*This study assessed Biomedical Waste Management (BMWM) practices at Omdurman Military Hospital (OMH), Khartoum State, Sudan, between September 2020 and March 2021. A descriptive cross-sectional study using a mixed-methods approach was employed to evaluate biomedical waste handling processes, knowledge, attitudes, and practices among relevant stakeholders. Data were collected through direct observation, field notes, structured questionnaires, focus group discussions, and key informant interviews involving medical staff, internal waste handlers, and municipal waste personnel. Quantitative data were analyzed using SPSS version 20, while qualitative data supported contextual interpretation. The respondents were predominantly male (62.07%), while females constituted 39.93%. Biomedical waste classification at the point of generation was reported by 86.21% of participants, although 13.39% indicated that waste was not classified. Occupational health risks were substantial, with 48.28% of respondents reporting injuries during biomedical waste handling. The consistent use of personal protective equipment (PPE) was low, as only 48.28% reported wearing protective clothing, compared with 51.72% who did not. Hand hygiene practices were relatively satisfactory, with 72.41% of respondents reporting frequent handwashing with soap after waste handling, while 27.59% did not. Vaccination coverage among workers was comparatively high, as 79.31% reported being vaccinated during their work, whereas 20.69% were not vaccinated. However, formal training in biomedical waste management remained inadequate, with only 48.28% of respondents trained and 51.72% untrained. Despite the existence of institutional policies broadly aligned with World Health Organization (WHO) recommendations, gaps in training, PPE compliance, and occupational safety practices undermine effective BMWM at OMH, increasing risks to healthcare workers and the environment.*

***Keywords:*** *Khartoum; Omdurman Military Hospital; Biomedical Waste Management; Occupational Safety; Knowledge; Attitudes; Practices*


Citation: Tahirhamad, A. M., Mofadel, H. I. A., Kheiry, M. A., Hamadto, A.S., Mahmoud, T. E., & Elhabib, M. A. (2025). Biomedical Waste Management at Omdurman Military Hospital in Khartoum State, Sudan: Knowledge and Practices. *Direct Research Journal of Public Health and Environmental.* Vol. 10(3), Pp. 150-156.
https://doi.org/10.26765/DRJPHET12112293

## INTRODUCTION

The management of healthcare waste (HCW) is a crucial public health and environmental challenge worldwide, governed by a complex interplay of technical, cultural, social, and economic factors. Health institutions, including hospitals and clinics, generate various waste streams, many of which are classified as biomedical waste (BMW). This hazardous category includes infectious materials, pathological waste (such as human parts), contaminated sharps, expired pharmaceuticals, and toxic chemicals. Improper handling of BMW poses serious risks, enabling the spread of many pathogens, including but not limited to HIV, Hepatitis B and C, anthrax, and various bacterial and parasitic infections (World Health Organization, 2020). Besides infection risks, improper disposal leads to environmental pollution and endangers healthcare workers (HCWs), waste handlers, and the public with toxic or harmful chemical and radiological substances. Therefore, a well-structured waste management policy is a key responsibility for all healthcare facilities, requiring strict procedures for screening, classification, collection, treatment, and disposal (Prüss et al., 1999; Fadel, 2010).

Reddy et al. (2024), drawing on a recent WHO report, assert that the improper handling of Biomedical Waste (BMW) is a persistent global problem, amplified by the expansion of healthcare services and the COVID-19 pandemic. The scale of this issue is immense, with over 85 million tons of BMW resulting partly from 16 million annual global injections, underscoring the critical need for proper segregation, collection, treatment, and disposal to safeguard healthcare workers and the public from infectious diseases. The authors view this challenge as an opportunity to implement durable, sustainable solutions, such as converting BMW into valuable resources like fertilizer for agriculture, or using it for energy generation (biogas, biofuel, electricity), or incorporating it into manufacturing and construction materials like cement. The book chapter calls on stakeholders to collaborate and adopt fresh thinking, converting the risks posed by BMW into possibilities to ensure a healthier, more sustainable, and resilient future.

The Waste Management Theory provides a unified framework for understanding waste, aiming to prevent harm to health and the environment (Pongrácz, 2002). According to recent literature (Suram et al., 2025), Biomedical Waste Management (BMWM) practices are evaluated using the Knowledge, Attitude, and Practice (KAP) model, guided by the Waste Management Hierarchy and Theory. At Omdurman Military Hospital (OMH) in Khartoum, assessing Biomedical Waste Management (BMM) involves understanding the waste lifecycle: generation, segregation, collection, storage, transportation, treatment, and disposal. Effective frameworks also account for healthcare personnel's knowledge, attitudes, practices, resource availability (e.g., color-coded bins), and regulatory compliance. Using questionnaires and observation, assessments identify gaps and improve waste handling to protect health and the environment (Suram et al., 2025). While many high-income countries have established strict legislative frameworks and enforce penalties for violations, low- and middle-income countries (LMICs) often face different challenges. Although the total amount of BMW generated in poorer nations may be smaller due to lower healthcare spending, the main issue is poor management and inadequate infrastructure for safe handling and final disposal (World Health Organization, 2020). In Sudan, as a developing nation, HCW management is often not prioritized, leading to significant safety lapses. Existing healthcare clinics frequently lack formal waste management plans, resulting in the common practice of mixing BMW with general municipal solid waste. This negligence directly exposes personnel, especially nursing staff, cleaners, and waste collection workers, to preventable infections and injuries, such as needlestick incidents. Environmental contamination caused by improper disposal is also a persistent concern (Badri and Dawood, 2024). Military institutions, including hospitals, often operate under stricter internal policies and organizational discipline compared to civilian counterparts, potentially providing a valuable case study in compliance. Omdurman Military Hospital is one of the largest healthcare facilities in Khartoum State and plays a vital role in military medical services. Given the severity of the risks involved with improper BMW management, there is an urgent need for a systematic, scientific study to evaluate the current situation.

The significance of this research lies in its potential to offer a robust, data-driven analysis of BMW management practices within a key institution. The findings will be directly useful in developing a scientifically sound and systematic approach to managing medical waste across the entire military medical service department at the national level.

### Research questions

This study aims to address the following key questions about biomedical waste management at Omdurman Military Hospital.

1. How effective are the current hospital processes for the segregation, collection, internal transport, treatment, and final disposal of medical waste?
2. What are the methods and mechanisms currently in use for effective medical waste management?
3. Are formalized training plans and sufficient safety precautions, such as Personal Protective Equipment (PPE), provided to medical waste handlers?

4. What are the key weaknesses and challenges in the current BMW management system?

**Research objectives**

Based on the issues identified, the objectives of this research are:

1. To evaluate the knowledge, attitudes, and practices (KAP) of the medical waste handlers (medical team, cleaners, and transport staff).
2. To assess the involvement and role of the Khartoum State municipality in the external transport and final disposal of the hospital's BMW.
3. To develop evidence-based recommendations and a general improvement plan for the management of medical waste, bringing the hospital's systems in line with national legislation and international standards and guidelines.

## METHODOLOGY

A descriptive design based on cross-sectional study used a mixed-methods approach, combining data collection techniques to comprehensively evaluate the Biomedical Waste Management (BMWM) knowledge and practices at Omdurman Military Hospital.

**Study setting and population**

The research was conducted at Omdurman Military Hospital, a major central healthcare facility in Khartoum State. Inclusion criteria used include all personnel involved in generation, segregation, handling, and management of biomedical waste within the hospital, specifically, medical staff include, including doctors, nurses, laboratory technicians, pharmacists, and medical trainees. Internally, waste handlers, include cleaners, solid waste drivers, and transport vehicle drivers. The external stakeholders included municipal counterparts responsible for off-site collection and disposal of the hospital's waste. The selection of these groups ensured a holistic perspective on BMWM, covering knowledge, attitudes, and practices (KAP) from the perspective of the stakeholders' generation.

**Data collection methods**

The researcher used direct observation and field notes to systematically monitor the BMWM process across different hospital sections, such as wards, operating theatres, and laboratories, throughout the study period extended from September 2020 to March 2021. Detailed notes were kept to document physical conditions, adherence to segregation protocols, container use, storage practices, and staff handling techniques. Focus group discussions (FGDs) and key informant interviews (KIIs) were also conducted. FGDs involved specific groups, including medical staff (5), cleaners/internal handlers (7), and municipal or external handlers (6), to explore their perceptions, challenges, training experiences, and safety concerns related to BMWM. Meanwhile, KIIs were held with relevant managerial staff, including the hospital's Environmental Health Officer (1) and municipal supervisors (2), to understand policy enforcement, resource allocation, and regulatory compliance. A structured questionnaire, which had been amended based on pilot testing feedback to ensure question clarity, was used to assess the Knowledge, Attitudes, and Practices (KAP) of the defined hospital personnel involved in Biomedical Waste (BMW) handling. The assessment focused on segregation, safety precautions, and emergency procedures. With a distribution of 40 questionnaires, a total of 30 were returned. Data analysis was conducted using the Statistical Package for Social Sciences (SPSS), specifically SPSS Statistics for Windows, Version 20 (IBM Inc., 2020).

**Ethical Considerations**

Ethical approval was obtained from the research ethics committee Faculty of Geographical and Environmental Sciences at the University of Khartoum and from Research Department, Ministry of Health in Khartoum state, on 20/9/2020. The purpose and objectives of the research were also explained to the participants in simple and clear words and their right to withdraw from the research whenever they wanted, and to assure the participants the confidentiality of their information and data and their names and identities not been disclosed. The collected information will not be used for any purpose other than the objectives of this study.

## RESULTS AND DISCUSSION

This section presents the findings of the study on Biomedical Waste Management (BMWM) at Omdurman Military Hospital (OMH) and discusses them in the context of existing literature and best practices.

**Historical context of Omdurman military hospital**

Omdurman Military Hospital was originally established in February 1956. Its institutional status was dual. it was technically affiliated with the Ministry of Health but administered by the Sudan Defense Force. Following the institutional changes after May 1969, the hospital's administrative head became a branch of the General Command's Medical Military, and the hospital was renamed the Branch of Medical Services. This historical structure is relevant as military administration often implies specific, and sometimes more rigorous, internal policies and enforcement mechanisms, which should ideally extend to waste management. The study's findings, as depicted in (Figure 1), indicate a higher proportion of male

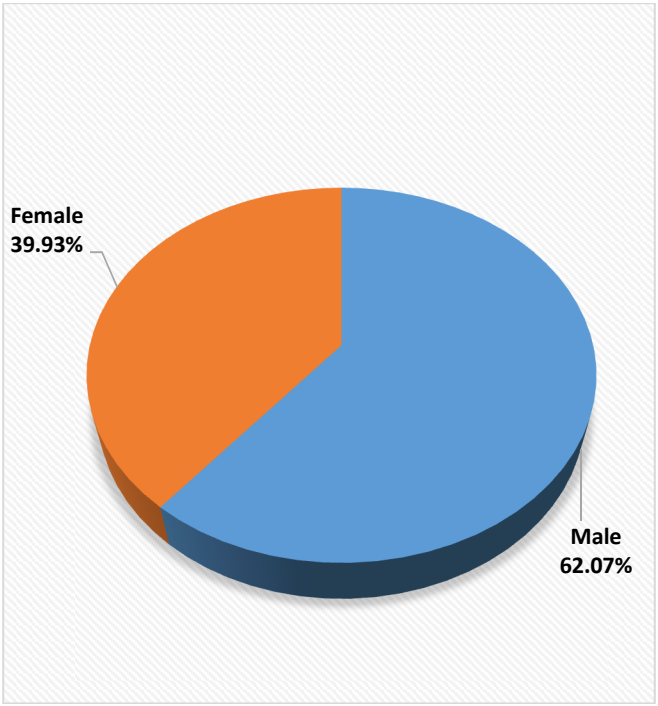


**Figure 1:** Percentages of the interviewed personal based on gender.

workers among those interviewed in the specific field of biomedical waste management. This observation is particularly relevant when considering the labor segmentation within healthcare facilities, where roles with higher direct exposure to waste handling (e.g., dedicated waste handlers, laborers, and some maintenance staff) may traditionally be male dominated, contrasting with the overall gender distribution of healthcare workers (nurses, doctors) as stated by Islam et al. (2025).

## Biomedical waste collection, segregation, and final disposal

### Collection and classification practices

The study confirmed that biomedical waste (BMW) is collected in plastic bags from all generation points, including wards, operating theatres, the central laboratory, the blood bank, and various clinics. A key finding concerning segregation at the source is the use of safety boxes for needles and other sharp instruments, which in line with the studies conducted by both Gonibeedu et al. (2021) and Mathur et al. (2011). Crucially, the results indicate that waste segregation is widely practiced, with 86.21% of interviewees reporting that BMW is classified within the hospital prior to transportation for final disposal as presented in (Figure 2). Furthermore, all interviewees demonstrated fundamental awareness regarding the difference between medical and ordinary waste, acknowledging the hazardous nature of BMW and its potential for disease transmission.

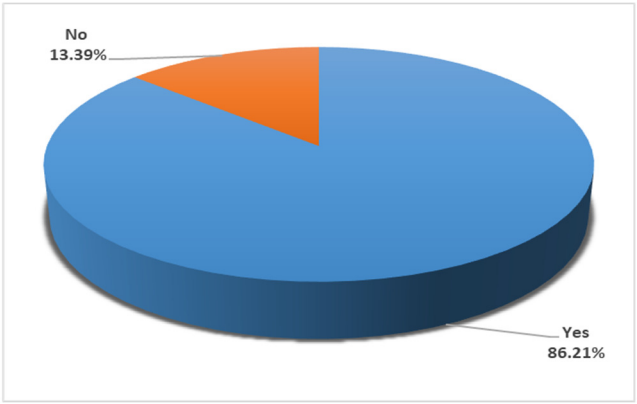


**Figure 2:** Biomedical waste (BMW) classified or not.

This high level of reported knowledge suggests a baseline foundation for effective BMWM, though successful implementation relies on consistent practice.

### Disposal methods and challenges

The study identified a major challenge with the internal storage and transportation of BMW, which is currently stored alongside regular waste in several designated areas. This co-location raises the risk of cross-contamination and accidental mixing, potentially compromising initial segregation efforts. This finding is strongly supported by numerous sources and official health guidelines, including but not limited to World Health Organization (2024) and Sensoneo (2024). The co-location and mixing of biomedical waste (BMW) with general waste during storage and transport is a well-documented risk factor for cross-contamination and infection spread (Gupta et al., 2023). The final disposal routes reported are as follows:

Firstly, the regular waste is transported by vehicle to a transfer station south of Khartoum for compaction before being taken to designated landfills. Secondly, human tissues and organs are subjected to autoclaving (a high-heat, steam sterilization process) before being disposed of by dumping in the Abu Wladat landfill in West Omdurman. The practice of disposing of autoclaved human tissues and organs in a landfill, while a form of final disposal, must be critically assessed for compliance with pathological waste guidelines, which often mandate incineration or burial in deep, secured pits (WHO, 2017). The study's findings regarding the overall disposal strategy align with a previous study by Yusuf (2006) in Khartoum Hospital, suggesting a consistent, but potentially non-optimal, disposal pattern across the region's healthcare facilities.

### Safety procedures and training

The findings revealed significant gaps in occupational safety and health (OSH) for waste handlers, despite a general awareness of the waste's hazardous nature.

### Injury rate and personal protective equipment (PPE)

A stark finding was that half (50%) of the interviewees reported having been injured during the handling of biomedical waste (Figure 3). This high injury rate is indicative of systematic failures in safe handling procedures, adequate training and/or the consistent provision and use of appropriate Personal Protective Equipment (PPE). Although nearly half of the interviewers reported wearing protective clothing during work, this is not enough since universal PPE use is required for BMW handling to reduce exposure risks as shown in (Figure 4). Encouragingly, over 70% said they frequently wash their hands with soap after work, showing a fairly strong commitment to post-exposure hygiene, as illustrated in (Figure 5).

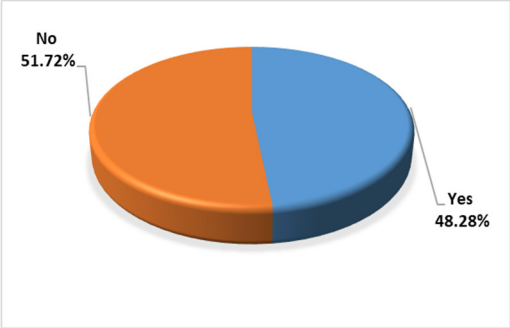


**Figure 3**: Percentage of injured workers during the handling of the biomedical waste

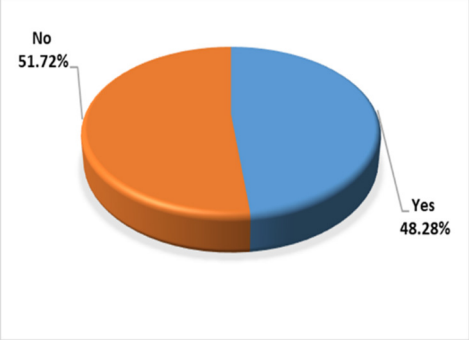


**Figure 4**: Wearing protective clothing (PPE) while dealing with biomedical waste

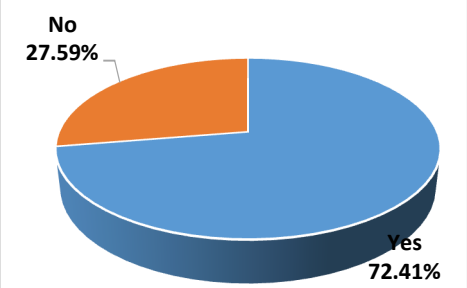


**Figure 5:** washing hands with soap frequently after finishing the work with biomedical waste

### Training and vaccination status

Training and occupational vaccinations are essential components of a strong BMWM safety program. Nearly 80% of the interviewees had received vaccinations during their work (Figure 6). Given the risks, especially for Hepatitis B and Tetanus, this relatively high percentage is positive but still leaves a significant minority vulnerable. For the training, only around half (48.28%) of the interviewees had received specific instruction in biomedical waste management and disposal methods, as shown in (Figure 7). The low training rate (50%) is a weakness, as well lack of PPE likely leading to the high injury rate nearly to 50%. Effective training has been shown to greatly improve segregation practices, boost safety knowledge, and ensure consistent PPE use, thereby reducing workplace hazards (World Health Organization, 2020). This supports the study's conclusion in the abstract, which highlights the "huge lack and weaknesses in training areas and safety needs, especially for workers."

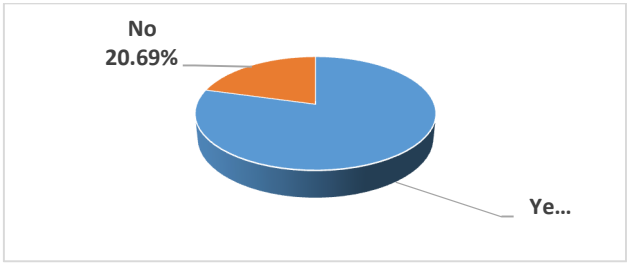


**Figure 6:** Interviewers received vaccination during their work

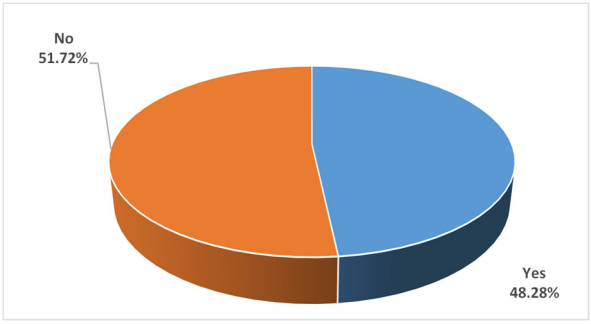


**Figure 7:** Interviewers received training in biomedical waste management and disposal methods

### Workflow for biomedical waste organization

The study highlighted clearly lack in biomedical waste management routes and stream in Omdurman Military Hospital as some non-hazards (general) waste mixed with hazards biomedical waste. They claiming adopting. Despite that the follow chard adopted by Omdurman Military Hospital is according to World Health Organization (2020**)** **(**Figure 8), which highlights a systematic, six-step


**Figure 8:** Biomedical waste flow chart as recommended by World Health Organization (2020).

process, including:

1. Source Segregation/Classification: Mandatory separation at the point of generation.
2. Collection: Follow standardized internal collection protocols.
3. Storage: Use dedicated, secure, and regulated temporary storage areas.
4. Waste Treatment: Conduct on-site or off-site processing (e.g., autoclaving, incineration) to neutralize hazards.
5. Transporting Waste out of the Hospital: Ensure safe external transport with dedicated, specialized vehicles.
6. Final Disposal: Dispose of waste in a secure landfill or designated facility (e.g., incineration ash disposal).

Implementing a detailed flow chart that outlines specific steps from source to final disposal is essential for transitioning from potentially risky practices to a system that meets international health and environmental standards. The study observation revealed that mixing of the waste might be due to the practice of the workers in the first steps of segregation at source. This again highlighted the need of training. This also in line with Capoor & Parida (2021), basic waste management services were available in only 27% of health-care facilities in the least developed countries.

## Conclusion

This study comprehensively evaluated the biomedical waste management system at Omdurman Military Hospital. While the hospital's overall waste disposal strategy broadly aligns with WHO guidelines (2005) and the Khartoum State Environmental Health Act, significant operational deficiencies were identified, presenting substantial risks to occupational health and environmental safety. Key Findings Summarized: Firstly, although staff demonstrated high levels of knowledge regarding the hazardous nature of BMW and the importance of segregation, the persistent high incidence of injuries and inconsistent use of personal protective equipment (PPE) indicate a gap between knowledge and consistent safe practice. Secondly, while segregation practices, including the use of safety boxes for sharps, are in place, the co-location of BMW and regular waste during collection and internal transport undermines initial segregation efforts. Pathological waste treatment (autoclaving followed by landfilling) warrants further evaluation against international best practices to ensure efficacy and compliance. Thirdly, the high injury rate (50% of handlers) coupled with the low rate of specialized training (50% of handlers) highlights a critical deficit in investment toward worker safety, systematic training, and regulatory oversight in daily hazardous waste handling. OMH maintains foundational policies for safe BMW disposal, substantial deficiencies in training, safety provisions, and operational oversight render the system vulnerable. Addressing these gaps through structured training programs, enhanced safety protocols, and rigorous monitoring is imperative to mitigate risks and achieve full compliance with international standards.

## Recommendations

To address the identified shortcomings and enhance the safety and effectiveness of BMWM at Omdurman Military Hospital, the following recommendations are proposed:

### Policy and strategy implementation

Develop a formal, clear BMWM strategy to establish a detailed, written strategy and policy document endorsed by hospital management. This policy must explicitly define responsibilities, workflows, monitoring mechanisms, and clear Key Performance Indicators (KPIs) for every department involved in waste generation and handling. Enforce mandatory resource provision of all necessary infrastructure at the source, including safety boxes, distinctive waste containers, and appropriately color-coded bags (red and yellow) across all wards and clinics. Management must ensure consistent follow-up and supervision to guarantee compliance. Implement first-hand screening processes and strict internal regulations to monitor segregation at the point of generation. Introduce clear, escalating penalties for non-compliance among staff.

### Training and education

Develop and implement a mandatory, comprehensive training program focusing on BMW management, safe handling techniques, decontamination procedures, and emergency response. Periodic refresher training should be implemented for all staff, including doctors, nurses, cleaners, and transport workers. Establish and display clear guidelines and posters in prominent areas (wards, clinics, waiting areas) to educate patients, companions, and visitors about the dangers of medical waste and the importance of not tampering with waste containers.

### Occupational health and safety (OSH)

Ensure the consistent supply and mandatory use of appropriate Personal Protective Equipment (PPE) (e.g., heavy-duty gloves, protective clothing, face shields, utility shoes) for all workers dealing with BMW. Provide clear instructions and supervision to protect workers from

exposure and injuries. Establish a formal system for the immediate reporting, investigation, and tracking of all occupational injuries (especially sharps injuries). Use this data to continuously refine safety protocols and target training efforts. Safeguard 100% coverage for relevant occupational vaccinations (e.g., Hepatitis B, Tetanus) for all personnel involved in handling or potentially exposed to BMW.

**REFERENCES**


Badri, R., and Dawood, I. (2024). The implications of the Sudan war on healthcare workers and facilities: A health system tragedy. Conflict and Health, 18(22). https://doi.org/10.1186/s13031-024-00581-w

Capoor, M. R. & A., Parida (2021) Biomedical Waste and Solid Waste Management in the Time of COVID-19: A Comprehensive Review of the National and International Scenario and Guidelines. J Lab Physicians Vol. 13:175–182 DOI https://doi.org/10.1055/s-0041-1729132ISSN 0974-2727

Fadel, F. O. (2010). Following health education to raise awareness of the management of medical waste at Bahri Educational Hospital [Master's thesis]. Bahri University.

Gonibeedu, V., Sundar, M., Santhosh, H. C., and Swamy, D. M. (2021). Outcome of biomedical waste management training among staff nurses of primary health centers of Hassan district. International Quarterly of Community Health Education, 41, 349–353.

Gupta, P. P., Bankar, N. J., Mishra, V. H., et al. (2023). The efficient disposal of biomedical waste is critical to public health: Insights from the Central Pollution Control Board guidelines in India. Cureus, 15(10), e47303. https://doi.org/10.7759/cureus.47303

IBM Inc. (2020). Statistical Package for Social Sciences (SPSS) Statistics for Windows (Version 20) [Software]. Armonk, NY.

Islam, M. T., Rafi, M. A., and Hasan, J. (2025). Knowledge, attitude, and practice of healthcare workers on solid medical waste management in two urban hospitals of Bangladesh: A mixed-method study. Journal of Health, Population and Nutrition, 44, 34. https://doi.org/10.1186/s41043-025-00748-y

Mathur, V., Dwivedi, S., Hassan, M. A., and Misra, R. P. (2011). Knowledge, attitude, and practices about biomedical waste management among healthcare personnel: A cross-sectional study. Indian Journal of Community Medicine, 36(2), 143–145.

Pongrácz, E. (2002). Re-defining the concepts of waste and waste management: Evolving the theory of waste management (Doctoral dissertation). University of Oulu, Finland.

Sensoneo. (2024). How biomedical waste differs from regular waste. https://sensoneo.com

Suram, S., Rudra, V. G., Miryala, R. K., and Parine, N. R. (2025). Knowledge, attitude, and practices toward biomedical waste management among healthcare workers. Asian Journal of Water, Environment and Pollution, 22(5), 204–213. https://doi.org/10.36922/AJWEP025090058

World Health Organization. (2024). Health-care waste. https://www.who.int/news-room/fact-sheets/detail/health-care-waste

Yusuf, O. (2006). Study on medical waste management at Khartoum Hospital. University of Khartoum. April- 2006.