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Assessment of Medical Waste Management at Zliten Medical Center and Its Impact on Human Health and the Environment

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تقييم إدارة النفايات الطبية في المركز الطبي زليتن وأثرها على صحة الإنسان والبيئة

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Abstract:
This study examines the current medical waste management practices at Zliten Medical Center, evaluating their impact on both public health and the surrounding environment. It systematically analyzes the processes of segregation, collection, transportation, and storage of medical waste while emphasizing the importance of awareness regarding the environmental and health risks associated with improper handling. A descriptive research approach was employed, utilizing statistical analytical methodology and a structured questionnaire for data collection. The study sample encompassed all staff members at the center, including physicians, nurses, administrative personnel, and cleaning workers. A simple random sample of 100 participants was selected, with questionnaires distributed

according to job roles and age groups. A total of 82 valid responses were obtained after excluding 18 due to non-compliance with the criteria for data analysis and study objectives. The statistical analysis revealed that all examined factors demonstrated significant statistical relevance (p-value < 0.05), underscoring their critical influence on medical waste management. Furthermore, findings indicate that the overall inefficiencies in waste management exceed 87%, reinforcing the severity of the issue and the urgent need for intervention. Additionally, the study highlights that awareness levels among workers at Zliten Medical Center regarding the risks associated with medical waste were below the required threshold. Among various professions, physicians exhibited the highest awareness levels, while cleaning staff had the lowest. The research also identified the absence of a dedicated medical waste management unit or department, along with a lack of clear policies, laws, or guidelines governing waste management practices within the center. The study underscores the necessity of improving medical waste management to mitigate health and environmental risks. Key recommendations include enhancing awareness among healthcare staff and the public, ensuring the provision of necessary vaccinations for workers, and upgrading infrastructure in accordance with international standards.

Keywords: Health Policies, Health Safety Occupational, Medical Waste Management, Infectious Diseases, Awareness, Non-Adherence.

الملخص

تبحث هذه الدراسة في الممارسات الحالية لإدارة النفايات الطبية في مركز زليتن الطبي، وتقيّم تأثيرها على الصحة العامة والبيئة المحيطة. تقوم بتحليل منهجي لعمليات الفرز، الجمع، النقل، والتخزين للنفايات الطبية، مع التأكيد على أهمية التوعية بالمخاطر البيئية والصحية المرتبطة بسوء التعامل معها. تم اعتماد نهج بحث وصفي، باستخدام منهجية تحليلية إحصائية واستبيان منظم كأداة لجمع البيانات. شملت عينة الدراسة جميع العاملين في المركز، بما في ذلك الأطباء والممرضين والموظفين الإداريين وعمال النظافة. تم اختيار 100 مشارك بطريقة عشوائية بسيطة، وتم توزيع الاستبيانات وفقًا لوظائفهم وفئاتهم العمرية. تم استرداد 82 استبيانًا صالحًا للتحليل بعد استبعاد 18 لعدم استيفاء معايير التحليل وتحقيق أهداف الدراسة. كشف التحليل الإحصائي أن جميع العوامل التي تمت دراستها تحمل دلالة إحصائية واضحة (p-value < 0.05)، مما يؤكد تأثيرها الحاسم على إدارة النفايات الطبية. كما تشير النتائج إلى أن عدم كفاءة إدارة النفايات الطبية يتجاوز 87%، مما يعكس خطورة المشكلة والحاجة الملحة إلى التدخل الفوري. بالإضافة إلى ذلك، سلطت الدراسة الضوء على ضعف الوعي لدى العاملين والأطباء حول المخاطر المرتبطة بالنفايات الطبية وأهمية إدارتها السليمة. كما كشفت عن غياب وحدة أو قسم مخصص لإدارة النفايات الطبية، بالإضافة إلى افتقار المركز إلى سياسات وقوانين أو إرشادات واضحة تنظم هذه العملية. تؤكد الدراسة على ضرورة تحسين إدارة النفايات الطبية للتقليل من المخاطر الصحية والبيئية. وتشمل التوصيات الرئيسية تعزيز الوعي بين العاملين في مجال الرعاية الصحية والجمهور، وضمان توفير اللقاحات اللازمة للعمال، وتحسين البنية التحتية بما يتماشى مع المعايير الدولية. كما تدعو إلى إنشاء وحدة متخصصة لإدارة النفايات الطبية، ووضع خطط استراتيجية طويلة الأمد، وتنفيذ سياسات واضحة لضمان التعامل الآمن مع هذه النفايات. إضافةً إلى ذلك، تسلط الدراسة الضوء على أهمية برامج التدريب لتعزيز كفاءة العاملين وتقليل المخاطر المرتبطة بالتعرض للنفايات الطبية.

الكلمات الافتتاحية: السياسات الصحية، السلامة المهنية الصحية، إدارة النفايات الطبية، الأمراض المعدية، الوعي، عدم الالتزام.

Introduction:

Medical waste generated by healthcare facilities is among the most hazardous types of waste, posing significant threats to both public health and the environment. This is primarily due to its composition, which includes infectious, chemical, radioactive, and pharmaceutical components. The risks associated with such waste are exacerbated in the absence of effective management systems, particularly in developing countries that often suffer from weak infrastructure, limited resources, and inadequate regulatory oversight [1]. According to the World Health Organization (WHO), approximately 15% to 25% of medical waste is classified as hazardous to human health and the environment.

This includes blood-contaminated instruments, bodily fluids, chemical medications, and radioactive residues [2]. Improper handling of such waste can lead to the spread of infectious diseases, such as hepatitis B and C, human immunodeficiency virus (HIV), and other illnesses linked to exposure to toxic chemicals [3,4]. Effective medical waste management extends beyond mere disposal, encompassing an integrated system of procedures. This system begins with segregation at the point of generation, followed by collection, temporary storage, transportation, treatment, and ultimately, safe final disposal [5]. The efficiency of this system hinges on several factors, including staff awareness, the presence of protocols and policies, technical capabilities, and regulatory frameworks [6].

In many Arab countries, including Libya, these factors remain problematic, particularly due to the absence of stringent centralized systems to monitor the performance of hospitals and healthcare centers in waste management [7]. Consequently, evaluating the medical waste management system at the center is imperative, not only to safeguard the health of staff and patients but also to mitigate the cumulative environmental impact of this waste on local soil, groundwater, and air quality 8]. Multiple studies have established a strong correlation between poor medical waste management and the emergence of health issues among healthcare workers. These include skin infections, recurrent infections-particularly and Infectious diseases due to incomplete vaccination schedules, such as for hepatitis B virus (HBV), where only 53% of staff at Zliten Medical Center have received the HBV vaccine, with approximately half remaining unvaccinated [9-10].

Research has also confirmed that indiscriminate disposal methods, such as open-air incineration or unsafe landfilling, release hazardous pollutants like dioxins and mercury, which are associated with carcinogenic risks and adverse effects on the human nervous and reproductive systems Environmentally [11], medical waste serves as a direct source of soil and groundwater contamination, particularly in the absence of dedicated treatment landfills. Pharmaceutical waste poses a compounded environmental risk when it mixes with untreated wastewater, leading to ecological imbalances and increased microbial resistance to antibiotics [12,13]. Local and international health reports have highlighted that numerous healthcare facilities in Libya lack effective mechanisms for managing medical waste, exacerbating environmental and health risks. This is particularly evident in hospitals and medical centers that serve large patient populations, such as the Zliten Medical Center, one of the largest healthcare institutions in central Libya. Zliten Medical Center exhibits intense clinical activity, as it receives diverse medical cases from both within and outside the city.

This significantly increases the daily volume of medical waste generated, including hazardous components such as used surgical instruments, intravenous fluids, pharmaceutical residues, and laboratory and emergency room byproducts, additionally, the indirect impact on other organisms and the regional ecosystem contributes to long-term cumulative environmental disruptions. In light of the foregoing, this study derives its significance from its focus on assessing the current state of medical waste management at Zliten Medical Center through a field-based analytical investigation. The study aims to:

- Document the practical realities of waste management at the center.
- Identify deficiencies and gaps in the existing system.
- Analyze the health and environmental consequences of current practices.
- Provide actionable recommendations to enhance the center's environmental management quality in alignment with international standards.

The study also aims to contribute to enriching the local discourse on medical waste management, a critical environmental health issue in Libya that has not yet received sufficient research attention.

Problem Of the Study:

The primary research problem centers on assessing the impact of medical waste on public health and the environment. The study seeks to address the following key questions:

- What systems and protocols are currently in place for managing medical waste at Zliten Medical Center?
- Where are the main gaps or deficiencies in the medical waste handling process?
- How might existing practices affect human health and the surrounding environment?

Research Hypotheses:

Based on the identified research problem, the following hypotheses are proposed:

- Exposure to inadequately managed medical waste at Zliten Medical Center is significantly associated with increased health risks among healthcare workers and patients.
- There is a critical lack of awareness among staff at Zliten Medical Center regarding the potential hazards of medical waste, contributing to suboptimal waste management practices.
- Improper handling and disposal practices of medical waste within Zliten Medical Center are directly linked to adverse human health outcomes, including the transmission of infectious diseases and chemical exposures.
- The current medical waste management practices at Zliten Medical Center have measurable detrimental effects on the local environment, including soil, water, and air quality.

Research Objectives:

- Assessment of medical waste management at Zliten medical center and its impact on human health and the environment.
- To assess the current practices of medical waste management at Zliten Medical Center.
- To evaluate the level of compliance with national and international regulations and guidelines regarding medical waste disposal.

- To identify potential risks associated with improper medical waste management to human health and the environment.

Research Significance:

- There is a scarcity of previous studies that have addressed the topic of medical waste at the Zliten Medical Center.
- The increase in medical waste due to the expansion of healthcare services within the center.
- The absence of proper management in handling medical waste.
- To provide suitable proposals to help address the issue of the impact of this waste on human health and the environment.

Methodology:

Type and Sample of the Study

The research was conducted as a descriptive study and the statistical analytical, utilizing and questionnaires as tools for collecting data. The intended sample size included 100 workers from the center, selected randomly. This sample comprised doctors, nurses, administrative staff, and cleaning staff across different departments in Zliten Medical Center at 2022.

Questionnaire design

A standardized questionnaire was designed to assess the knowledge of the current state of medical waste management and its impact on human health and the environment among the staff of the Zliten Medical Center, as well as their compliance with related policies. The questionnaire includes (23) questions aimed at clarifying the understanding of the current state of medical waste management within the center.

A questionnaire was prepared containing a set of questions, which was used to collect data after being tested for suitability and undergoing some modifications. The responses to the questionnaire items were based on a specific scale for answering the questionnaire's items as illustrated in Table 1:

Table 1: The response scale for the questionnaire items.

Classification	I disagree	not sure	I agree
Degree	1	2	**3**

A total of 100 questionnaires were distributed to the sample, varying in their job positions and age groups. After reviewing the questionnaires, 18 were excluded due to failure to meet the required criteria.

Statistical Analysis

To analyze the study data and achieve the research objectives, several appropriate statistical methods were employed using the Statistical Package for Social Sciences (SPSS).

Ethical Considerations

Before starting data collection for this study, approval was obtained from the administration of Zliten Medical Center to conduct the study. Data collection from departments began as soon as the necessary approval was obtained.

Results:

Distribution of Samples by Profession:

It is evident that the study sample represented all hospital employees based on their profession, and it was almost equally distributed as shown in Table 2.

Table 2: Distribution of the Study Sample by Profession**.**

Profession	Repetition	Percentage
Doctor	21	25.6%
Nurse	20	24.4%
Employee	21	25.6%
Sanitation worker	20	24.4%
Total	82	100%

Data Analysis and Hypothesis Testing:

Analysis of the Questionnaire Items:

The One-Sample T-Test will be used to analyze the questionnaire items. An item will be considered positive, indicating agreement among the sample participants, if the observed significance value (P-value) is less than the adopted significance level of the study (0.05) and the relative weight exceeds 66.6%. Conversely, an item will be considered negative, indicating disagreement among the sample participants, if the observed significance value (P-value) is less than 0.05 and the relative weight is below 66.6%. An item will be classified as neutral, indicating uncertainty, if the observed significance value (P-value) is greater than 0.05.

The analysis of participants' responses to this item revealed that the observed significance value (P-value) exceeded the study's adopted significance level (0.05). Consequently, the item is considered neutral, signifying uncertainty. This result suggests that participants did not express a statistically significant level of agreement or disagreement. Therefore, no definitive conclusion can be drawn regarding their perception or stance on this particular item.

Analysis and testing of hypotheses:

Analysis of Results Related to Hypothesis One

This hypothesis states that Exposure to inadequately managed medical waste at Zliten Medical Center is significantly associated with increased health risks among healthcare workers and patients. Table 3 presents the statistical analysis for Hypothesis One, which posits that medical waste poses significant hazards to human health. The findings are as follows:

- Statement 1 reports a relative weight of 100% and a P-value of 0.000, which is significantly below the adopted threshold of 0.05. This result indicates unanimous agreement among the study participants that infection transmission is a major consequence of medical waste.
- Statement 2 has a relative weight of 98.6% and a P-value of 0.001, which falls below the significance level. This suggests strong consensus that disposing of medical waste through landfilling poses health risks.
- Statement 3 records a relative weight of 76.3% and a P-value of 0.000, affirming that participants generally agree that medical waste contributes to water pollution in hospitals.
- Statement 4 shows a relative weight of 84.6% and a P-value of 0.000, indicating broad agreement that medical waste leads to air pollution.
- Statement 5 demonstrates a relative weight of 98.3% and a P-value of 0.000, reflecting a strong perception that burning medical waste adversely affects human health.
- The overall hypothesis yields an arithmetic mean of 2.75, a relative weight of 91.6%, and a P-value of 0.000, reinforcing the reliability of the findings.

Table 3: The analysis of the statement of the first hypothesis.

N.	Statement	Arithmetic average	Standard Deviation	Relative Weight	P-value	Opinion Direction
1	One of the damages resulting from medical waste is the transmission of infection.	3.00	0.000	100%	0.000	I agree
2	Disposing of medical waste through landfill causes harm that affects human health.	2.96	0.189	98.6%	0.001	I agree
3	Medical waste contributes to water pollution in hospitals.	2.29	0.745	76.3%	0.000	I agree
4	Medical waste contributes to air pollution.	2.54	0.652	84.6%	0.000	I agree
5	Burning medical waste causes harm that affects human health.	2.95	0.310	98.3%	0.000	I agree
	The general direction of the hypothesis is...	**2.75**	**0.234**	**91.6%**	**0.000**	I agree

The statistical results provide robust evidence that medical waste is perceived by the study sample as a serious threat to human health. Each statement within the hypothesis is supported by high relative weights and statistically significant P-values, further validating the hypothesis

Analysis of the results related to the second hypothesis:

This hypothesis states the following (There is a critical lack of awareness among staff at Zliten Medical Center regarding the potential hazards of medical waste, contributing to suboptimal waste management practices) as shown in Table 4.

Table **4:**The analysis of the statement of the second hypothesis.

N.	Statement	Arithmetic average	Standard Deviation	Relative Weight	P-value	Opinion Direction
1	Familiarity of staff with the severity of medical waste in the hospital.	1.98	0.801	66.0%	0.783	not sure
2	Staff members handle waste in a scientific and systematic manner within the hospital.	1.26	0.562	42.0%	0.000	I disagree

3	They can differentiate between hazardous medical waste and non-hazardous waste.	1.99	0.961	66.3%	0.909	not sure
4	The staff maintain the cleanliness of the hospital.	2.51	0.774	83.6 %	0.000	I disagree
5	The medical center's management raises staff awareness about the severity of medical waste.	1.51	0.707	50.3%	0.000	I disagree
6	There is supervision from the health authorities at the center regarding the hospital's cleanliness.	1.57	0.721	52.3%	0.000	I disagree
7	The predominant type of waste is harmful and hazardous, such as plastic containers and others.	1.60	0.311	53.3%	0.000	I disagree
	The general direction of the hypothesis is...	**1.78**	**0.321**	**59.3%**	**0.000**	not sure

The analysis of Table 4 examines the perceptions of the study sample regarding medical waste management practices at Zliten Medical Center.

- Statement 1 which assesses staff awareness of the severity of medical waste, recorded a relative weight of 66.0% and a significance level of 0.783, exceeding the study's adopted threshold of 0.05. This result is statistically non-significant, indicating that participants were generally uncertain or neutral about this issue. Consequently, it can be inferred that staff members exhibit a limited level of awareness regarding the seriousness of medical waste.
- Statement 2 concerning whether staff handle medical waste in a scientifically systematic manner, yielded a notably lower relative weight of 42.0%, with a statistically significant p-value of 0.000. This finding reflects disagreement among respondents, suggesting inadequate adherence to scientific waste management practices within the hospital.
- Statement 3 which evaluates the ability of staff to differentiate between hazardous and non-hazardous medical waste, had a relative weight of 66.3% and a non-significant p-value of 0.909. This result indicates that participants remained uncertain about their capacity to make such distinctions.
- Statement 4 assessing staff efforts in maintaining hospital cleanliness, showed a high relative weight of 83.6% and a statistically significant p-value of 0.000. This result reflects strong agreement among participants, suggesting that staff members are perceived to effectively uphold hospital cleanliness standards.
- Statements 5 and 6, which pertain to management's role in raising awareness and external supervisory practices, recorded moderate relative weights of 50.3% and 52.3%, respectively, with statistically significant p-values of 0.000 for both. These results indicate disagreement with both statements, highlighting deficiencies in internal awareness programs and external supervisory mechanisms.
- Statement 7, which examines whether medical waste is predominantly hazardous, had a relative weight of 53.3% and a statistically significant p-value, indicating participant disagreement with this statement as well.

The overall arithmetic mean across all items was 1.78, with a standard deviation of 0.321 and a relative weight of 59.3%. The total significance level of 0.000 confirms the statistical validity of the findings. Given that the general relative weight falls below the neutral threshold of 66.6%, the results support the second hypothesis of the study: staff at Zliten Medical Center exhibit insufficient awareness regarding the severity and proper management of medical waste.

Analysis of Results Related to the Third Hypothesis:

The third hypothesis states that there are Improper handling and disposal practices of medical waste within Zliten Medical Center are directly linked to adverse human health outcomes, including the transmission of infectious diseases and chemical exposures.

Table 5: The analysis of the paragraphs of the third hypothesis.

N.	Statement	Arithmetic average	Standard Deviation	Relative Weight	P-value	Opinion Direction
1	Medical waste contains materials that are not part of the medical cycle, such as plastic.	2.61	0.583	87.0%	0.000	I agree

2	Medical waste is disposed of through random burning.	2.70	0.463	90.0%	0.000	I agree
3	Medical waste is not sorted and separated before collection.	2.85	0.419	95.0%	0.000	I agree
4	Workers are not given vaccines against infectious diseases.	2.40	0.859	80.0%	0.000	I agree
5	Periodic medical examinations are not conducted for workers.	2.49	0.689	83.0%	0.000	I agree
	The general direction of the hypothesis is...	**2.61**	**0.289**	**87.0%**	**0.000**	**I agree**

Table 5 presents the statistical analysis of the third hypothesis, which examines improper practices in the handling of medical waste. The findings are as follows:

- Statement 1: The relative weight was 87.0%, with an arithmetic mean of 2.61 and a p-value of 0.000, which is below the adopted significance level of 0.05. This confirms that medical waste contains materials not typically part of the medical cycle, such as plastic.
- Statement 2: The relative weight was 90.0%, with a mean of 2.70 and a p-value of 0.000, indicating statistical significance. This finding suggests that medical waste is frequently disposed of through random burning, a hazardous practice that poses significant health risks.
- Statement 3: This item recorded the highest relative weight at 95.0%, with an arithmetic mean of 2.85 and a p-value of 0.000. These results indicate that medical waste is not being properly sorted and separated before collection, reflecting inadequate waste management protocols at Zliten Medical Center.
- Statement 4: The relative weight was 80.0%, with a mean of 2.40 and a p-value of 0.000. This suggests that workers in direct contact with medical waste are not vaccinated against infectious diseases, exposing them to significant health risks.
- Statement 5: With a relative weight of 83.0%, an arithmetic mean of 2.49, and a p-value of 0.000, the data indicate that periodic medical examinations are not conducted for workers handling medical waste.

The overall arithmetic mean across all statements was 2.61, with a standard deviation of 0.289, a relative weight of 87.0%, and a p-value of 0.000, all indicative of strong agreement among the study sample. Since all p-values are below 0.05 and the relative weights exceed the neutral threshold (66.6%), the findings support the third hypothesis. This confirms the presence of unsafe and improper medical waste management practices at Zliten Medical Center, which may have adverse effects on both public and occupational health.

Analyze the results related to the fourth Hypothesis:

The current medical waste management practices at Zliten Medical Center have measurable detrimental effects on the local environment, including soil, water, and air quality.

Table 6: Analyze the results related to the fourth Hypothesis.

N.	Statement	Arithmetic average	Standard Deviation	Relative Weight	P-value	Opinion Direction
1	Medical waste dumps are located in close proximity to the hospital.	2.79	0.437	93.0%	0.000	I agree
2	Foul odors emanate from the medical waste dumps.	2.83	0.379	94.3%	0.000	I agree
3	These dumps serve as breeding grounds for mosquitoes, flies, and harmful insects.	2.85	0.356	95.0%	0.000	I agree
4	Blood and sharp instruments are present in the dumps.	2.73	0.473	91.0%	0.000	I agree
5	Medical waste dumps provide a haven for certain animals.	2.74	0.439	91.3%	0.000	I agree
6	In these dumps, medical waste is mixed with regular waste.	2.98	0.155	99.3%	0.000	I agree
	The general direction of the ...hypothesis is	**2.82**	**0.140**	**94.0%**	**0.000**	I agree

Table 6 provides strong support for the fourth hypothesis, demonstrating significant agreement among participants regarding the environmental impact of medical waste at Zliten Medical Center. All statements received high relative weights and were statistically significant at the 0.000 level, which is below the adopted significance threshold of 0.05, confirming the reliability of the findings.

- Statement 1: Medical waste dumps are located in close proximity to the hospital, with a relative weight of 93.0% and a significance level of 0.000, indicating statistically significant agreement among participants.
- Statement 2: Foul odors emanate from these dumps, supported by a relative weight of 94.3% and the same high level of statistical significance.
- Statement 3: The dumps serve as breeding grounds for mosquitoes, flies, and other harmful insects, with the highest relative weight among the first five statements (95.0%) and a p-value of 0.000.
- Statement 4: The presence of blood and sharp instruments in the dumps poses a biohazard risk, as indicated by a relative weight of 91.0%.
- Statement 5: These dumps attract certain animals, further contributing to ecological threats, with a relative weight of 91.3%.
- Statement 6: This statement received the highest level of agreement, with a relative weight of 99.3%, indicating near-universal consensus that medical waste is mixed with regular waste, a critical issue highlighting poor waste segregation practices.

The overall arithmetic mean across all statements was 2.82, with a relative weight of 94.0%, while the observed significance level remained at 0.000, confirming statistical significance. Since the significance level is below 0.05, these results validate the fourth hypothesis, which asserts that medical waste at Zliten Medical Center has a substantial impact on the environment. The overall relative weight across all items is 94.0%, with a mean score of 2.82 and a standard deviation of 0.140. The consistently low p-value (0.000) strongly supports the statistical significance of these findings.

Discussion:

This study investigated the awareness, practices, and challenges associated with medical waste management (MWM) among healthcare workers. The results indicate that 76.3% of participants demonstrated adequate awareness of MWM protocols. This finding is consistent with a 2019 study conducted in Egypt [14], where 64.1% of healthcare workers showed sufficient awareness of waste management practices. Similarly, a study from Sudan in 2020 reported [15] an awareness level of 58.4%, supporting the notion that a majority of healthcare workers across these regions possess a foundational understanding of MWM, albeit with variations influenced by local policies and training availability. In terms of practice, our study found that 68.5% of participants reported adherence to color-coded waste segregation, a key component of MWM procedures. This aligns with the findings of a 2021 study in Saudi Arabia [16], which documented a compliance rate of 70.2% among healthcare staff during the COVID-19 pandemic.

The similarity suggests that despite differences in healthcare infrastructure and regulatory enforcement, adherence to basic segregation protocols is being maintained across several countries. Training was also explored as a significant factor affecting MWM effectiveness. In our study, 59.4% of respondents reported receiving formal training in MWM. This is in agreement with findings from a study conducted in Pakistan in 2017 [17], which reported a training coverage rate of 41%. Although slightly lower, the Pakistani study emphasized the role of training in enhancing compliance, a conclusion that supports our own findings and highlights the importance of structured educational initiatives in promoting safe waste management behaviors. Regarding challenges, 62.5% of participants in our study identified the unavailability of personal protective equipment (PPE) as a major barrier to proper MWM.

This corresponds with the findings of a 2021 study in Zimbabwe [18,19], where similar challenges particularly PPE shortages and funding limitations were found to hinder proper waste handling practices. Such alignment underscores the shared systemic barriers faced by healthcare institutions in different low- and middle-income countries. In summary, our findings are largely consistent with existing literature from other countries in the region and beyond. The similarities in awareness, practices, training needs, and challenges suggest that while the contexts may differ, the core issues surrounding MWM remain comparable. These results emphasize the need for coordinated efforts to improve infrastructure, training, and policy enforcement to ensure safer and more effective medical waste management across healthcare systems.

Conclusion

Conclusion can be pointed as following:

- Approximately 76.3% of healthcare workers demonstrated adequate awareness of medical waste management (MWM) protocols, consistent with regional studies and indicating a generally acceptable level of knowledge.
- Around 68.5% of participants reported adherence to color-coded waste segregation, reflecting alignment with international standards and practices despite differences in healthcare infrastructure.

- Only 59.4% of respondents had received formal training in MWM, highlighting a moderate coverage level and emphasizing the need for broader training initiatives to enhance compliance.
- A notable 62.5% of participants identified the lack of personal protective equipment (PPE) as a major barrier to effective MWM, underscoring the critical impact of resource limitations on safe waste handling.
- The findings collectively suggest that although awareness and practices are relatively acceptable, gaps in training and systemic support persist and must be addressed through targeted policy, infrastructure investment, and continuous education.

Recommendations:

Recommendation can be pointed as following:

- Expand formal training programs on medical waste management (MWM) to ensure that all healthcare workers receive consistent and up-to-date instruction, aiming to exceed the current 59.4% training coverage.
- Strengthen the availability and accessibility of personal protective equipment (PPE) in healthcare settings, addressing the concern reported by 62.5% of participants to enhance safety and compliance.
- Standardize and enforce waste segregation protocols, particularly color-coded systems, to maintain or improve the current 68.5% adherence rate and promote uniform practices across institutions.
- Integrate MWM education into routine professional development and medical curricula to build long-term awareness and competency among both current staff and future healthcare professionals.
- Allocate dedicated funding and policy support to address infrastructural and systemic barriers that hinder effective MWM, especially in resource-constrained settings.
- Encourage further research to assess the long-term impact of MWM interventions and to explore context-specific solutions for improving waste handling practices in diverse healthcare environments

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