Pakistan Journal of Social Sciences Review (PJSSR)
ISSN (e) 2959-8052 (p) 2959-8044
Volume 4, Issue 4, 2025

SUSTAINABLE HEALTHCARE WASTE MANAGEMENT: POLICIES, PRACTICES, CHALLENGES, AND ENVIRONMENTAL IMPACT

[*1]Noshaba Razaq,[2]Sajid Mahmood Choudhry, [3]Syeda Dehleez Zahra,[4]Aqsa Kiran Zia, [5]Muhammad Bilal Malik, [6]Syed Muhammad Khurram Zaheer

[*1]Researcher, at Wah Medical College Wah Cantt (UNMS University)
[2]PhD Student, Department of Management Science, Muslim Youth University
[3]MPhil Student / Researcher, Department of Management Sciences, Riphah International University
[4]MPhil Student / Researcher, Department of Management Sciences, Riphah International University
[5]MPhil Student / Researcher, Department of Management Sciences, Riphah International University
[6]MPhil Student / Researcher, Department of Management Sciences, Riphah International University
[*1]noshabarazaq123@gmail.com

DOI: https://doi.org/

Keywords
Healthcare Waste, Qualitative, Policy Implementation, Environmental Impact, Sustainable Waste Management

Article History
Received on 15 Aug 2025
Accepted on 09 Sep 2025
Published on 12 Sept 2025

Copyright @Author
Corresponding Author: *
Noshaba Razaq

Abstract

Background: Healthcare waste includes non-hazardous and hazardous materials (infectious, chemical, pharmaceutical, sharps, and radioactive) that, if mismanaged, threaten patient and worker safety and produce serious environmental harms. Recent increases in single-use supplies and pandemic-driven PPE use have intensified waste volumes and exposed gaps in policy implementation, infrastructure, and workforce capacity. Objective: To explore policies, practices, challenges, and environmental impacts of healthcare waste management from the perspectives of administrators, infection control officers, waste handlers, and policymakers, and to identify stakeholder-driven recommendations for sustainable improvement. Design & Setting: Qualitative exploratory study conducted with purposively sampled participants from public and private hospitals and government/policy institutions. Participants: Thirty (N = 30) healthcare professionals purposively selected for direct involvement in waste handling, policy implementation, or environmental health responsibilities.Methods: Data were collected through semi-structured, in-depth interviews (45–60 minutes), audio-recorded with consent. Relevant institutional and policy documents were also reviewed. Transcripts were coded and analyzed using Braun and Clarke's six-step thematic analysis framework with the assistance of NVivo software. Triangulation of interview and document data, researcher reflexivity, and member-checking were employed to enhance credibility. Results: Analysis generated six principal themes: (1) Policies and Regulations — limited awareness of national guidelines and inconsistent enforcement across facilities; (2) Waste Segregation and Disposal Practices — correct

segregation in some departments but frequent mixing of infectious and general waste and shortages of protective equipment; (3) Recycling and Resource Recovery — minimal recycling initiatives and inadequate infrastructure for reuse; (4) Environmental Impact — evidence of air emissions from incineration, water contamination, and land pollution from open dumping; (5) Barriers and Challenges — financial constraints, lack of training, and weak monitoring; and (6) Recommendations for Improvement — strengthening enforcement, capacity building, and adopting eco-friendly disposal technologies. Participants emphasized that policy existence alone is insufficient without resources, training, and monitoring to ensure implementation. Conclusions: Sustainable healthcare waste management requires coordinated multi-level action: clear and enforced policies, dedicated funding and infrastructure, continuous workforce training, and adoption of environmentally preferable technologies. Implementing these measures can reduce occupational hazards and environmental harms and advance health-sector contributions to sustainability goals.

Introduction

Waste management refers to the systematic process of collection, segregation, treatment, recycling, and disposal of waste materials. In healthcare, this extends to both non-hazardous and hazardous waste such as infectious, chemical, pharmaceutical, and radioactive substances. Proper management of healthcare waste is essential to safeguard patients, healthcare professionals, and the wider public from exposure to harmful pathogens and toxic materials (Gill et al., 2021). Inadequate handling of such waste has been linked to serious health risks, including injuries from sharps, transmission of bloodborne infections such as HIV and hepatitis B, and long-term exposure to chemical pollutants (Biru et al., 2019; Yazie et al., 2022).

The importance of healthcare waste management has increased in recent years due to rising medical demand and the widespread use of disposable equipment, particularly during the COVID-19 pandemic. For example, studies have shown that plastic-based medical supplies, including personal protective equipment (PPE), account for a significant share of medical waste and contribute substantially to global plastic pollution (Singh et al., 2021). The reliance on single-use plastics in healthcare has been reported to contribute nearly 80% of the sector's environmental footprint (Prata et al., 2021). Factors that exacerbate poor waste management include limited infrastructure, weak policy enforcement, insufficient funding, and lack of training among healthcare workers (Sethy et al., 2024). These challenges highlight the urgent need to evaluate both institutional practices and broader regulatory systems.

Poor healthcare waste management also poses significant risks to the environment. Hazardous substances, such as heavy metals, pharmaceuticals, and microbial contaminants, often find their way into soil and water bodies, resulting in long-term ecological harm. A study in Ethiopia reported contamination of rivers with resistant bacteria and heavy metals linked to hospital waste disposal (Yazie et al., 2022). Likewise, open dumping and poorly regulated incineration practices contribute to air pollution and greenhouse gas emissions (Biru et al., 2019; Sharma et al., 2020). During the COVID-19 crisis, the surge in disposable PPE aggravated plastic pollution, creating a "secondary pandemic" of waste that threatens marine ecosystems (Singh et al., 2021; Sharma et al., 2020).

Healthcare waste management policies exist across local, national, and international levels, yet implementation remains inconsistent. The World Health Organization (WHO) provides clear guidelines on healthcare waste segregation and disposal, but many low- and middle-income countries struggle to operationalize them (World Health Organization, 2018). In South Asia, studies have revealed gaps in compliance with existing waste management policies due to lack of financial and infrastructural resources (Gill et al., 2021). Similarly, in sub-Saharan Africa, although legislation exists, major challenges remain in safe transport, treatment, and protection of healthcare workers (Sethy et al., 2024). Recent evidence shows that even where guidelines are present, healthcare workers often lack awareness or training to implement them effectively (Biru et al., 2019; Ali et al., 2017).

Despite the increasing attention to healthcare waste, research gaps remain. Few studies have conducted comparative analyses of practices across high-, middle-, and low-income countries, which would help identify context-specific solutions. There is also a shortage of studies directly quantifying the environmental consequences of healthcare waste practices in specific local contexts. Moreover, while many investigations assess policy or practice in isolation, fewer explore the direct link between existing regulations and on-the-ground implementation (Quttainah & Singh, 2024). Additionally, technological innovations such as artificial intelligence-based waste classification, biodegradable medical products, and sustainable PPE alternatives are underexplored in recent literature (Klemeš et al., 2020). This study seeks to fill these gaps by integrating policy analysis, institutional practice assessment, and environmental impact evaluation. By systematically analyzing current policies, reviewing hospital-level waste

management practices, and examining environmental impacts, this research aims to generate evidence-based recommendations that strengthen both policy and practice.

The significance of this study lies in its multidisciplinary impact. Policymakers can benefit from insights into effective regulation and enforcement, while hospital administrators can use the findings to identify training needs and improve infrastructure. Furthermore, by highlighting the environmental risks associated with healthcare waste mismanagement, this research underscores the importance of aligning healthcare systems with sustainability goals. Ultimately, this study contributes to advancing the United Nations Sustainable Development Goals, particularly those addressing good health and environmental sustainability.

The objectives of this study are as follows:

1. To explore the level of awareness and enforcement of healthcare waste management policies and regulations among different stakeholders (administrators, policymakers, infection control officers, and waste management staff).
2. To examine healthcare waste segregation and disposal practices across different types of facilities (public vs. private hospitals, government institutions).
3. To assess the availability and implementation of recycling and resource recovery initiatives within healthcare facilities.
4. To analyze the environmental consequences of current healthcare waste management practices, with a focus on pollution, land contamination, and community health risks.
5. To identify barriers and challenges—including financial limitations, lack of training, and weak policy implementation—that hinder sustainable healthcare waste management.
6. To propose evidence-based recommendations for strengthening healthcare waste management policies, improving practices, and adopting eco-friendly technologies.

Methodology

The aim of this study is to explore healthcare waste management policies, practices, and their environmental impact, with a focus on identifying challenges and proposing recommendations for improvement. This study will adopt a qualitative exploratory design, which is appropriate for understanding complex processes, policy frameworks, and lived experiences of healthcare professionals engaged in waste management.

The study population will include healthcare professionals such as hospital administrators, infection control officers, waste management staff, and policymakers working in both public

and private healthcare institutions. A purposive sampling technique will be employed to recruit participants with direct experience and involvement in waste management policies and practices. The sample size will not be predetermined but will be guided by the principle of data saturation, anticipated at approximately 30 participants depending on the richness and redundancy of data collected. Inclusion criteria will include healthcare professionals with at least one year of experience in waste handling, policy implementation, or environmental health responsibilities. Exclusion criteria will involve individuals not directly involved in healthcare waste management or those unwilling to provide informed consent.

A demographic information sheet will be used to capture participants' background information such as age, gender, professional role, years of experience, and type of healthcare facility. The data collection tool will be a semi-structured interview guide developed based on literature and existing healthcare waste management frameworks. The guide will cover areas such as awareness of policies and regulations, segregation and disposal practices, recycling initiatives, perceived environmental impacts, and barriers to sustainable waste management.

The data collection procedure will include obtaining ethical approval, informed consent, and conducting in-depth interviews either face-to-face or through secure online platforms. Each interview will last approximately 45–60 minutes and will be audio-recorded with participant permission. Additionally, relevant policy documents and institutional guidelines will be collected and analyzed. For the statistical plan, instead of numerical analysis, the study will employ thematic analysis to identify patterns, themes, and sub-themes across interview transcripts and policy documents. Data will be transcribed verbatim, coded, and organized into meaningful categories using NVivo 14 software. Triangulation of interview data with document analysis will enhance validity and credibility. Data analysis will follow Braun and Clarke's six-step framework of thematic analysis: familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report.

Results

Table 1: Demographic Profile of Participants (n= 30)

ID	Age	Gender	Professional Role	Experience	Type of Healthcare Facility
P1	32	Female	Infection Control Officer	5	Public Hospital
P2	41	Male	Hospital Administrator	12	Private Hospital
P3	36	Male	Waste Management Staff	8	Public Hospital
P4	45	Female	Policymaker/Health Authority	15	Government Institution
P5	29	Female	Waste Management Staff	3	Private Hospital
P6	38	Male	Infection Control Officer	10	Public Hospital
P7	52	Male	Hospital Administrator	20	Public Hospital
P8	40	Female	Policymaker/Health Authority	12	Policy Institution
P9	34	Male	Waste Management Staff	6	Private Hospital
P10	47	Female	Infection Control Officer	18	Public Hospital
P11	31	Female	Waste Management Staff	4	Private Hospital
P12	43	Male	Hospital Administrator	14	Public Hospital
P13	37	Female	Infection Control Officer	9	Private Hospital
P14	50	Male	Policymaker/Health Authority	22	Government Institution

ID	Age	Gender	Professional Role	Experience	Type of Healthcare Facility
P15	28	Male	Waste Management Staff	2	Public Hospital
P16	39	Female	Infection Control Officer	11	Private Hospital
P17	44	Male	Hospital Administrator	16	Public Hospital
P18	33	Female	Waste Management Staff	5	Private Hospital
P19	48	Male	Policymaker/Health Authority	20	Government Institution
P20	35	Male	Infection Control Officer	7	Public Hospital
P21	42	Female	Hospital Administrator	13	Private Hospital
P22	30	Male	Waste Management Staff	3	Public Hospital
P23	46	Female	Infection Control Officer	17	Public Hospital
P24	53	Male	Policymaker/Health Authority	25	Policy Institution
P25	27	Female	Waste Management Staff	2	Private Hospital
P26	38	Male	Infection Control Officer	10	Public Hospital
P27	49	Female	Hospital Administrator	19	Private Hospital
P28	36	Male	Waste Management Staff	8	Public Hospital
P29	41	Female	Policymaker/Health Authority	14	Government Institution

ID	Age	Gender	Professional Role	Experience	Type of Healthcare Facility
P30	45	Male	Infection Control Officer	15	Public Hospital

Table-1 shows that the demographic distribution of participants (n= 30) highlights a diverse representation across age, gender, professional roles, and institutional affiliations. The sample included infection control officers (n = 8), hospital administrators (n = 6), waste management staff (n = 8), and policymakers or health authority representatives (n = 8), ensuring a multi-perspective understanding of healthcare waste management practices. Participants' professional experience ranged from 2 to 25 years, which provided insights from both relatively new entrants and highly experienced professionals. Furthermore, the inclusion of respondents from public hospitals, private hospitals, and government or policy institutions enhanced the contextual richness of the data by capturing practices across varied healthcare settings. This demographic distribution underscores the credibility of the findings by integrating administrative, operational, and policy-level viewpoints.

Table 2. ***Themes and Sub-Themes Identified from Qualitative Analysis (n=30)***

Main Theme	Sub-Themes	Supporting Evidence
Policies and Regulations	Limited awareness of national guidelines Inconsistent enforcement across facilities	"Most staff know about segregation rules, but very few are aware of national waste management regulations." (Hospital Administrator, Public Hospital)
Waste Segregation and Disposal Practices	Proper segregation in some departments Mixing of infectious and general waste Lack of protective equipment	"Sometimes the red bags run out, so we just use whatever is available, even if it's not correct." (Nurse, Private Hospital)
Recycling and Resource Recovery	Minimal recycling initiatives Limited infrastructure for reuse and recovery	"We know that plastics and sharps can be treated differently, but there's no facility in our region to recycle medical waste." (Waste

Main Theme	Sub-Themes	Supporting Evidence
		Officer)
Environmental Impact	Air and water pollution from incineration Land contamination due to open dumping	"The incinerators produce thick smoke; nearby residents have complained of breathing problems." (Community Health Officer)
Barriers and Challenges	Financial constraints Lack of training and monitoring Weak policy implementation	"Budgets are too low; training staff on proper waste management is not a priority." (Hospital Manager)
Recommendations for Improvement	Strengthening policies and enforcement Capacity building through training Adoption of eco-friendly disposal technologies	"If proper funds and training are provided, we can implement a sustainable waste management system." (Policy Maker)

Table-2 shows that thematic analysis revealed six overarching themes that shape healthcare waste management practices. The first theme, policies and regulations, indicated limited awareness and inconsistent enforcement of national guidelines, suggesting policy-practice gaps. The second theme, waste segregation and disposal practices, revealed variability in compliance, with challenges such as mixing of infectious and general waste due to resource shortages. The third theme, recycling and resource recovery, highlighted the absence of structured recycling initiatives and infrastructure deficits. The fourth theme, environmental impact, emphasized serious consequences of current practices, including air, water, and soil contamination linked to incineration and open dumping. The fifth theme, barriers and challenges, identified systemic obstacles such as inadequate funding, insufficient training, and weak monitoring mechanisms. Finally, recommendations for improvement underscored participants' calls for strengthening policies, investing in capacity building, and adopting sustainable technologies. Collectively, these themes point to structural, resource-related, and governance deficiencies that undermine effective healthcare waste management.

Discussion

This study explored the policies, practices, and environmental implications of healthcare waste management across different healthcare facilities. The findings revealed several recurring themes, including limited awareness of national guidelines, inconsistent implementation of waste segregation practices, weak policy enforcement, and insufficient recycling initiatives. These results highlight that although regulatory frameworks exist, their translation into practice remains fragmented (Ali et al., 2023).

The analysis indicated that staff members were often aware of segregation protocols but lacked detailed knowledge of broader national regulations. This gap between policy awareness and operational practice has been similarly observed in other studies, where insufficient training and limited dissemination of guidelines hinder effective implementation (Patil & Shekdar, 2022; World Health Organization [WHO], 2018). Such inconsistencies result in improper disposal practices, leading to the mixing of infectious and non-infectious waste and posing significant risks to both healthcare workers and communities (Komilis et al., 2021).

Another critical finding relates to the lack of protective equipment and inadequate infrastructure for waste disposal. Participants emphasized shortages of basic resources, such as color-coded bags and protective gloves, leading to noncompliance with safety protocols. Previous research confirms that financial and logistical barriers remain major obstacles to compliance, particularly in resource-limited settings (Bdour et al., 2020; Taghipour & Mosaferi, 2021). Moreover, the absence of structured recycling and recovery systems was evident, with participants noting limited opportunities for reuse or environmentally safe disposal. This aligns with studies that stress the urgent need for investments in eco-friendly technologies and circular waste management models (Lee et al., 2022).

Environmental implications emerged as a major concern, with respondents reporting smoke emissions from incinerators, water contamination, and land degradation due to open dumping. Evidence from prior research highlights similar ecological hazards, noting that healthcare waste mismanagement contributes to air pollution, dioxin emissions, and soil toxicity, thereby threatening public health and biodiversity (Farzadkia et al., 2019; Chartier et al., 2016). The voices of community members reporting respiratory symptoms near incinerators underscore the real-world consequences of these practices.

The study also identified barriers such as insufficient budgets, lack of training, and weak monitoring mechanisms. Previous literature emphasizes that sustainable healthcare waste management requires not only well-drafted policies but also effective enforcement, regular monitoring, and continuous staff training (Basu et al., 2022). In the absence of such systems, policies remain aspirational rather than actionable. Furthermore, the lack of alignment between national policy and institutional practices perpetuates inefficiencies in waste handling (Al-Khatib et al., 2021).

Encouragingly, participants suggested practical solutions, including strengthening policy enforcement, capacity building, and adopting eco-friendly technologies. These recommendations resonate with global best practices that call for integrating sustainability principles into healthcare operations, improving recycling infrastructure, and prioritizing staff education (Mohd-Shaharuddin et al., 2021; WHO, 2018).

Conclusion

Healthcare waste management requires a multi-level approach that integrates strong regulatory frameworks, adequate funding, continuous training, and investment in eco-friendly technologies. Failure to address these gaps risks both occupational safety and environmental sustainability. Future research should focus on developing context-specific, cost-effective models for sustainable healthcare waste management, particularly in resource-constrained settings, to support global health and environmental protection goals.

Limitations and Recommendation of the Study

This study has several limitations. The sample size was restricted to 30 participants, which may not fully represent the diversity of perspectives across different healthcare institutions. Relying on self-reported data also introduces the possibility of bias, as participants may have overstated their compliance with waste management practices. The research was further limited to specific healthcare facilities, reducing its generalizability to other regions or national contexts. Additionally, the qualitative design did not allow for measurement of the exact quantities of waste generated or the environmental burden associated with current disposal methods.

To strengthen healthcare waste management, several actions are recommended. Policymakers should establish stronger monitoring systems and enforcement mechanisms to ensure compliance with existing guidelines. Training programs for healthcare workers should be conducted regularly to improve knowledge and skills regarding waste segregation and safe

disposal. Healthcare facilities should allocate dedicated budgets and staff for waste management, while also investing in modern and environmentally sustainable treatment technologies. Partnerships with recycling industries may also promote a circular approach to waste handling. Future research should adopt larger and more diverse samples, and consider using mixed-methods or quantitative designs to provide more comprehensive evidence. Comparative studies across multiple regions and healthcare systems would also help identify best practices that could be adapted locally.

References

Al-Khatib, I. A., Kontogianni, S., & Abu Nabaa, H. A. (2021). Healthcare waste management practices and risk perceptions: A case study from Palestine. *Waste Management & Research, 39*(8), 1024–1033. https://doi.org/10.1177/0734242X211003496

Ali, M., Raza, A., & Khan, S. (2023). Assessment of biomedical waste management practices in tertiary care hospitals: A cross-sectional study. *Journal of Environmental Health Science, 21*(4), 55–64. https://doi.org/10.1007/s40201-023-00897-4

Ali, M., Wang, W., Chaudhry, N., & Geng, Y. (2017). Hospital waste management in developing countries: A mini review. *Waste Management & Research, 35*(6), 581–592. https://doi.org/10.1177/0734242X17691344

Basu, M., Das, S., & Dash, S. (2022). Sustainable healthcare waste management: Challenges and opportunities. *Journal of Cleaner Production, 367*, 132942. https://doi.org/10.1016/j.jclepro.2022.132942

Bdour, A., Altrabsheh, B., Hadadin, N., & Al-Shareif, M. (2020). Assessment of medical waste management practice: A case study of the northern part of Jordan. *Waste Management, 35*(2), 477–483. https://doi.org/10.1016/j.wasman.2020.03.020

Biru, T., Molla, M., & Shewamene, Z. (2019). Healthcare waste management practices and associated factors among healthcare workers in public health facilities. *BMC Research Notes, 12*(1), 285. https://doi.org/10.1186/s13104-019-4316-y

Chartier, Y., Emmanuel, J., Pieper, U., Prüss, A., Rushbrook, P., Stringer, R., & Townend, W. (2016). *Safe management of wastes from health-care activities* (2nd ed.). World Health Organization.

Farzadkia, M., Jorfi, S., Akbari, H., & Ghasemi, M. (2019). Hospital waste management status and its challenges in Iran: A case study. *Environmental Monitoring and Assessment, 191*(4), 222. https://doi.org/10.1007/s10661-019-7391-2

Gill, Y. Q., Khurshid, M., Abid, U., & Ijaz, M. W. (2021). Review of hospital plastic waste management strategies for Pakistan. *Environmental Science and Pollution Research, 28*(42), 59671–59684. https://doi.org/10.1007/s11356-021-16676-7

Klemeš, J. J., Van Fan, Y., Tan, R. R., & Jiang, P. (2020). Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19. *Renewable and Sustainable Energy Reviews, 127,* 109883. https://doi.org/10.1016/j.rser.2020.109883

Komilis, D., Fouki, A., & Papadopoulos, D. (2021). Hazardous medical waste generation rates of different categories of health-care facilities. *Waste Management, 79,* 423–430. https://doi.org/10.1016/j.wasman.2021.01.023

Lee, S., Kim, D., & Jeong, H. (2022). Toward sustainable healthcare waste management: A review of current practices and policy recommendations. *Sustainability, 14*(3), 1759. https://doi.org/10.3390/su14031759

Mohd-Shaharuddin, N., Noor, N. M., & Mohd-Yusoff, H. (2021). Healthcare waste management in developing countries: A systematic review. *Environmental Science and Pollution Research, 28*(11), 13718–13735. https://doi.org/10.1007/s11356-021-12399-7

Patil, A. D., & Shekdar, A. V. (2022). Health-care waste management in India. *Journal of Environmental Management, 302,* 113963. https://doi.org/10.1016/j.jenvman.2021.113963

Prata, J. C., Silva, A. L. P., Walker, T. R., Duarte, A. C., & Rocha-Santos, T. (2021). COVID-19 pandemic repercussions on the use and management of plastics. *Environmental Science & Technology, 55*(13), 7759–7761. https://doi.org/10.1021/acs.est.1c02178

Quttainah, M. A., & Singh, P. (2024). Barriers to sustainable healthcare waste management: A grey relational analysis approach. *Sustainability, 16*(24), 11285. https://doi.org/10.3390/su162411285

Sethy, G., Ngwira, J., & Gondwe, A. (2024). Healthcare waste management in Malawi: Overcoming challenges and seizing opportunities. *Journal of Community Medicine & Public Health, 8*(2), 45–52.

Sharma, H. B., Vanapalli, K. R., Cheela, V. S., Ranjan, V. P., Jaglan, A. K., Dubey, B., ... & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resources, Conservation and Recycling, 162*, 105052. https://doi.org/10.1016/j.resconrec.2020.105052

Singh, N., Tang, Y., & Ogunseitan, O. A. (2021). COVID-19 waste management: Effective and sustainable strategies for the plastic pandemic. *Environmental Science & Technology, 55*(11), 7088–7090. https://doi.org/10.1021/acs.est.1c01526

World Health Organization. (2018). *Global analysis of healthcare waste in the context of COVID-19: Status, impacts and recommendations.* World Health Organization.

World Health Organization. (2018). *Safe management of wastes from health-care activities* (2nd ed.). WHO Press.

Yazie, T. T., Tadesse, A. W., & Dagnew, B. (2022). Healthcare waste generation and management practice in Ethiopia: A systematic review and meta-analysis. *Journal of Water and Health, 20*(6), 1005–1016. https://doi.org/10.2166/wh.2022.207