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Sustainable Healthcare: Medical Waste Management, Energy Resource Efficiency, and Environmentally Preferable Behaviors

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Original Article

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Abstract

This study explores the perceptions of respondents toward environmental sustainability in the healthcare sector, focusing on three key areas: Medical Waste Management (MWM), Energy and Resource Efficiency (ERE), and Environmentally Preferable Behaviors (EPB). A structured questionnaire was administered to 209 participants, and descriptive statistics along with one-sample t-tests were employed to analyze the data. The results revealed high levels of agreement across all three dimensions, with mean scores of 4.10 for MWM, 4.12 for ERE, and 4.19 for EPB on a 5-point Likert scale. One-sample t-test results confirmed the statistical significance of these findings ($p < .001$), indicating strong environmental awareness and preference for sustainable healthcare practices among respondents. Particularly, participants emphasized the need for safe disposal of medical waste, adoption of energy-efficient systems, and training of healthcare professionals in sustainability. The study concludes that there is a strong public inclination toward integrating green practices within healthcare institutions.

Keywords: Behaviors, Energy, Healthcare, Management, Waste

Introduction

In the face of escalating environmental concerns and resource scarcity, the healthcare sector has emerged as both a provider of essential services and a contributor to environmental degradation (Nguyen et al., 2023). Hospitals, clinics, and other healthcare institutions generate vast quantities of waste, consume large amounts of energy, and often operate without fully integrating sustainable practices. As such, the concept of sustainable healthcare which balances

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patient care with environmental responsibility has become increasingly significant in global policy and institutional reform (Olawade et al., 2025).

One of the most pressing issues in sustainable healthcare is Medical Waste Management (MWM). Hazardous medical waste, including infectious materials, used syringes, pharmaceuticals, and chemical by-products, poses severe threats to human health and environmental safety if not managed appropriately (Janik-Karpinska et al., 2023). In many developing countries, inadequate infrastructure, lack of awareness, and insufficient regulation contribute to the mishandling of medical waste, which can lead to soil and water contamination, air pollution through burning, and the spread of infections (Ankit et al., 2021). Addressing MWM is not only a matter of compliance but also an ethical responsibility for public health protection.

Equally important is Energy Resource Efficiency (ERE) in healthcare institutions. These facilities operate continuously and rely heavily on energy-intensive systems such as heating, ventilation, air conditioning, lighting, and diagnostic equipment (Simpeh et al., 2022). Without strategic energy management, healthcare institutions contribute significantly to carbon emissions and face escalating operational costs. Energy efficiency initiatives ranging from the use of renewable energy sources to the implementation of smart building technologies can reduce environmental impact while enhancing the economic sustainability of healthcare services (Silva et al., 2024).

Complementing both MWM and ERE is the role of Environmentally Preferable Behaviors (EPB) among healthcare professionals and institutions. These behaviors include actions such as segregating waste at the source, reducing plastic usage, recycling materials, conserving water and energy, and supporting green procurement policies (Bhandari et al., 2025). EPBs reflect the environmental awareness, attitudes, and commitment of healthcare workers and administrators toward sustainability. Encouraging these behaviors is essential for embedding sustainability within the institutional culture of healthcare systems (Hoxha et al., 2024).

Given this background, this study is grounded on two primary objectives. The first is to assess the current practices and status of Medical Waste Management, Energy Resource Efficiency, and Environmentally Preferable Behaviors in selected healthcare settings. The second objective is to examine the relationship between these three dimensions, with the aim of identifying how improvements in waste and energy management might influence or be associated with a greater adoption of environmentally responsible behaviors.

This research is particularly relevant in the context of Nepal, where healthcare infrastructure is developing, and environmental regulations are still evolving. Understanding how sustainable practices are integrated or neglected within Nepalese healthcare institutions can inform policy interventions, capacity-building programs, and institutional reforms aimed at achieving greener and more sustainable health services.

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Research Methodology

This study is cross-sectional in nature and employed a descriptive and correlational research design to explore the current status and interrelationship among Medical Waste Management, Energy Resource Efficiency, and Environmentally Preferable Behaviors in the context of sustainable healthcare practices.

The research was conducted across multiple colleges using an online survey platform, Google Forms. The target population consisted of undergraduate students who were actively enrolled and attending academic classes during the study period. Eligibility was limited to students who were at least 18 years old. A total of 209 valid responses were included as the final sample size. A convenient sampling technique was employed to select participants. Data were collected using a structured questionnaire comprising Likert scale items designed to measure perceptions and practices related to the three core dimensions of sustainable healthcare.

The responses were coded and analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to summarize demographic data and mean scores, while correlation analysis was applied to examine relationships between the variables under study. This methodological approach was chosen to provide a clear and data-driven understanding of behavioral patterns and environmental practices among undergraduate students.

Results

The information was gathered via an online survey sent to college students at different campuses. This segment provides the demographic characteristics of the respondents and describe the techniques employed to examine and understand the primary data collected via the survey.

Table 1: Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	108	51.7	51.7	51.7
	Male	96	45.9	45.9	97.6
	Others	5	2.4	2.4	100.0
	Total	209	100.0	100.0	

Source: Field survey 2025

The table presents the gender distribution of the 209 study participants. The figures indicate that the sample is nearly evenly split along traditional gender lines, with 51.7% of the respondents identifying as female (108 students) and 45.9% as male (96 students). Another 2.4% (or 5 students) ticked "Others," which may account for non-binary, or other gender identities not accounted for in the binary options. The cumulative percent column shows that by including all three categories, the data accounts for 100% of respondents with no missing values (as reflected by equal "Percent" and "Valid Percent" columns).

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Table 2 Semester

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	First Semester	15	7.2	7.2	7.2
	Second Semester	12	5.7	5.7	12.9
	Third Semester	14	6.7	6.7	19.6
	Fourth Semester	14	6.7	6.7	26.3
	Fifth Semester	18	8.6	8.6	34.9
	Sixth Semester	44	21.1	21.1	56.0
	Seventh Semester	30	14.4	14.4	70.3
	Eighth Semester	62	29.7	29.7	100.0
	Total	209	100.0	100.0	

Source: Field survey 2025

The data presents the distribution of respondents across different academic semesters. Out of a total of 209 participants, the highest number of respondents (62 individuals or 29.7%) were from the Eighth Semester, followed by the Sixth Semester with 44 respondents (21.1%) and the Seventh Semester with 30 respondents (14.4%). The Fifth Semester contributed 18 respondents (8.6%), while the First, Third, and Fourth Semesters had relatively similar participation, with 15 (7.2%), 14 (6.7%), and 14 (6.7%) respondents respectively. The lowest participation was recorded from the Second Semester, which had only 12 respondents, making up 5.7% of the total. This distribution indicates that the majority of the respondents were in the later stages of their academic programs, particularly the final semester, which may suggest a greater interest or relevance of the study topic to senior students.

Table 3 Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SLC	79	37.8	37.8	37.8
	High school	64	30.6	30.6	68.4
	Bachelor's Degree	48	23.0	23.0	91.4
	Master's Degree	17	8.1	8.1	99.5
	PHD	1	.5	.5	100.0
	Total	209	100.0	100.0	

Source: Field survey 2025

The data on fathers' education levels among the 209 respondents shows that the largest group, comprising 79 fathers or 37.8%, had completed their School Leaving Certificate (SLC). This is followed by 64 fathers (30.6%) who attained education up to the high school level. A notable portion, 48 fathers (23.0%), had completed a bachelor's degree, while 17 fathers (8.1%) had advanced to a master's degree. Only a very small fraction, just 1 father (0.5%), had achieved a PhD. Overall, the data suggests that most fathers had education levels up to secondary school or slightly beyond, with progressively fewer fathers attaining higher academic degrees.

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Table 4 Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SLC	92	44.0	44.0	44.0
	High school	51	24.4	24.4	68.4
	Bachelor's Degree	48	23.0	23.0	91.4
	Master's Degree	18	8.6	8.6	100.0
	Total	209	100.0	100.0	

Source: Field survey 2025

The data on respondents' education levels indicates that the largest group, consisting of 92 individuals or 44.0%, had completed their School Leaving Certificate (SLC). The next largest group, 51 respondents (24.4%), had attained education up to the high school level. A significant number, 48 respondents (23.0%), had completed a bachelor's degree, while a smaller portion, 18 respondents (8.6%), had advanced to a master's degree. This distribution shows that nearly half of the respondents had education up to the secondary level, while a combined 31.6% had pursued higher education at the bachelor's or master's levels.

Table 5 Faculty of previous study

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma	49	23.4	23.4	23.4
	Management	71	34.0	34.0	57.4
	Science	89	42.6	42.6	100.0
	Total	209	100.0	100.0	

Source: Field survey 2025

The data regarding the faculty of previous study among the 209 respondents reveals that the largest proportion, 89 individuals or 42.6%, had studied in the Science faculty. Following this, 71 respondents (34.0%) had a background in Management, while 49 respondents (23.4%) came from a Diploma faculty. This distribution shows that nearly half of the participants had a science background, with management and diploma faculties making up the remaining share. The variety in previous study faculties suggests a diverse academic background among the respondents.

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Descriptive Statistics

Table 6: Medical Waste Management

	N	Minimum	Maximum	Mean	Std. Deviation
Hazardous medical waste (e.g., syringes, chemicals) should be disposed of safely.	209	1	5	4.31	.947
Improper medical waste management poses serious environmental/health risks.	209	2	5	4.40	.721
Hospitals in my area visibly segregate and recycle medical waste.	209	1	5	3.60	1.005
I support stricter government regulations on medical waste disposal.	209	1	5	4.36	.707
I know about alternatives to incineration (e.g., autoclaving, chemical treatment) for waste disposal.	209	1	5	3.84	.905

The descriptive statistics on medical waste management reveal important insights into respondents' awareness and perceptions. The statement "Improper medical waste management poses serious environmental/health risks" received the highest mean score of 4.40 (SD = 0.721), indicating strong agreement among respondents about the seriousness of the issue. Similarly, the item "I support stricter government regulations on medical waste disposal" also showed a high level of agreement, with a mean of 4.36 (SD = 0.707). The belief that "Hazardous medical waste should be disposed of safely" had a mean of 4.31 (SD = 0.947), reflecting a widely shared understanding of proper waste handling. However, responses were less strong for the item "Hospitals in my area visibly segregate and recycle medical waste", which had a lower mean of 3.60 (SD = 1.005), suggesting that visible waste segregation and recycling practices might be lacking in some areas. Finally, the statement "I know about alternatives to incineration (e.g., autoclaving, chemical treatment) for waste disposal" received a moderate mean of 3.84 (SD = 0.905), indicating some awareness among respondents about safer disposal methods beyond incineration. Overall, the data suggests high awareness of the risks and the need for regulation, but mixed perceptions about local implementation and personal knowledge of alternative disposal methods.

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Table 7 Energy and Resource Efficiency

	N	Minimum	Maximum	Mean	Std. Deviation
I recognize the importance of energy-efficient equipment (e.g. LED lighting, solar power) in hospitals.	209	1	5	4.11	.735
Water conservation systems (e.g., rainwater harvesting) should be mandatory in healthcare facilities.	209	1	5	4.09	.709
Digital records (e.g., EHRs) are more sustainable than paper-based systems.	209	1	5	4.29	.757
I am aware of hospitals using renewable energy (solar/wind) to reduce carbon footprints.	209	1	5	3.88	.860
Sustainable architecture (e.g. natural ventilation, green roofs) can improve healthcare environments.	209	1	5	4.23	.787

The descriptive statistics on energy and resource efficiency in healthcare highlight generally strong awareness and positive attitudes among respondents. The statement "Digital records (e.g., EHRs) are more sustainable than paper-based systems" received the highest mean score of 4.29 (SD = 0.757), indicating broad agreement on the environmental benefits of digitalization. Closely following is the belief that "Sustainable architecture (e.g., natural ventilation, green roofs) can improve healthcare environments", which had a mean of 4.23 (SD = 0.787), reflecting strong support for eco-friendly building design in healthcare settings. The recognition of the importance of energy-efficient equipment such as LED lighting and solar power also showed high agreement, with a mean of 4.11 (SD = 0.735). Similarly, respondents agreed that water conservation systems should be mandatory in healthcare facilities, with a mean of 4.09 (SD = 0.709). However, awareness levels were slightly lower for the item "I am aware of hospitals using renewable energy (solar/wind) to reduce carbon footprints", which had a mean of 3.88 (SD = 0.860). Overall, the results indicate strong environmental consciousness and support for sustainable practices in healthcare, though actual awareness of renewable energy usage in hospitals is comparatively moderate.

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Table 8: Environmentally Preferable Behaviors

	N	Minimum	Maximum	Mean	Std. Deviation
I would choose a "green hospital" over a conventional one if given the option.	209	1	5	4.00	.710
Healthcare workers should be trained in sustainable practices (e.g., reducing unnecessary resource use).	209	1	5	4.23	.777
Pharmaceutical companies should adopt eco-friendly packaging and drug disposal programs.	209	1	5	4.34	.717
I avoid clinics/hospitals with poor environmental policies when possible.	209	1	5	4.08	.787
Sustainable healthcare may improve patient outcomes in the long term.	209	1	5	4.29	.730

The descriptive statistics on environmentally preferable behaviors reveal strong support for sustainable practices in healthcare settings among the respondents. The highest mean score of 4.34 (SD = 0.717) was observed for the statement "Pharmaceutical companies should adopt eco-friendly packaging and drug disposal programs," indicating widespread agreement on the importance of environmental responsibility in the pharmaceutical sector. Similarly, respondents strongly agreed that "Sustainable healthcare may improve patient outcomes in the long term," with a mean of 4.29 (SD = 0.730), and that "Healthcare workers should be trained in sustainable practices," which had a mean of 4.23 (SD = 0.777). These responses highlight a recognition of the connection between sustainability and quality of care. The item "I avoid clinics/hospitals with poor environmental policies when possible" had a mean of 4.08 (SD = 0.787), suggesting that environmental considerations influence healthcare choices for many respondents. Lastly, "I would choose a 'green hospital' over a conventional one if given the option" also received a favorable response, with a mean of 4.00 (SD = 0.710). Overall, the data reflects a high level of environmental awareness and a preference for sustainable practices in both personal healthcare decisions and broader healthcare systems.

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Table 9: Comparison between variables

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
MWM	209	4.1005	.50882	.03520
ERE	209	4.1196	.52992	.03666
EPB	209	4.1866	.51198	.03541

One-Sample Test						
	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
MWM	116.506	208	.000	4.10048	4.0311	4.1699
ERE	112.388	208	.000	4.11962	4.0474	4.1919
EPB	118.217	208	.000	4.18660	4.1168	4.2564

The one-sample t-test results assess whether the mean scores of three variables—Medical Waste Management (MWM), Energy and Resource Efficiency (ERE), and Environmentally Preferable Behaviors (EPB)—are significantly different from a test value of zero. All three variables have mean values well above 4, with MWM = 4.10, ERE = 4.12, and EPB = 4.19, indicating strong agreement or positive perception across the board.

The t-values for MWM (t = 116.51), ERE (t = 112.39), and EPB (t = 118.22) are extremely high and statistically significant at $p < .001$, showing that these means are significantly greater than zero. The 95% confidence intervals further support these findings, with none of the intervals crossing zero for example, the confidence interval for EPB ranges from 4.1168 to 4.2564.

In summary, the results clearly indicate that respondents consistently demonstrated a high level of agreement with environmentally sustainable practices across all three areas, and these perceptions are statistically significant compared to the null hypothesis value.

Conclusion

The findings from the one-sample t-test reveal that respondents hold highly positive perceptions toward environmentally sustainable practices in healthcare. All three measured areas Medical Waste Management (MWM), Energy and Resource Efficiency (ERE), and Environmentally Preferable Behaviors (EPB) showed mean scores above 4 on a 5-point scale, indicating strong agreement. The statistical significance ($p < .001$) confirms that these scores are not due to chance and reflect a genuine commitment among participants toward environmental sustainability in healthcare settings. These results highlight the importance of integrating green practices into healthcare policies, infrastructure, and staff training to align with public expectations and support long-term environmental and health benefits.

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