Volume 3, Issue 7, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

FROM KNOWLEDGE TO PRACTICE: A CROSS-SECTIONAL ANALYSIS OF BIOMEDICAL WASTE DISPOSAL COMPLIANCE AND ITS DETERMINANTS AMONG PRIMARY CARE PHYSICIANS IN KARACHI, PAKISTAN

Nazish Waris[*1], Irfanullah Khan[2], Uzma Ali[3], Shazia Fahmi[4], Madiha Nizami[5], Syed Muhammad Irfan Ali[6],

*[*1]PhD Assistant Professor Department of Biochemistry Manager Research Office of Research, Innovation & Commercialization Baqai Medical University*

[2]MS-MLS Scholar Medical Technologist Baqai Medical University Laboratory Supervisor Insaf Medical Complex and Diagnostic Lab

[3]MBBS, MPhil Scholar Baqai Medical University

[4]MBBS, MPhil Anatomy, Ph.D. Scholar Baqai Medical University

[5]MS-MLS Scholar Medical Technologist Fatima Hospital Laboratory Baqai Medical University

[6]MBBS, FCPS (Specialist Internal Medicine) Medical Unit 1 Abbasi Shaheed Hospital, KMU

*[*1]nazishwaris@baqai.edu.pk*

DOI: https://doi.org/10.5281/zenodo.17150536

Keywords
Biomedical waste management, Healthcare waste disposal, General practitioners, Awareness and compliance, Pakistan

Article History
Received: 26 June 2025
Accepted: 05 September 2025
Published: 18 September 2025

Corresponding Author: *
Nazish Waris

Abstract

This study assesses awareness and compliance with national biomedical waste disposal guidelines among general practitioners in District Karachi, Pakistan. A cross-sectional design was employed, with data collected from 79 practitioners from Sohail trust hospital and Abbasi Shaheed Hospital who were also doing private clinics using a validated questionnaire. Results revealed significant gaps between theoretical knowledge and practical implementation. While awareness levels were moderately high (64.8%), compliance rates remained suboptimal, particularly in waste segregation (OR=0.163, p<0.001) and transportation (OR=0.053, p<0.001). Logistic regression identified awareness as a stronger predictor than compliance for proper waste handling, though operational barriers hindered consistent practice. Key challenges included inadequate segregation, improper storage, and insufficient protective measures for waste handlers. The findings highlight the need for targeted interventions combining education, resource allocation, and stricter enforcement of waste management protocols. This study contributes to existing literature by identifying context-specific barriers in low-resource settings and proposes actionable strategies to improve biomedical waste disposal practices. Addressing these gaps is critical for reducing healthcare-associated infections and environmental contamination while aligning with Sustainable Development Goals 3 (Good Health) and 6 (Clean Water and Sanitation).

INTRODUCTION

The effective management of biomedical waste (BMW) is a critical component of public health and environmental safety within healthcare systems globally. Biomedical waste, encompassing infectious

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

sharps, pathological specimens, and pharmaceutical or chemical byproducts generated from healthcare activities, poses significant risks if not managed correctly [1,2]. Adherence to scientific protocols for its segregation, treatment, and disposal is imperative to mitigate occupational hazards for healthcare workers and waste handlers and to prevent broader community and environmental exposure [3,4].

Despite well-established international guidelines from bodies like the World Health Organization (WHO), a significant gap persists between policy and practice, particularly in low and middle-income countries [5,6]. This compliance deficit is often driven by systemic challenges such as insufficient training, inadequate disposal infrastructure, and weak regulatory monitoring [7]. The recent COVID-19 pandemic starkly highlighted these vulnerabilities, causing a dramatic surge in waste generation that overwhelmed existing management systems in many regions and exposed critical infrastructural weaknesses [8,9].

In Pakistan, the management of BMW is governed by the Hospital Waste Management Rules (2005) [10]. However, similar to global trends in resource-constrained settings, practical adherence to these regulations remains inconsistent [11,12]. Common malpractices, including the mixing of general and hazardous waste streams and inadequate segregation at the point of generation, are frequently reported [13,14]. These lapses present serious public health consequences, potentially facilitating the transmission of infections such as hepatitis B, hepatitis C, and HIV, alongside contributing to environmental pollution of soil and water resources [15, 16].

Existing research on BMW management in Pakistan has predominantly focused on large, tertiary care hospitals in major urban centers [11, 17]. These studies consistently identify key structural barriers, including fragmented oversight and a lack of continuous training programs. However, a substantial evidence gap exists concerning practices within smaller, private clinical settings, where general practitioners (GPs) operate as the first point of contact for a vast majority of the population [18, 19]. This is a critical oversight, as the scale and context of waste management in these clinics differ considerably from large hospitals.

The metropolitan area of Karachi, a dense urban center with a vast network of healthcare facilities, exemplifies this problem. There is a notable absence of recent empirical data focusing specifically on the awareness and practices of GPs in this district regarding BMW management [18]. Furthermore, a recurring theme in the literature is the observed "knowledge-practice gap," where healthcare professionals may demonstrate adequate theoretical knowledge but fail to implement correct procedures in their daily practice due to a lack of institutional support or effective accountability mechanisms [20,21,22].

This study is designed to address this identified gap. Its primary objectives are to assess the current level of awareness and compliance with national BMW disposal guidelines among general practitioners in District Karachi and to identify factors associated with these practices, such as years of experience, qualifications, and access to institutional support. The findings from this research will provide crucial, localized evidence to inform the development of targeted interventions and policy revisions, ultimately contributing to safer healthcare environments and aligning with the broader objectives of Sustainable Development Goals (SDGs) related to health (SDG 3) and clean sanitation (SDG 6).

Methodology

This study utilized a cross-sectional design to the magnitude of the disparity between theoretical knowledge and self-reported practical adherence to national biomedical waste management guidelines among general practitioners engaged in private practice within two major hospitals in Karachi, Pakistan.

The target population consisted of registered medical practitioners holding an MBBS degree who were concurrently operating private clinics and were affiliated with either Sohail Trust Hospital or Abbasi Shaheed Hospital. A sample size of 79 participants was determined to be necessary for the investigation. This calculation was derived using a reference compliance prevalence of 64.8% identified in prior literature, with a predetermined 95% confidence level and a 7% margin of error. A non-probability convenience sampling strategy was implemented to

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

facilitate participant recruitment, aiming for balanced representation from each of the two institutions while acknowledging constraints related to accessibility and practitioner availability.

Data were gathered using a structured questionnaire that had been validated and pretested, demonstrating high internal consistency with a Cronbach's alpha coefficient of 0.881. The instrument was organized into three distinct segments: 1) demographic and professional characteristics, 2) an assessment of awareness concerning waste segregation and disposal protocols, and 3) an evaluation of self-reported compliance behaviors in daily practice. To ensure data quality and consistency, trained research personnel conducted face-to-face interviews for questionnaire administration. Each interview session required approximately 20 to 25 minutes completing, and verbal informed consent was secured from every participant prior to commencement.

Ethical oversight was maintained throughout the research process. The study protocol received formal approval from the institutional review board, confirming adherence to the ethical principles outlined in the Declaration of Helsinki. Key ethical safeguards included emphasizing the voluntary nature of participation, guaranteeing confidentiality through the anonymization of all collected data, and ensuring participants were aware of their right to withdraw at any stage without penalty.

To minimize potential biases and enhance the reliability of the data collection tool, all researchers were briefed about the questionnaire and the study, and a pilot study involving 18 participants (approximately 10% of the sample size) was conducted prior to the main data collection phase. This approach was designed to uphold methodological rigor within the practical realities of conducting research in private healthcare environments.

Research Questions

The study sought to address the following research questions: To what degree does a gap exist between knowledge of official protocols and self-reported implementation of biomedical waste management procedures among general practitioners in Karachi? To what extent do practitioners report adhering to core BMWM procedures, including segregation, collection, transportation, and storage, in their clinical settings? What statistical relationship exists between a practitioner's score on awareness measures and their self-reported compliance behaviors? What are the principal barriers, both perceived and systemic, that prevent full compliance with BMWM guidelines? Based on the study's findings, what specific, actionable interventions are most warranted to effectively bridge the knowledge-practice gap in a resource-constrained urban environment like Karachi?

Data Analysis

Table 1 Demographic and Professional Profile of Respondents

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	55	69.6
	Female	24	30.4
Years of Practice	< 5 years	22	27.8
	5 - 10 years	26	32.9
	11 - 15 years	18	22.8

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

	> 15 years	13	16.5
Hospital Affiliation	Sohail Trust Hospital	40	50.6
	Abbasi Shaheed Hospital	39	49.4

The respondent profile indicates a majority male practitioner cohort. Experience levels are varied, with the largest group having practiced for 5-10 years. The sample was drawn equally from the two specified hospital affiliations, ensuring balanced institutional representation for the study's analysis.

Table 2 Awareness and Compliance on Biomedical Waste Management Practices

Variable	B	S.E.	Wald	Sig.	Exp(B)	95% CI for Exp(B)
Waste Segregation						
Awareness_WS(1)	-2.250	0.401	31.465	<0.001	0.105	-
Compliance_WS(1)	0.649	0.469	1.915	0.166	1.913	-
Constant	-0.590	0.444	1.768	0.184	0.554	-
Waste Collection						
Awareness_HWC(1)	-1.797	0.384	21.930	<0.001	0.166	-
Compliance_HWC(1)	0.205	0.444	0.214	0.644	1.228	-
Constant	-0.516	0.438	1.390	0.238	0.597	-
Waste Transportation						
Awareness_HWT(1)	-2.934	0.461	40.509	<0.001	0.053	-
Compliance_HWT(1)	-0.254	0.467	0.295	0.587	0.776	-
Constant	0.214	0.420	0.260	0.610	1.239	-
Compliance Score						
Awareness_WS(1)	0.422	0.458	0.846	0.358	1.524	-
Compliance_WS(1)	-1.813	0.390	21.589	<0.001	0.163	-

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Constant	-0.744	0.442	2.837	0.092	0.475	-
Combined Model						
Awareness_HWC(1)	-0.550	0.585	0.884	0.347	0.577	-
Compliance_HWC(1)	-0.214	0.585	0.134	0.002*	0.807	-
Awareness_HWT(1)	0.402	0.595	0.457	0.005*	1.495	-
Compliance_HWT(1)	-0.362	0.525	0.476	<0.001*	0.696	-
Constant	0.876	0.585	2.244	0.995	2.402	-

Applied Logistic Regression Analysis

The logistic regression analyses reveal distinct patterns in the roles of awareness and compliance across different biomedical waste management practices. For waste segregation, collection, and transportation, awareness demonstrates a statistically significant protective effect ($p < 0.001$), with odds ratios ranging from 0.053 to 0.166. This indicates that increased awareness is associated with a substantially reduced likelihood of improper practices, most notably in waste transportation, where aware participants were 94.7% less likely to engage in incorrect methods.

Conversely, compliance measures show inconsistent effects. In segregation, collection, and transportation models, compliance fails to reach statistical significance ($p = 0.166–0.644$), suggesting a disconnect between knowledge and implementation. However, when examining overall compliance scores, behavioral compliance emerges as a strong significant predictor ($p < 0.001$, OR = 0.163), indicating that actual practice adherence, rather than awareness alone, is critical for proper waste segregation.

The combined model further clarifies these relationships, showing that compliance in both collection and transportation significantly influences proper practices ($p = 0.002$ and $p < 0.001$, respectively). These findings suggest that while awareness is foundational, its translation into consistent practice is mediated by operational and contextual factors. Interventions must therefore address not only knowledge gaps but also systemic barriers, such as resource limitations, workflow integration, and institutional support, to effectively improve biomedical waste management outcomes.

Discussion

This study's findings critically contextualize the documented challenges in biomedical waste management (BMW) within low-resource settings. The significant protective effect of awareness on proper practices ($p < 0.001$) affirms the foundational importance of knowledge, as underscored by WHO guidelines (21,23). However, the recurrent lack of statistical significance in compliance measures ($p = 0.166–0.644$) empirically validates the persistent knowledge-practice gap noted across South Asian healthcare systems (1,12). This indicates that theoretical awareness, though necessary, remains insufficient for ensuring adherence to protocols, a problem extensively attributed to systemic weaknesses and inconsistent enforcement (7,8).

A pivotal insight emerges from the compliance score analysis, where behavioral compliance proves to be a strong, significant predictor ($p < 0.001$, OR = 0.163). This suggests that when practitioners actively comply, the impact on correct waste segregation is substantial. This nuance aligns with research indicating that structural factors, such as

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

institutional support, resource availability, and effective monitoring, are frequently more influential than individual knowledge alone (4,5,11). The significant results for compliance within the combined model ($p = 0.002$, $p < 0.001$) further reinforce that enhancing practical implementation is crucial.

These results corroborate prior studies highlighting key barriers in Pakistan, including insufficient training, inadequate disposal facilities, and weak regulatory oversight (1,9,24). The evident disconnect between awareness and actual practice underscores that interventions must transcend conventional educational campaigns. As argued by scholars such as Capoor and Parida (4,5), sustainable improvement necessitates integrated strategies addressing structural and operational barriers, such as targeted resource allocation, streamlined workflows, and robust accountability mechanisms, to effectively translate knowledge into consistent practice.

Conclusion

This study examined biomedical waste management among general practitioners in Karachi, Pakistan, revealing a significant gap between theoretical knowledge and practical compliance. While awareness of guidelines was relatively high, actual adherence to protocols, particularly in waste segregation and collection, proved inconsistent. The findings suggest that awareness alone is insufficient to ensure compliance, highlighting the role of structural barriers such as limited resources, inadequate infrastructure, and weak regulatory enforcement.

The study emphasizes the need for integrated interventions that combine targeted training with systemic improvements. These include providing appropriate disposal facilities, strengthening oversight mechanisms, and fostering accountability. A multifaceted approach involving healthcare institutions, policymakers, and community stakeholders is essential to bridge the knowledge-practice gap.

Ultimately, effective biomedical waste management is both a public health necessity and an environmental imperative. This research contributes actionable insights for developing context-specific strategies in resource-constrained settings, supporting efforts to reduce infection risks and promote sustainable healthcare practices.

References

Asadullah, Jameel N, Jafry SI, Naqvi SM, Jahan F. Knowledge, Attitude And Practices Regarding Management Of Biomedical Waste Among House Officer And Nursing Staff In Teaching Hospitals Of District South, Karachi. Ann Abbasi Shaheed Hosp Karachi Med Dent Coll. 2023 May 30;28(2):104-11.

Bansod HS, Deshmukh P, Bansod H. Biomedical waste management and its importance: a systematic review. Cureus. 2023 Feb 3;15(2).

Bansod HS, Deshmukh P. Biomedical waste management and its importance: a systematic review. Cureus. 2023 Feb;15(2).

Capoor MR, Parida A. Biomedical waste and solid waste management in the time of COVID-19: a comprehensive review of the national and international scenario and guidelines. Journal of laboratory physicians. 2021 Jun;13(02):175-82.

Capoor MR, Parida A. Current perspectives of biomedical waste management in context of COVID-19". Indian Journal of Medical Microbiology. 2021 Apr 1;39(2):171-8.

Dehal A, Vaidya AN, Kumar AR. Biomedical waste generation and management during COVID-19 pandemic in India: challenges and possible management strategies. Environmental Science and Pollution Research. 2022 Feb 1:1-6.

Goswami M, Goswami PJ, Nautiyal S, Prakash S. Challenges and actions to the environmental management of Bio-Medical Waste during COVID-19 pandemic in India. Heliyon. 2021 Mar 1;7(3).

Government of Pakistan, Ministry of Environment. Notification: Hospital Waste Management Rules, 2005. Available from: https://mocc.gov.pk/SiteImage/Misc/files/Hospital%20Waste%20Management%20Rules%2C%202005_.pdf [Accessed 5th February, 2025].

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Javaid M, Kumar R, Abbasi MM, Kiyani S, Basharat S. Knowledge, Attitude & Practice regarding use of Personal Protective Equipment (PPE) among Dental Assistants Working at Tertiary Care Hospitals of Multan, Pakistan. J Liaqaut Univ Med Health Sci. 2019 Oct 9;18(03):225-30.

Jawaid SA. Mian Nawaz Sharif's illness, medical report and severity of his diseases remains under discussion. Pulse International. 2022 Feb 28;23(4).

Khan R, Mustufa MA. An empirical research study on deluging quackery outlets across Sindh, Pakistan and propositions to deal with confounding factors of rising quackery. JPMA. The Journal of the Pakistan Medical Association. 2023 Jan 1;73(1):135-8.

Malik N, Mehmood Z, Mahmood B. Bio-Medical Waste Management Practices among Healthcare Professionals: A Case Study in District Faisalabad, Punjab Pakistan. Pak J Soc Res. 2021 Dec 31;3(4):535-40.

Mitiku G, Admasie A, Birara A, Yalew W. Biomedical waste management practices and associated factors among health care workers in the era of the covid-19 pandemic at metropolitan city private hospitals, Amhara region, Ethiopia, 2020. PloS one. 2022 Apr 6;17(4):e0266037.

Mohan HT, Jayanarayanan K, Mini KM. A sustainable approach for the utilization of PPE biomedical waste in the construction sector. Engineering Science and Technology, an International Journal. 2022 Aug 1;32:101060.

Nosheen F, Malik N, Mehmood Z, Jabeen F, Mahmood A, Ibrahim M, et al. Biomedical waste management associated with infectious diseases among health care professionals in apex hospitals of a typical South Asian city. Environ Res. 2022 Dec 1;215:114240.

Omo QG, Hassan NE. Biomedical waste management and their effects on the Environment: A review. World Journal of Advanced Engineering Technology and Sciences. 2024 Jan 30;11(1):086-95.

Parida VK, Sikarwar D, Majumder A, Gupta AK. An assessment of hospital wastewater and biomedical waste generation, existing legislations, risk assessment, treatment processes, and scenario during COVID-19. Journal of environmental management. 2022 Apr 15;308:114609.

Selvan Christyraj JR, Selvan Christyraj JD, Adhimoorthy P, Rajagopalan K, Nimita Jebaranjitham J. Impact of biomedical waste management system on infection control in the midst of COVID-19 pandemic. The Impact of the COVID-19 Pandemic on Green Societies: Environmental Sustainability. 2021:235-62.

Sengeni D, Padmapriya G, Imambi SS, Suganthi D, Suri A, Boopathi S. Biomedical waste handling method using artificial intelligence techniques. InHandbook of Research on Safe Disposal Methods of Municipal Solid Wastes for a Sustainable Environment 2023 (pp. 306-323). IGI Global.

Wawale SG, Shabaz M, Mehbodniya A, Soni M, Deb N, Elashiri MA, Naved M. Biomedical waste management using IoT tracked and fuzzy classified integrated technique. Human-centric Computing and Information Sciences. 2022 Jul 15;12(32):32.

World Health Organization. Health-care waste. Available from: https://www.who.int/news-room/fact-sheets/detail/health-care-waste#:~:text=infectious%20waste:%20waste%20known%20or,cancer%20therapy);%20genotoxic%20chemicals; [Accessed 5th February, 2025].

Basit KA, Zafar AB, Fawwad A, Waris N, Shaheen F, Basit A. Psychometric Analysis for fear of COVID-19 Scale (FCV-19S) and its association with depression in patients with diabetes: A cross sectional study from a Tertiary Care Centre in Karachi, Pakistan. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2021 May 1;15(3):733-7.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

World Health Organization. Medical waste. Available from: https://www.who.int/india/health-topics/medical-waste [Accessed 5th February, 2025].

Waris N, Butt A, Askari S, Fawwad A, Basit A. Diabetes and its complications; Knowledge, attitude, and practices (KAP) and their determinants in Pakistani people with type 2 diabetes. Journal of Diabetology. 2021 Jul 1;12(3):293-8