Environ Health Eng Manag 2027;14:1814
http://ehemj.com

doi:10.34172/EHEM.1814

Environmental Health Engineering and Management Journal

Original Article

Environmental Health Engineering and Management

Open Access Publish Free

Governance Gaps and Segregation Without Treatment: Comparative Assessment of Healthcare Waste Management in Public and Private Hospitals in Bheemdatta Municipality, Nepal

Sagar Hamal[1*], Crimsan Singh Negi[1], Sangam Jagari[1], Dhundi Raj Pathak[2], Subash Dhakal[3]

[1]School of Engineering, Far Western University, Mahendranagar, Kanchanpur, 10400, Nepal
[2]Center of Research for Environment, Energy and Water, Baluwatar, Kathmandu, Nepal
[3]School of Science, Kathmandu University, Dhulikhel, Nepal

Abstract

Introduction: Although the decentralization of governance in Nepal has delegated oversight of healthcare waste management (HCWM) to municipalities, comparisons of the performance of public and private hospitals under this localized framework remain limited. This comprehensive municipal census of all hospitals in Bheemdatta Municipality offers a novel, system-level evaluation of HCWM performance across both sectors within a decentralized context.

Methods: A cross-sectional census of all eligible hospitals (1 public, 2 private) employed the WHO and Nepal hospital definitions. HCWM performance was assessed via the standardized UNDP I-RAT (61 yes/no indicators) covering governance/administration (Domain I) and operations/infrastructure (Domain II). Domain and aggregate scores were calculated as percentages of full compliance.

Results: Public hospital (A) achieved an overall score of 88.7% ("Excellent"), with strong performance in both governance (77.7%) and operations (94.5%). In contrast, private hospitals (B & C) scored 38.4% and 44.2% overall (both "Poor"), driven primarily by weak governance capacity (26.6–43.6%) and near-absence of compliant infectious-waste treatment (2.1%). Despite this, all facilities demonstrated uniformly high performance in segregation, handling, and sharps management (>98%). This revealed a consistent pattern of systematic segregation without compliant treatment in private hospitals.

Conclusion: In Bheemdatta Municipality, HCWM disparities were primarily due to governance deficiencies and insufficient infectious-waste treatment facilities within private hospitals–not routine waste-handling practices. These findings offer local-level evidence to strengthen regulatory oversight, scale centralized treatment infrastructure, and reinforce accountability through targeted policy interventions, facilitating progress toward SDGs 3 and 6.

Keywords: Hazardous waste, Occupational health, Sustainable development, Developing countries, Waste management

Citation: Hamal S, Negi CS, Jagari S, Pathak DR, Dhakal S. Governance gaps and segregation without treatment: comparative assessment of healthcare waste management in public and private hospitals in bheemdatta municipality, nepal. Environ Health Eng Manag 2027;14:1814. doi:10.34172/EHEM.1814

Article History:
Received: December 3, 2025
Revised: June 16, 2026
Accepted: July 15, 2026
ePublished: November 4, 2026

***Correspondence to:**
Sagar Hamal, Email: hamal.sagar@fwu.edu.np

Introduction

Effective healthcare waste management (HCWM) is fundamental to infection prevention and control, safeguarding patient safety, personnel, and the environment. Although hazardous waste constitutes only 15–25% of total healthcare waste (HCW), improper management remains a major public health risk. In 2010, inadequate waste management linked to unsafe injection practices caused an estimated 33,800 HIV, 1.7 million hepatitis B, and 315,000 hepatitis C infections. Despite recent progress, access to basic HCWM services remains insufficient, with only 61% of hospitals equipped in 2021, and coverage declining to 25% in fragile settings by 2023 (1,2).

In Nepal, rapid urbanization (~0.92% annual population growth) and healthcare services expansion (from 301 private facilities in 2014 to 533 hospitals by 2015/16) have exacerbated this challenge, increasing hazardous waste generation to an estimated 3,094 tons annually and straining existing systems (3-6). While waste segregation is common, only 38.7–39% of hospitals comply with national HCWM standards (5,7,8). This has created a "segregation-

© 2027 The Author(s). Published by Kerman University of Medical Sciences. This is an open-access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

without-treatment" paradox: clinical waste is separated at the source but often disposed of alongside general municipal waste in landfills or open pits. Approximately 27% of infectious waste is commingled with general waste, with contamination reaching 55% of the total infectious stream (5,8). Chronic underinvestment, inadequate human resources, and weak regulation further compound these issues. Notably, 79.03% of facilities lack proper waste transportation; nearly 70% rely on non-functional incinerators —resorting to open burning, burial, or disposal through municipal waste streams—58% allocate less than 5% of their annual budget to HCWM activities (8,9).

International evidence regarding HCWM practices is inconsistent. Studies from Pakistan suggest superior performance in public institutions, whereas Indian data often favor private providers regarding segregation, despite both sectors struggling with terminal treatment (10,11). Nepal exhibits similar variance. Public hospitals face overcrowding and resource deficits while managing high waste volumes, sometimes exceeding 723.8 kg/day (12). Conversely, while private facilities frequently report high segregation rates, this may reflect "visual compliance" rather than verified treatment capacity. Ultimately, the public–private performance gap remains ambiguous, likely driven more by institutional governance and clinical guideline adherence than by ownership model (10,11,13).

Despite established policy frameworks, such as the National Health Care Waste Management Guideline (2014) and related Standards and Operating Procedures (2020), implementation remains deficient (9,14,15). Critical evaluation of these policy instruments reveals that the National guideline is non-binding, lacking enforceable standards, mandates for specific treatment technologies, or performance indicators like biological sterilization validation. Similarly, the Standards and Operating Procedures lack robust enforcement or penalty mechanisms. Consequently, facilities may demonstrate surface-level compliance through color-coded bin usage while discharging untreated infectious waste into municipal systems (7). Empirically, the lack of dedicated storage and functional treatment infrastructure, such as autoclaves, often results in non-compliant processing, even when internal policies mandate otherwise (12).

Institutional oversight in Nepal is hindered by fragmented governance and weak intergovernmental coordination. Although the Ministry of Health and Population is responsible for establishing national policy, it lacks authority for routine field inspections (16). Provincial health directorates provide technical support but have limited legal power to enforce compliance or impose sanctions. Following the federal restructuring of 2015, monitoring responsibilities were devolved to 753 municipalities; however, many local governments, including Bheemdatta Municipality, operate within a technical and regulatory vacuum (7,16). Municipalities often lack specialized personnel, laboratory capacity for biological indicator testing, and monitoring equipment required to verify sterilization performance (7,17). Consequently, inspections primarily focus on visible indicators, such as the presence of color-coded bins and personal protective equipment, rather than treatment effectiveness or process validation (18). The absence of a centralized reporting mechanism and the lack of documented penalties, license suspensions, or legal actions further highlight the existence of an enforcement vacuum (16,17). This systemic weakness enables many private healthcare facilities, which account for approximately 78% of the country's healthcare institutions, to operate without adequate treatment infrastructure (4).

Despite growing attention, critical research gaps remain. Existing studies often focus on major urban centers (e.g., Kathmandu, Biratnagar, Nepalgunj, etc.) with limited evidence from rapidly urbanizing municipalities in Sudurpaschim province, rely on self-reported data rather than standardized assessment—limiting reliability and comparability, and lack systematic public–private comparisons in the post-federal context (5,7,8,12,16,18-21). This is particularly relevant for Bheemdatta Municipality in Kanchanpur District, where rapid urbanization, population growth (2.28% annually) driven by internal migration, and healthcare expansion have intensified patient load and HCW generation (22,23,24). Addressing these gaps, this study presents a novel municipality-level census of all Bheemdatta hospitals, utilizing the United Nations Development Programme's Individualized Rapid Assessment Tool (UNDP I-RAT) for the first comprehensive comparison of HCWM performance between public and private hospitals. Although not intended for national generalization, these findings provide municipality-level evidence to strengthen regulatory oversight, expand access to compliant centralized treatment infrastructure, and guide targeted interventions in support of Sustainable Development Goals (SDGs) 3 and 6 (25). Moreover, this UNDP I-RAT demonstrates a replicable baseline for other municipalities in Nepal and comparable low- and middle-income country (LMIC) settings.

Materials and Methods

Study area and healthcare system characteristics

The study was conducted in Bheemdatta Municipality (formerly Mahendranagar), located in Sudurpaschim Province, Nepal, serving as the administrative and commercial hub of Kanchanpur District. Geographically, it spans from 28°52′–29°08′ N latitude and 80°06′–80°15.5′ E longitude (Figure 1), encompassing 171.63 km^2 and 19 administrative wards. The municipality features varied topography, with elevations ranging from 222.5 to 1,192 m above mean sea level. Its subtropical climate is characterized by an average annual rainfall of 2,377 mm, summer temperatures between 35 and 43°C, and winter temperatures from 5 to 19°C. According to the National Population and Housing Census 2021, the municipality recorded a population of 122,320 residing in 27,570 households (22-24,26).

The municipal healthcare system consists of 16 health facilities: one public hospital, one health post, seven

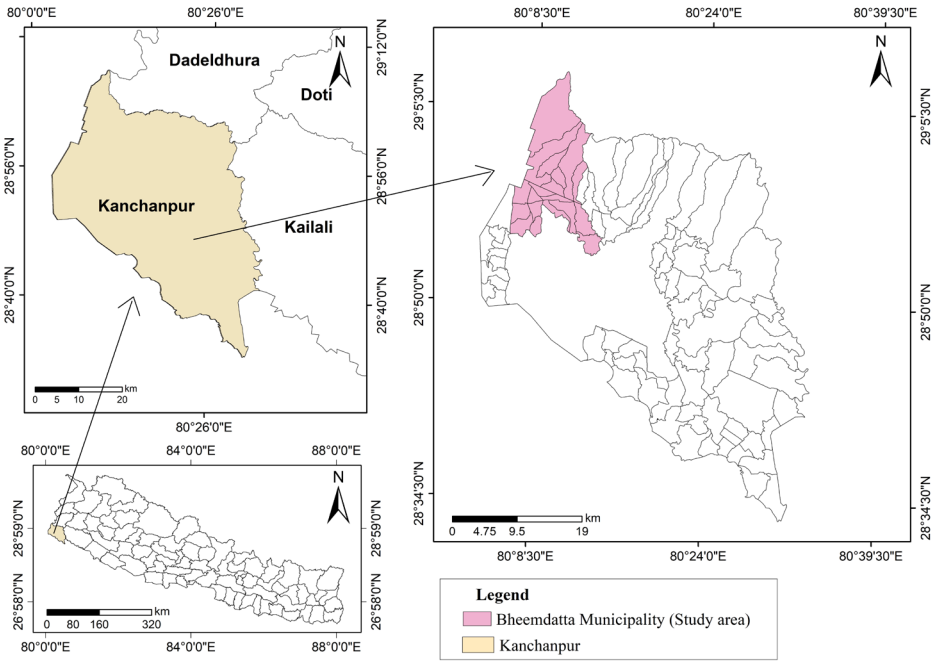


Figure 1. Map of (a) Nepal, (b) Kanchanpur District, and (c) Bheemdatta Municipality (Study Area)

urban health centers, and seven private facilities including hospitals, clinics, diagnostic centers, and pharmacies (27). This hybrid healthcare arrangement, featuring a single public hospital alongside numerous private providers, reflects the service delivery model prevalent in many Nepali municipalities following federal decentralization. With its increasing population, expanding healthcare services, and evolving local governance responsibilities, Bheemdatta Municipality offers an appropriate context for examining HCWM practices within a rapidly urbanizing setting.

Study design and hospital selection

A cross-sectional municipal census design was utilized in September 2024 to compare HCWM performance between public and private hospitals within Bheemdatta Municipality. This municipal census approach was chosen to ensure comprehensive coverage of all hospitals under the same local governance, allowing for a thorough evaluation of HCWM performance within Nepal's decentralized federal framework. Hospitals were selected from healthcare facilities due to their role as primary generators of diverse and high-risk HCW streams, necessitating more extensive HCWM systems, including institutional governance structures, operational mechanisms, and treatment infrastructure, compared to smaller outpatient facilities (6,28). All healthcare facilities in the municipality were screened based on the World Health Organization's (WHO) definition of a hospital, which describes a hospital as a facility that provides inpatient accommodation and active medical/nursing care under the supervision of at least one physician (29). This definition is consistent with Nepal's Public Health Service Regulations (2020), which classify facilities offering inpatient services as hospitals (30).

Out of 16 healthcare facilities operating in the municipality, only three met the inclusion criteria and were thus included in the study: one public hospital (Hospital A) and two private hospitals (Hospitals B and C). All three institutions operate under the same local governance framework.

HCWM assessment tool: UNDP I-RAT

The UNDP I-RAT consists of a structured set of 70 binary (yes/no) questions or indicators that cover various HCWM system components. These indicators are weighted according to their relative importance, with scores ranging from 0.5 to 5. Autoclave use is assigned a score of 6, and treatment is assigned a score of 25. This binary scoring approach reduces assessor subjectivity and generates standardized quantitative scores, facilitating objective comparison among hospitals and aiding evidence-based HCWM planning and prioritization. The tool has been successfully applied and validated in various healthcare settings globally (18,19,31).

The I-RAT tool proved especially suitable for this study as it distinguishes between governance and administrative functions (Domain I) and operational and infrastructure practices (Domain II), enabling identification of whether HCWM deficiencies stem primarily from governance weaknesses or operational capacity gaps or both (19,31).

- **Domain I:** Governance and Administration (maximum score: 47), which evaluated organizational structure, policy, and planning frameworks, staff training, occupational health and safety (OHS) measures, monitoring and evaluation systems, corrective action mechanisms, and financing arrangements, including budget allocation and adequacy.
- **Domain** II: Operations and Infrastructure (maximum score: 91), which assesses waste segregation and classification, color-coding and labeling systems, waste quantification and documentation, collection and handling procedures, internal transportation, storage facilities, treatment technologies, and final disposal

practices.

Data collection procedures and rigor

Following written approval from hospital administrations and obtaining informed consent from participants, data were collected over one week, contingent on personnel availability. Fieldwork was conducted by a three-member research team, including a supervisor, who received two days of training from an HCWM specialist. This training covered national HCWM standards, UNDP I-RAT guidance, indicator scoring procedures, and methods for resolving common scoring ambiguities.

The assessment utilized 61 contextually relevant I-RAT questionnaires, organized into 15 components across two domains (Supplementary Table S1). Before data collection, the questions were translated into Nepali, the national language, with assistance from an HCWM specialist and supervisor. They were then pre-tested in a non-study health post to evaluate comprehensibility, refine assessment procedures, improve question clarity, enhance inter-rater reliability, and identify operational challenges. Inter-rater agreement was established through consensus scoring, with any discrepancies resolved via discussion and reference to the I-RAT guidance and standardized study materials (19).

Consistent with the I-RAT methodology, HCWM performance was evaluated through key informant interviews, direct observation, and document review. This approach facilitated comprehensive verification and triangulation of evidence while minimizing reporting bias (19,21).

- **Key informant interviews:** Interviews, based on the 61-question I-RAT, were conducted with personnel directly responsible for HCWM activities (if available) and staff representing various organizational levels within each hospital (Table 1). Including respondents from multiple administrative and operational levels helped cross-validate reported practices. Interviews were conducted in Nepali, audio-recorded with participant consent, and transcribed verbatim to support subsequent indicator verification and scoring decisions (20).
- **Direct observation:** Systematic observation was undertaken to validate interview findings and assess HCWM practices in real time (18,20). Following the I-RAT framework, a walkthrough of the entire HCWM pathway was conducted, from points of generation, including wards, intensive care units (ICUs), and operating theatres (OTs), to treatment and final disposal sites (e.g., equipment functionality) (12,20). Photographic evidence was collected where permitted to support indicator verification and scoring decisions.
- **Document review:** Relevant HCWM records were systematically reviewed using a structured checklist aligned with I-RAT indicators (19). Documents examined included HCWM committee and in-charge appointment records, policies and standard operating procedures; staff training records and attendance logs (if available); monitoring and supervision reports (if available); budget and financing documents, procurement and maintenance records for HCWM equipment and treatment materials (e.g., needle cutters, autoclaves, and treatment chemicals), waste generation and disposal logs, occupational health records, vaccination records of waste handlers, and available audit reports, supporting indicator verification and scoring decisions.

Following data collection, a debriefing session was held with hospital administrators and relevant personnel to confirm factual accuracy and reconcile inconsistencies across data sources. Final indicator scores were determined by triangulating findings from interviews, direct observations, document reviews, and debriefing evidence, with scoring founded on the consistency and convergence of results across these sources.

Table 1. Key informants interviewed in each hospital

Key Informant	Hospital A	Hospital B	Hospital C
Hospital Administrator	1	1	1
Medical Superintendents	1	-	-
Senior Nursing Staff	2	1	1
HCWM focal person	1	-	-
Ward In-charge	5	2	1
Waste Handler	2	1	1
Total	12	5	4

Data analysis

Indicator scores were entered into Microsoft Excel and aggregated at the component, domain, and overall levels, yielding a maximum potential score of 138. For each indicator, a "yes" response received the full allocated score, whereas a "no" response was awarded zero points. These total scores were subsequently converted into percentages to facilitate the comparison of HCWM performance across hospitals. Based on the standardized UNDP I-RAT criteria, each hospital's overall percentage score was categorized into one of four performance levels: Excellent (76–100%), Good (51–75%), Poor (26–50%), or Very Poor (0–25%) (18,31). HCWM performance between public and private hospitals was compared descriptively using domain- and overall-level scores and percentages.

Results

Overall HCWM performance

The assessment of HCWM performance across public and private hospitals in Bheemdatta Municipality, using the UNDP I-RAT framework, revealed pronounced sectoral disparities. Hospital A (public) achieved an overall score of 88.7% (122.5/138), categorizing its performance as "Excellent." In contrast, Hospital B and C (private) scored 38.4% (53/138) and 44.2% (61/138), respectively, both classified as "Poor" (Table 2, Figure 2). A detailed analysis across domains revealed the drivers of this disparity (Table S1).

Table 2. Comparison of HCWM performance across assessed public and private hospitals and the findings from previous studies

Domain/Component	Max. score	Hospital					
		Public Private Private A B C			Public Private Public * * **		
		Present Study			Previous Studies (18**,19*)		
Governance and Administration (Domain I)	**47**	**36.5**	**12.5**	**20.5**	**40.5**	**37.5**	**4**
a. Organization, Policy and Planning	19	12.5	3.5	3.5	17	16.5	0
b. Training	12	11	0	8	11	11	0
c. Occupational Health and Safety (OHS)	7	7	4	4	4	2	0
d. Monitoring, Evaluation and Finance	9	6	5	5	8.5	8	4
Operations and Infrastructure (Domain II)	91	86	40.5	40.5	–	–	32
e. Segregation, Handling, Sharps Management and Transport	34.5	34	34	34	33.5	33	4
f. Waste Generation Data	2	1.5	0	0	2	1.5	
g. Storage	2.5	2.5	1.5	1.5	2.5	2.5	0
h. Hazardous Waste	5	5	4	4	5	5	0
i. Treatment and Disposal	47	43	1	1	–	–	28
Total Score (%)	138	122.5 (88.7%)	53 (38.4%)	61 (44.2%)	– (91%)	– (88%)	36 (26.1%)
Performance Category		Excellent	Poor	Poor	Excellent	Excellent	Poor

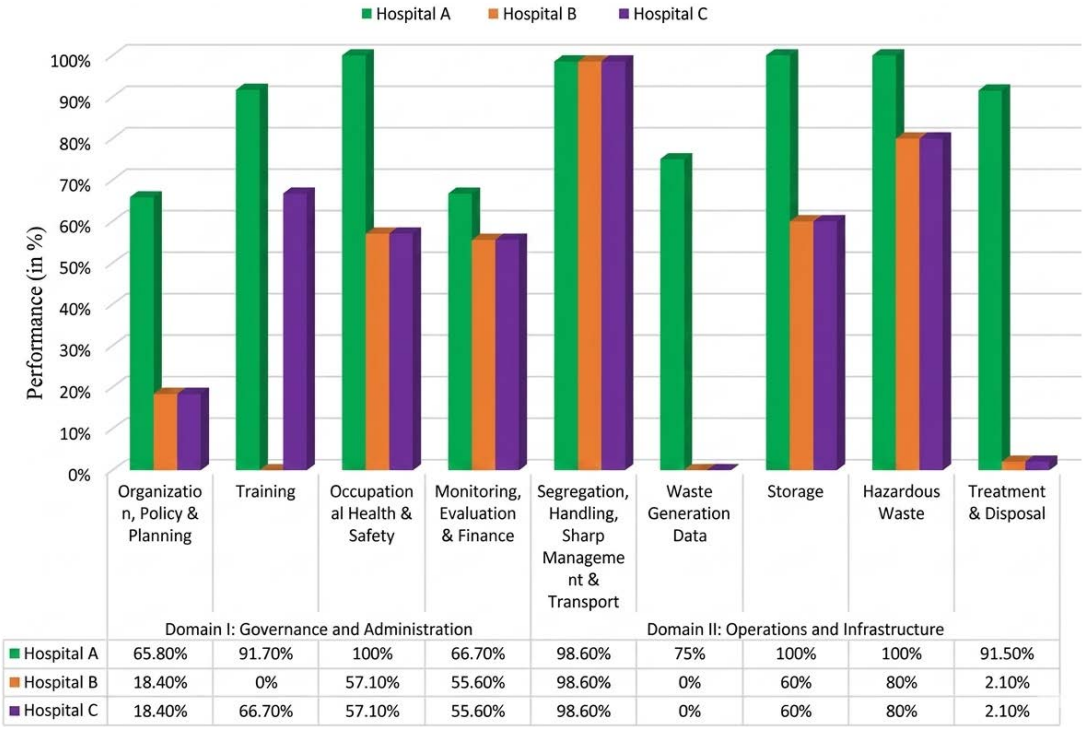


Figure 2. Comparative HCWM performance (in %) across the assessed public and private hospitals

Governance and administration (Domain I)

In Domain I, Hospital A scored 77.7% (36.5/47), significantly outperforming Hospitals B and C, which scored 26.6% (12.5/47) and 43.6% (20.5/47), respectively. This divergence stemmed from differential performance across key components (Table S1, Table 2, Figure 2).

In 'organization, policy, and planning', Hospital A scored 65.8% (12.5/19), whereas Hospitals B and C each scored 18.4% (3.5/19). Hospital A was the only facility with a designated HCWM in-charge (5/5) and documented HCWM policies (2/2), whereas both private hospitals scored zero on both indicators. All three hospitals had written HCWM plans or procedures (2/2). However, none had policies, plans, or procedures consistent with national regulations (0/3.5) or a mercury phase-out plan (0/1.5). 'Training' practices further highlighted disparities. Hospital A provided comprehensive training covering national laws and technical procedures, including induction for new staff, achieving a score of 91.7% (11/12). Hospital C had a training program but did not train new staff upon employment, scoring 66.7% (8/12). Hospital B lacked a formal training program entirely, scoring zero. Notably, no hospital conducted annual refresher training. Regarding 'OHS', all hospitals provided proper personal protective

equipment (PPE) and vaccinations to relevant workers. However, only Hospital A formally integrated OHS within its HCWM policies and plans, achieving a perfect score of 100% (7/7) for this component. Hospitals B and C, lacking this formal integration, each scored lower at 57.1% (4/7). In 'monitoring, evaluation, and finance', Hospital A, which scored 66.7% (6/9), was the only facility with a system for internal monitoring (1/1), whereas Hospitals B and C each scored 55.6% (5/9). All three hospitals had an annual budget allocation for HCWM (4/4) and a system for corrective action (1/1). However, none reported sufficient current funding (0/2), a long-term financing plan (0/0.5), or annual policy reviews (0/0.5).

Operations and infrastructure (Domain II)

Domain II showed a stark disparity, with Hospital A achieving 94.5% (86/91) compared to only 44.5% (40.5/91) in both Hospitals B and C (Table S1, Table 2, Figure 2).

Performance in core operational components like 'segregation, handling, sharps management, and transport' was uniformly high and nearly identical across all hospitals, with scores near 98.5% (34/34.5). All facilities demonstrated proper segregation, sharps management, use of appropriate containers, and followed correct transport practices, though none performed daily cleaning of transport carts. Critical gaps emerged in other components. Only Hospital A systematically measured 'daily waste generation' and the proportion of infectious waste (1.5/2). For 'storage', Hospital A met all requirements (2.5/2.5), while Hospitals B and C had deficient storage areas, resulting in scores of 1.5 each. All hospitals segregated hazardous chemical and pharmaceutical waste, but only Hospital A also had a specific treatment and disposal plan for such waste, scoring 5 out of 5, while Hospitals B and C (4/5). The most profound disparity was in the 'treatment and disposal' of infectious waste. Hospital A operated on-site autoclaves meeting international standards, supported by regular maintenance and safety protocols, scoring 91.5% (43/47). Conversely, Hospitals B and C did not treat their infectious waste before disposal, lacked contingency plans, and had no treatment technology or maintenance programs. Consequently, each private hospital scored only 2.1% for treatment and disposal, a point earned solely for keeping PVC plastics out of burned waste (Table S1, Table 2, Figure 2).

Discussion

This study conducted in Bheemdatta Municipality reveals a distinct governance–treatment disconnect within Nepal's decentralized healthcare system. Overall HCWM performance varied significantly: the public hospital achieved excellent (88.7%), while private hospitals performed poorly (38.4–44.2%). Despite uniform high compliance with waste segregation and sharps management (98.6%), terminal treatment in private hospitals was nearly absent (2.1%), indicating a "segregation-treatment paradox" previously observed in Nepal (7). These disparities likely reflect "visual compliance," where private hospitals prioritized visible indicators like color-coded bins while neglecting treatment infrastructure, institutional policies, staff training, occupational safety, and designated HCWM focal personnel. Furthermore, the absence of enforceable provisions provides little incentive to prevent the disposal of untreated waste into municipal waste streams (7,19). Comparison with previous studies indicates substantial public sector improvement. The public hospital score (88.7%) greatly exceeded the 26.1% reported from a tertiary government hospital in Kathmandu a decade earlier (18), consistent with evidence of strengthening HCWM systems elsewhere in Kathmandu. In contrast, the private hospitals performed below previously reported private-sector benchmarks from Kathmandu (19), suggesting that governance, rather than ownership alone, determines HCWM performance. Unlike earlier studies reporting poor HCWM performance despite existing treatment infrastructure (18), this study identified strong segregation practices alongside near-absent treatment. Together with evidence from other LMICs documenting persistent treatment deficiencies (28,32), these findings demonstrate that upstream practice improvements do not necessarily ensure downstream biosafety outcomes. The substantial variation among facilities within the same municipality indicates that decentralization alone is insufficient to ensure regulatory compliance. Extending the technical vacuum framework, the findings suggest that post-2015 federal restructuring devolved oversight without providing municipalities with the technical capacity required for biological validation of treatment. Consequently, treatment effectiveness is often assessed via staff perceptions rather than objective verification. This is concerning given evidence that 71% of autoclave cycles in Nepal fail biological indicator testing despite appearing functional (33), highlighting structural weaknesses in the relationship between federal policy and municipal enforcement.

Three priority actions emerge. First, centralized treatment facilities (CTF) may offer a scalable, cost-effective alternative for resource-constrained private hospitals, provided they are supported by municipal investment, public–private partnerships, and mandatory biological validation. Second, annual hospital license renewal should require documented treatment receipts, designated HCWM focal personnel, and regular staff training. Third, regulatory frameworks must incorporate enforceable sanctions to address the accountability gap. Routine waste handling improvements are unlikely to achieve meaningful biosafety outcomes without parallel investments in governance and treatment systems.

A major strength of this study was its municipal census design, which included all Bheemdatta Municipality hospitals and employed the validated UNDP I-RAT framework, providing a replicable approach for Nepal and similar LMICs. Limitations include the small number of facilities (n = 3), which restricts generalizability, and the cross-sectional design, which precludes assessment of temporal changes or causal inference between governance factors and treatment outcomes. Future research should adopt longitudinal, multisite designs to assess temporal

HCWM trends, alongside costing studies comparing the long-term financial viability of on-site autoclaves versus CTFs in private hospital settings.

Conclusion

This municipal census identifies a clear "segregation-without-treatment" paradox in Bheemdatta Municipality: while all hospitals demonstrate high compliance in waste segregation and handling, private hospitals have almost no compliant infectious waste treatment, resulting in poor overall HCWM performance compared with the excellent performance of the public hospital. The findings indicate that decentralization alone has not closed this gap; rather, the problem is driven by weak governance, lack of enforceable sanctions, and limited access to treatment infrastructure, rather than ownership differences. Sustainable improvement requires stronger enforcement and institutional accountability, including designated HCWM focal persons, institutional policies, regular staff training, and centralized treatment facilities with mandatory biological validation as a licensing requirement. Limited by a small sample and cross-sectional design, the study suggests future longitudinal research to assess causal pathways. Without enforceable regulation and accessible treatment systems, the segregation–treatment paradox will persist, undermining SDGs 3 and 6. The UNDP IRAT framework offers a replicable baseline for other municipalities.

Acknowledgments

The authors gratefully acknowledge the administration and staff of the participating hospitals within Bheemdatta Municipality, Nepal, for their invaluable support and cooperation throughout this study.

Authors' Contribution

Conceptualization: Sagar Hamal, Dhundi Raj Pathak
Data Curation: Sagar Hamal, Crimsan Singh Negi, Sangam Jagari
Formal Analysis: Sagar Hamal, Crimsan Singh Negi, Sangam Jagari, Subash Dhakal
Investigation: Sagar Hamal, Crimsan Singh Negi, Sangam Jagari
Methodology: Sagar Hamal
Project Administration: Sagar Hamal, Subash Dhakal, Dhundi Raj Pathak
Software: Sangam Jagari
Supervision: Sagar Hamal
Validation: Sagar Hamal, Crimsan Singh Negi, Sangam Jagari
Visualization: Sagar Hamal, Sangam Jagari
Writing–Original Draft: Sagar Hamal
Writing–Review & Editing: Sagar Hamal, Dhundi Raj Pathak

Competing Interests

The authors declare that there are no conflicts of interest associated with this publication.

Ethical Approval

The study protocol was approved by the administration of each participating hospital (Reg. No. 1285). Verbal informed consent was secured from all individual participants after a detailed explanation of the study's purpose, procedures, and their rights; this method was deemed most appropriate and was formally approved to ensure inclusivity and minimize barriers to participation. Verbal consent was formally documented. Confidentiality and anonymity for both individuals and institutions were rigorously maintained. All data were stored securely and accessed exclusively by the research team to ensure the confidentiality and integrity of the collected information.

Funding

This research received no specific grant.

Supplementary Files

The datasets supporting this study are available in this article and the associated supplementary file (Table S1).

References

1. Janik-Karpinska E, Brancaleoni R, Niemcewicz M, Wojtas W, Foco M, Podogrocki M, et al. Healthcare waste-a serious problem for global health. Healthcare (Basel) 2023;11(2):242. doi:10.3390/healthcare11020242
2. World Health Organization (WHO). Health Care Waste. Geneva: WHO; 2024. Available from: https://www.who.int/news-room/fact-sheets/detail/health-care-waste. Accessed October 2, 2025.
3. Acharya C. An overview of population trends and pattern of Nepal. J Contemp Rev 2025;3(3):30-5. doi:10.3126/jcr.v3i3.88124
4. Adhikari RP, Shrestha ML, Satinsky EN, Upadhaya N. Trends in and determinants of visiting private health facilities for maternal and child health care in Nepal: comparison of three Nepal demographic health surveys, 2006, 2011, and 2016. BMC Pregnancy Childbirth 2021;21(1):1. doi:10.1186/s12884-020-03485-8
5. Karki S, Niraula SR, Karki S. Perceived risk and associated factors of healthcare waste in selected hospitals of Kathmandu, Nepal. PLoS One 2020;15(7): e0235982. doi:10.1371/journal.pone.0235982
6. Shrestha R, Adhikari S. Factors affecting choice of health care facilities among the adults of an urban community. Med J Shree Birendra Hosp 2021;20(2):123-9. doi:10.3126/mjsbh.v20i2.30777
7. Pathak DR, Nepal S, Thapa T, Dhakal N, Tiwari P, Sinha TK. Capacity assessment and implementation analysis of common treatment facility for the management of infectious healthcare waste in rapidly urbanising city of Nepal. Waste Manag Res 2021;39(1_Suppl):64-75. doi:10.1177/0734242x211013910
8. Subba NR. Practices of waste management in health care facilities in Nepal's Biratnagar metropolitan city. World J Adv Res Rev 2021;12(3):398-404. doi:10.30574/wjarr.2021.12.3.0722
9. Joshi HD, Acharya T, Ayer R, Dhakal P, Karki KB, Dhimal M. Health care waste management practice in health care institutions of Nepal. J Nepal Health Res Counc 2017;15(1):7-11. doi:10.3126/jnhrc.v15i1.18006
10. Badar S, Saeed MA, Yasmeen S, Hussain W, Amjad MA, Abbas H. Health care waste management practices in public and private sector hospitals. J Rawalpindi Med Coll 2014;18(1):145-7.
11. Kumar S, Mazta SR, Gupta AK. Comparing the biomedical waste management practices in major public and private sector hospitals of Shimla city. Int J Sci Study 2015;2(11):112-8. doi:10.17354/ijss/2015/63
12. Budha N, Koirala MP. Bridging community and hospital waste management: insights from Birendranagar, Surkhet. Journal of UTEC Engineering Management 2025;3(1):70-89. doi:10.3126/juem.v3i1.84854
13. Assemu DM, Tafere TE, Gelaw YM, Bantie GM. Healthcare waste management practice and associated factors among private and public hospitals of Bahir Dar city administration. J Environ Public Health 2020;2020:7837564. doi:10.1155/2020/7837564
14. Ministry of Health and Population, Government of Nepal. Health Care Waste Management Guideline (2014). Kathmandu: Ministry of Health and Population; 2014. Available from: https://hcwm.mddohs.gov.np/index.php/resources/guidelines-acts. Accessed September 1, 2025.

15. Ministry of Health and Population, Government of Nepal. National Health Care Waste Management Standards and Operating Procedures—2020. Kathmandu: Ministry of Health and Population; 2020. Available from: https://www.washinhef.org/resource/national-health-care-waste-management-standards-for-nepal-2020/. Accessed September 1, 2025.
16. Wasti SP, van Teijlingen E, Rushton S, Subedi M, Simkhada P, Balen J. Overcoming the challenges facing Nepal's health system during federalisation: an analysis of health system building blocks. Health Res Policy Syst 2023;21(1):117. doi:10.1186/s12961-023-01033-2
17. Patel JN, Upadhyay SK, Rajbhandari A. Healthcare waste management in health institution in Madhesh province: a key stakeholder's perspective. Journal of Ayurveda Campus 2024;5(1):8-14. doi:10.51648/jac104
18. Sapkota B, Gupta GK, Mainali D. Impact of intervention on healthcare waste management practices in a tertiary care governmental hospital of Nepal. BMC Public Health 2014;14:1005. doi:10.1186/1471-2458-14-1005
19. McPherson J. Healthcare Waste Management for Hospitals in Resource-Constrained Settings: What Determines Effective Implementation? [dissertation]. Chapel Hill, NC: University of North Carolina at Chapel Hill; 2015. doi:10.17615/3jwb-bh64
20. Adhikari CB, Roy M, Raman RK, Kafle B, Adhikari HP. Assessing the effectiveness and challenges of healthcare waste management practices in federal government hospitals of Nepal: a qualitative investigation. Int J Med Public Health 2025;15(4):1290-5. doi:10.70034/ijmedph.2025.4.231
21. Paudel P, Aryal A, Joshi YP, Thapa B, Thapa J, Yamuna M, et al. Healthcare waste management practices in selected healthcare institutions within Kailali district of Nepal. A Bi-Annu South Asian J Res Innov 2023;10(2):15-25. doi:10.3126/jori.v10i2.71820
22. Hamal S, Jagari S, Bohara R, Bhatt B, Bhandari E, Joshi S, et al. Municipal solid waste management practices in urban areas of Bhimdatta municipality, Nepal. J NAST Coll 2025;1(1-2):1-21. doi:10.3126/jonc.v1i1-2.89047
23. National Statistics Office (NSO). National Population and Housing Census 2021: Population Results. Kathmandu: NSO; 2021. Available from: https://censusnepal.cbs.gov.np/results/local-level. Accessed October 2, 2025.
24. Hamal S. Towards sustainable solid waste management: estimating resource recovery potentials in Bhimdatta municipality, Kanchanpur, Nepal. Int J Sci Eng Technol 2024;12(2):624-9. doi:10.61463/ijset.vol.12.issue2.159
25. United Nations. The 17 Goals. New York: United Nations; 2015. Available from: https://sdgs.un.org/goals. Accessed December 3, 2025.
26. Bheemdatta Municipality. Brief Introduction. Kanchanpur: Bheemdatta Municipality; 2025. Available from: https://bheemdattamun.gov.np/pages/Brief%20Introduction. Accessed September 7, 2025.
27. Public Health Update. Number of Health Facilities in Sudurpashchim Province, Nepal. Public Health Update; 2019. Available from: https://publichealthupdate.com/number-of-health-facilities-in-sudurpashchim-province-nepal/. Accessed October 10, 2025.
28. Khan BA, Cheng L, Khan AA, Ahmed H. Healthcare waste management in Asian developing countries: a mini review. Waste Manag Res 2019;37(9):863-75. doi:10.1177/0734242x19857470
29. Centers for Disease Control and Prevention (CDC). Hospital. In: Health, United States: Sources & Definitions. CDC; 2024. Available from: https://www.cdc.gov/nchs/hus/sources-definitions/hospital.htm. Accessed October 10, 2025.
30. Government of Nepal. Public Health Service Regulations, 2020 (Section 70) Number 23 Nepal Gazette Part 3 Date 2020/09/21. Kathmandu: Ministry of Health and Population; 2020.
31. United Nations Development Programme (UNDP). Individualized Rapid Assessment Tool (I-RAT). UNDP; 2019. Available from: https://www.technet-21.org/en/resources/tool/individualized-rapid-assessment-tool-i-rat. Accessed September 1, 2025.
32. Ali M, Wang W, Chaudhry N, Geng Y. Hospital waste management in developing countries: a mini review. Waste Manag Res 2017;35(6):581-92. doi:10.1177/0734242x17691344
33. Panta G. Understanding Sterilization and Reuse of Medical Devices in Nepal [dissertation]. Christchurch: University of Canterbury; 2018.