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An Analysis of the Biomedical Waste Management Challenges at Chawama Level 1 Hospital in Lusaka District of Zambia

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Research Article

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Abstract

Background

Biomedical waste management (BMWM) remains a critical public health and environmental concern, particularly in low-resource healthcare settings. In Zambia, public healthcare facilities continue to face difficulties in implementing comprehensive BMWM systems despite the existence of national guidelines and environmental regulations. This study examined the institutional, infrastructural, and operational factors associated with BMWM at Chawama Level 1 Hospital in Lusaka, Zambia.

Methods

A cross-sectional study was conducted at Chawama Level 1 Hospital in Lusaka District. A total of 54 healthcare workers directly or indirectly involved in BMWM were selected using stratified random sampling. Data were collected through structured, self-administered questionnaires and an observational checklist. Data were analysed using SPSS version 25. Descriptive statistics were generated, and Chi-square tests were used to examine associations between key variables, with Cramér's V used to assess effect sizes. Statistical significance was set at $p < 0.05$.

Results

Of the 54 respondents, 34 (63.0%) were female and 20 (37.0%) were male. Nurses constituted the largest professional group (40.7%, n = 22). Only 55.6% (n = 30) of respondents were aware of the hospital's BMWM policy, 40.7% (n = 22) had received formal training, and 33.3% (n = 18) reported regular supervisory monitoring. Infrastructural challenges were prominent: 70.4% (n = 38) reported inadequate colour-coded bins, 63.0% (n = 34) reported inconsistent PPE supply, and 66.7% (n = 36) reported insufficient waste storage facilities. Only 25.9% (n = 14) demonstrated proper segregation compliance, and 57.4% (n = 31) lacked adequate orientation. Inferential analysis showed statistically significant associations between training and confidence ($\chi^2=8.76$, df = 1, $p = 0.003$, Cramér's V = 0.40), policy awareness and compliance ($\chi^2=7.42$, df = 1, $p = 0.006$, Cramér's V = 0.37), bin availability and segregation compliance ($\chi^2=9.15$, df = 1, $p = 0.002$, Cramér's V = 0.41), and supervisory monitoring and operational compliance ($\chi^2=10.28$, df = 1, $p = 0.001$, Cramér's V = 0.44). Observational findings showed only 35% compliance with correct segregation standards.

Conclusion

BMWM at Chawama Level 1 Hospital is associated with interconnected institutional weaknesses, resource limitations, and procedural inefficiencies. Improving BMWM may require a comprehensive approach that includes strengthening policy implementation, enhancing staff training and supervision,

and investing in essential infrastructure. These findings provide evidence-based recommendations for improving waste management practices in similar urban healthcare settings.

WHAT IS ALREADY KNOWN ON THIS TOPIC

- • BMWM remains a critical public health and environmental concern, particularly in low-resource healthcare settings (WHO, 2018).
- • In Zambia, public healthcare facilities continue to face difficulties in implementing comprehensive BMWM systems despite the existence of national guidelines and environmental regulations (ZEMA, 2020).
- • Common problems include inadequate infrastructure, insufficient staff training, limited financial resources, weak policy enforcement, and poor compliance with waste management procedures (Ministry of Health, 2021).
- • Facility-specific evidence on the combined institutional, infrastructural, and operational factors associated with BMWM in Level 1 hospitals within Lusaka District remains limited (Mulife et al., 2024).

WHAT THIS STUDY ADDS

- • BMWM at Chawama Level 1 Hospital is hindered by interconnected institutional weaknesses, resource limitations, and procedural inefficiencies.
- • Only 55.6% of healthcare workers were aware of the hospital's BMWM policy, 40.7% had received formal training, and 33.3% reported regular supervisory monitoring.
- • Infrastructural challenges are prominent: 70.4% reported inadequate colour-coded bins, 63.0% reported inconsistent PPE supply, and 66.7% reported insufficient waste storage facilities.
- • Only 25.9% of respondents demonstrated proper segregation compliance, and observational findings showed only 35% compliance with correct segregation standards.
- • Statistically significant associations exist between training and confidence ($p = 0.003$), policy awareness and compliance ($p = 0.006$), bin availability and segregation compliance ($p = 0.002$), and supervisory monitoring and operational compliance ($p = 0.001$).
- • The findings provide evidence-based recommendations for improving BMWM practices in similar urban healthcare settings in Zambia.

BACKGROUND

Biomedical waste (BMW) refers to waste generated during the diagnosis, treatment, or immunisation of humans or animals, as well as waste produced during research activities or the testing of biological products (WHO, 2018). Healthcare institutions produce approximately 0.5 to 2.0 kg of hazardous waste per bed per day in high-income countries and about 0.2 kg in low-income countries (WHO, 2021). When

BMW is poorly segregated or disposed of improperly, even non-hazardous waste becomes dangerous, contributing to air, soil, and water contamination and increasing the risk of disease transmission.

Developed countries have invested heavily in regulated BMWM systems that rely on advanced technologies such as high-temperature incineration, microwave irradiation, and autoclave sterilisation (UNEP, 2022). In contrast, low- and middle-income countries (LMICs) face substantial challenges due to inadequate infrastructure, weak regulatory enforcement, and limited financial resources. More than 70% of BMW in LMICs is not properly segregated, which increases infection risks and complicates safe disposal (WHO, 2020). Untreated medical waste is often disposed of in open dumps or municipal landfills, exposing waste handlers and nearby communities to serious health hazards, including occupational exposure to HIV, hepatitis B, and hepatitis C through needle-stick injuries.

The COVID-19 pandemic further intensified BMWM challenges worldwide. The increased use of disposable personal protective equipment (PPE), testing kits, and medical supplies led to a dramatic rise in healthcare waste, with BMW volumes increasing by approximately 300–400% during the pandemic (WHO, 2021). Many hospitals struggled to manage the sudden surge in waste due to limited storage and treatment capacity, leading to unsafe disposal practices.

Across Africa, BMWM remains a persistent challenge due to limited resources, inadequate infrastructure, and insufficient training of healthcare personnel. According to Bazeyo et al. (2020), only about 35% of healthcare facilities in Africa properly segregate BMW. Many hospitals rely on open burning or poorly designed incinerators that fail to reach temperatures required for safe waste treatment, resulting in the release of harmful pollutants such as dioxins and furans (UNEP, 2021).

In Zambia, public healthcare facilities continue to face difficulties in implementing comprehensive BMWM systems. Reports from the Zambia Environmental Management Agency indicate that many health institutions lack adequate infrastructure, training, and systems for proper waste segregation and disposal (ZEMA, 2020). Zambia generates an estimated 3,000 to 4,000 tons of BMW annually, much of which is not safely treated. Common problems include the mixing of infectious waste with general waste, the use of open burning pits, and inadequate protective equipment for waste handlers. Financial constraints further limit investments in waste management infrastructure, with less than 5% of operational hospital budgets allocated to waste management activities (Ministry of Health, 2021).

Lusaka faces additional BMWM challenges due to rapid urbanisation and increased demand for healthcare services. Many smaller health centres lack proper waste segregation systems, treatment facilities, and trained waste handlers. Waste is often mixed with general refuse and transported to dumping sites such as Chunga Landfill, exposing waste collectors and surrounding communities to potential health risks. These challenges highlight the urgent need to strengthen BMWM practices in healthcare facilities within Lusaka.

Chawama Level 1 Hospital, located in Lusaka District, is one of the health facilities that generates significant amounts of BMW as a result of increasing patient attendance and expanding healthcare

services. Concerns have been raised regarding waste segregation, storage, transportation, treatment, and disposal practices at the facility, which may expose healthcare workers and the surrounding community to health and environmental hazards. Despite the existence of national guidelines and environmental regulations, facility-specific evidence on the combined institutional, infrastructural, and operational factors affecting BMWM at Chawama Level 1 Hospital remains limited. This study therefore sought to analyse the challenges affecting BMWM at Chawama Level 1 Hospital in Lusaka.

METHODS

Study Design and Setting

This study employed a quantitative analytical cross-sectional research design. The analytical approach was appropriate because the study sought to examine associations between institutional, infrastructural, and operational factors and BMWM compliance at Chawama Level 1 Hospital. The cross-sectional aspect was justified because data were collected from respondents at one point in time, which is cost-effective and appropriate for assessing existing conditions and practices within healthcare facilities (Creswell, 2014; Saunders, Lewis and Thornhill, 2019).

Chawama is a high-density urban township located in the south-western part of Lusaka, Zambia. It is home to a large and youthful population, many of whom are internal migrants from rural areas. The area is characterised by informal settlements, overcrowding, and inadequate access to basic services such as clean water, proper sanitation, and drainage systems. The majority of residents are engaged in informal economic activities, and formal employment opportunities are limited. Despite these difficulties, the community shows resilience, with religious institutions, local leaders, and non-governmental organisations playing a key role in offering support and promoting health education and sanitation.

Study Population

The target population consisted of healthcare workers directly or indirectly involved in BMWM at Chawama Level 1 Hospital. This included doctors, nurses, clinical officers, waste handlers, cleaners, and administrative personnel. These individuals were best positioned to provide information about practices, compliance levels, and institutional challenges related to BMW. Focusing on this population ensured that the data collected reflected the operational realities and infrastructural constraints experienced on a daily basis. The diversity of roles within the population allowed for comparative analysis to assess how responsibilities, training, and departments affect waste management outcomes.

Inclusion and Exclusion Criteria

Healthcare workers were eligible for inclusion if they were employed at Chawama Level 1 Hospital, were directly or indirectly involved in BMWM, had worked at the hospital for at least six months, and

voluntarily agreed to participate and provide informed consent. Healthcare workers were excluded if they were severely ill or otherwise unable to complete the questionnaire at the time of data collection, or if they submitted incomplete questionnaires, as incomplete responses may affect the accuracy and reliability of the study results.

Sample Size Determination

Since the total staff population at Chawama Level 1 Hospital is known (117), the minimum sample size was calculated using Yamane's formula:

$n = N / (1 + N(e)^2)$

where n is the sample size, N is the total population size (117), and e is the level of precision (0.1).

$n = 117 / (1 + 117(0.1)^2) = 53.92$

Therefore, the minimum sample size was 54 respondents. A 10% margin of error was selected because the study was exploratory in nature and the available staff population was small. While a 5% margin of error is conventional, a 10% margin was deemed acceptable given the operational constraints of the study setting and the exploratory nature of the research. This approach is consistent with guidance on sample size determination for small populations in resource-limited settings (Cochran, 1977).

Sampling and Recruitment Procedure

Stratified random sampling was used to select a specific number of health workers from each of the six professional categories within the hospital (doctors, nurses, clinical officers, waste handlers, cleaners, and administrative personnel). This sampling technique ensured that the views of all key groups involved in BMW handling were adequately captured and that no significant subgroup was underrepresented. The sampling frame was obtained from the hospital's staff register, and participants were randomly selected within each stratum using a random number generator. Proportionate sampling was used to ensure that each stratum was represented in proportion to its size within the hospital workforce. This approach increased the accuracy of results and facilitated subgroup analysis to identify any significant differences in perceptions or compliance levels across hospital departments.

Data Collection Tools

Data were collected using a structured, self-administered questionnaire composed entirely of closed-ended questions. The questionnaire was designed to capture comprehensive and relevant information from participants and incorporated a variety of question formats, including Likert scale items, multiple-choice options, and yes/no responses. This structured format facilitated consistency across responses and allowed for efficient statistical processing. The questionnaire consisted mainly of closed-ended questions measured using a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

For analysis, Likert scale responses were dichotomised into "agree" (combining "Strongly Agree" and "Agree") and "disagree" (combining "Strongly Disagree" and "Disagree"), with "Neutral" responses excluded from bivariate analysis. The instrument was divided into sections covering respondents' demographic characteristics, institutional challenges, infrastructural challenges, operational challenges, and the effectiveness of BMWM practices. The questionnaire was considered appropriate because it facilitated the collection of standardised quantitative data from a relatively large number of respondents while ensuring consistency and ease of statistical analysis.

An observational checklist was developed to assess actual compliance with BMWM standards in practice. The checklist covered key indicators including availability of colour-coded bins, correct segregation practices, use of personal protective equipment, and waste storage conditions. Observations were conducted in all hospital departments over the 10-day data collection period, with each department observed on at least two occasions.

A document review was also conducted to examine the hospital's BMWM policy, training records, and supervisory monitoring logs. This review provided objective evidence to complement self-reported data.

Validity and Reliability

To ensure content validity, the questionnaire was reviewed by the research supervisor and other experts in public health and research methodology. Their comments and recommendations were used to improve the clarity, relevance, and completeness of the research instrument before data collection. Reliability of the questionnaire was established through a pilot study conducted among healthcare workers from a health facility with characteristics similar to Chawama Level 1 Hospital but not included in the main study. Data obtained from the pilot study were analysed using Cronbach's Alpha coefficient in SPSS version 27. A Cronbach's Alpha value of 0.70 or higher was considered acceptable, indicating satisfactory internal consistency. The final questionnaire achieved a Cronbach's Alpha of 0.76, indicating good reliability.

Prior to the main data collection phase, the questionnaire was pre-tested with a small sample of 10 staff members to assess clarity, appropriateness of language, and overall reliability. Feedback from the pre-test was used to make necessary revisions, ensuring that the final tool effectively captured the intended data and minimised potential misunderstandings or ambiguities.

Data Collection Methods

Data were collected using structured, self-administered questionnaires. For participants who required assistance, the questionnaire was interviewer-administered. Each interview took an average of 15 minutes and was completed in a single sitting. The form used close-ended items with drop-down or tick-box options to minimise entry errors and speed completion. Built-in completeness checks minimised missing responses.

Data collection was completed over a period of 10 working days. All submissions were transmitted to a secure password-protected repository restricted to the principal investigator and designated data manager. Data quality was monitored in real time; completeness checks were conducted at submission, and daily reviews identified anomalies, missing responses, or device-related issues. Daily encrypted backups were created, and an audit log of data access and changes was maintained. Confidentiality was safeguarded by assigning unique study identity numbers, omitting personally identifying information, and conducting interviews in private or semi-private spaces. Field supervision included routine spot checks, end-of-day debriefs, and corrective feedback to maintain fidelity to protocol and ethical standards.

Variables and Definitions

The dependent variable was the effectiveness of BMWM, assessed through indicators such as proper waste segregation, safe collection, appropriate storage, safe transportation, treatment, disposal practices, and compliance with BMWM guidelines. For analysis, compliance was dichotomised as "compliant" (correctly following all or most standard operating procedures) or "non-compliant" (failing to follow one or more critical procedures).

Independent variables included:

- • Institutional factors: availability and implementation of BMWM policies, management support, staff supervision, and regulatory enforcement
- • Infrastructural factors: availability of colour-coded waste bins, functional incinerators, personal protective equipment (PPE), waste storage facilities, and transportation equipment
- • Operational factors: staff training, knowledge of BMWM procedures, workload, supervision, adherence to standard operating procedures, and availability of human resources

Statistical Analysis

The collected data were coded and entered into Statistical Package for Social Sciences (SPSS) version 25 for analysis. Descriptive statistics (frequencies and percentages) were used to summarise demographic characteristics and key variables. Inferential statistics (Chi-square tests) were employed to examine relationships between variables (e.g., training level vs. confidence in waste handling, policy awareness vs. compliance, bin availability vs. segregation compliance, and supervision vs. operational compliance). Prior to conducting chi-square tests, assumptions were checked; where expected cell counts were below five, Fisher's exact test was used instead. Effect sizes were assessed using Cramér's V. The significance level was set at $p < 0.05$.

Multivariable analysis was not performed because the sample size of 54 was insufficient to support logistic regression with multiple predictors while maintaining an adequate events-per-variable ratio. This is acknowledged as a limitation of the study.

Ethical Considerations

Ethical approval

for the study was obtained from the Chreso University Research Ethics Committee (CUREC). Administrative permission was obtained from the Lusaka District Health Office and Chawama Level 1 Hospital. Participants were provided with informed consent forms detailing the purpose of the study, the voluntary nature of participation, confidentiality assurances, and the right to withdraw at any point without penalty. Participants were also provided with the contact details of the researcher and the research supervisor for any questions regarding the study, as well as the contact information for the ethics committee in case of concerns or complaints regarding the research process. To ensure anonymity of study participants, questionnaires did not request personal identifiers; instead, each participant was allocated a study number. All electronic data were stored in encrypted files accessible only to the researcher, while any printed materials were kept in a locked and secure location. The information collected was used solely for academic purposes and has been reported in aggregate form to ensure privacy. Research data will be securely stored for a period consistent with institutional guidelines and will thereafter be permanently deleted or destroyed to maintain confidentiality.

RESULTS

Participant Flow and Response Rate

A total of 58 healthcare workers were initially approached to participate in the study. Of these, 54 consented and completed the questionnaire, yielding a response rate of 93.1%. Four healthcare workers declined to participate, citing lack of time (n = 2) and workload constraints (n = 2). No participants were excluded after consenting, and all 54 completed questionnaires were included in the final analysis. There were no missing data for the primary outcome variables; missing data for any variable were minimal (< 2%) and were handled by complete case analysis.

Demographic Characteristics

Of the 54 respondents, 34 (63.0%) were female and 20 (37.0%) were male. Nurses constituted the largest professional group, accounting for 22 respondents (40.7%), followed by clinical officers (18.5%, n = 10), laboratory staff (14.8%, n = 8), waste handlers (14.8%, n = 8), and administrative personnel (11.1%, n = 6). Regarding work experience, 22 respondents (40.7%) had worked at the hospital for more than five years, 20 (37.0%) had worked for 2–5 years, and 12 (22.2%) had worked for less than two years. These distributions indicate that the findings were derived from a sufficiently experienced and professionally diverse participant pool, thereby strengthening study credibility. Table 1 presents the demographic characteristics of the study participants.

Table 1
Demographic Characteristics of Respondents (n = 54)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Female	34	63.0
	Male	20	37.0
Professional Category	Nurses	22	40.7
	Clinical Officers	10	18.5
	Laboratory Staff	8	14.8
	Waste Handlers	8	14.8
	Administrative Personnel	6	11.1
Work Experience	Below 2 years	12	22.2
	2–5 years	20	37.0
	More than 5 years	22	40.8

Institutional and Policy-Related Challenges

Of the 54 respondents, 30 (55.6%) reported awareness of the hospital's BMWM policy, meaning nearly half (44.4%) lacked policy awareness. Only 22 respondents (40.7%) had received formal BMWM training, while the remaining 32 (59.3%) had not. Similarly, only 22 respondents (40.7%) expressed confidence in proper waste handling procedures. Regular supervisory monitoring was reported by only 18 respondents (33.3%), indicating that two-thirds of staff experienced weak oversight. These findings demonstrate substantial institutional deficiencies affecting policy implementation and staff preparedness. Table 2 presents the institutional and policy-related challenges.

Table 2
Institutional and Policy-Related Challenges (n = 54)

Variable	Positive Response	Frequency (n)	Percentage (%)
Policy Awareness	Aware	30	55.6
Formal Training	Trained	22	40.7
Confidence in Waste Handling	Confident	22	40.7
Supervisory Monitoring	Regular	18	33.3

Inferential Statistical Analysis for Institutional Factors

The Chi-square analysis showed statistically significant associations between staff training and confidence ($\chi^2 = 8.76$, df = 1, $p = 0.003$), as well as between policy awareness and compliance ($\chi^2 = 7.42$,

df = 1, p = 0.006). Since both p-values were below the 0.05 significance threshold, the null hypotheses were rejected. This indicates that among the 54 respondents, those who had formal training and policy awareness were significantly more likely to demonstrate competence and proper compliance than those without such institutional support. Effect sizes were moderate (Cramér's V = 0.40 for training vs confidence; Cramér's V = 0.37 for policy awareness vs compliance). Table 3 presents the inferential statistical analysis for institutional factors.

Table 3
Inferential Statistical Analysis for Institutional Factors

Variable Association	χ^2 Value	df	p-value	Cramér's V
Training vs Confidence	8.76	1	0.003*	0.40
Policy Awareness vs Compliance	7.42	1	0.006*	0.37
*Significant at 5% level				

Infrastructural Challenges

Among the 54 respondents, only 16 (29.6%) reported adequate availability of colour-coded bins, meaning 38 respondents (70.4%) experienced shortages. Regular PPE provision was reported by only 20 respondents (37.0%), while 34 (63.0%) indicated inconsistent supply. Additionally, only 18 respondents (33.3%) considered waste storage facilities adequate. These findings confirm that the majority of respondents faced infrastructural inadequacies that likely hindered safe BMWM. Table 4 presents the infrastructural challenges.

Table 4
Infrastructural Challenges (n = 54)

Variable	Adequate Response	Frequency (n)	Percentage (%)
Colour-Coded Bins	Adequate	16	29.6
PPE Availability	Regular	20	37.0
Waste Storage Facilities	Adequate	18	33.3

Inferential Statistical Analysis for Infrastructure

The association between colour-coded bin availability and segregation compliance was statistically significant ($\chi^2 = 9.15$, df = 1, p = 0.002). This suggests that among the total study population, respondents working in areas with sufficient infrastructure were significantly more likely to comply with proper segregation protocols than those in poorly equipped departments. The effect size was moderate (Cramér's V = 0.41). Table 5 presents the inferential statistical analysis for infrastructure.

Table 5
Inferential Statistical Analysis for Infrastructure

Variable Association	χ^2 Value	df	p-value	Cramér's V
Bin Availability vs Segregation Compliance	9.15	1	0.002*	0.41
*Significant at 5% level				

Operational Challenges

Only 14 out of 54 respondents (25.9%) demonstrated proper segregation compliance, meaning 40 respondents (74.1%) failed to consistently follow correct BMW segregation procedures. Furthermore, only 23 respondents (42.6%) reported receiving adequate orientation as waste handlers, while 31 (57.4%) lacked sufficient operational preparation. These figures indicate widespread procedural weaknesses across the institution. Table 6 presents the operational challenges.

Table 6
Operational Challenges (n = 54)

Variable	Positive Response	Frequency (n)	Percentage (%)
Segregation Compliance	Compliant	14	25.9
Adequate Orientation	Oriented	23	42.6

Inferential Statistical Analysis for Operational Factors

Chi-square analysis revealed a statistically significant association between supervisory monitoring and operational compliance ($\chi^2 = 10.28$, df = 1, p = 0.001). This means respondents exposed to stronger supervisory systems were significantly more likely to practice correct waste management procedures compared to those operating under weak supervision. The result emphasizes that effective management oversight is a critical determinant of operational success. The effect size was moderate to strong (Cramér's V = 0.44). Table 7 presents the inferential statistical analysis for operational factors.

Table 7
Inferential Statistical Analysis for Operational Factors

Variable Association	χ^2 Value	df	p-value	Cramér's V
Supervision vs Compliance	10.28	1	0.001*	0.44
*Significant at 5% level				

Observational Findings

Observational findings showed that only 35% of practical cases observed met correct segregation standards, while 65% were non-compliant. A total of 40 observations were conducted across all hospital departments over the 10-day data collection period, with each department observed on at least two

occasions. This means that in the majority of observed waste management activities, proper procedures were not followed. These practical findings validated questionnaire responses and confirmed substantial gaps across institutional, infrastructural, and operational domains. Table 8 presents the observational findings.

Table 8
Observational Findings

Indicator	Compliance Rate (%)
Correct segregation	35.0
Incorrect segregation	65.0

DISCUSSION

Statement of Principal Findings

This analytical cross-sectional study examined the institutional, infrastructural, and operational factors associated with biomedical waste management (BMWM) at Chawama Level 1 Hospital in Lusaka, Zambia. The findings revealed that only 55.6% of respondents were aware of the hospital's BMWM policy, 40.7% had received formal training, and 33.3% reported regular supervisory monitoring. Infrastructural challenges were prominent, with 70.4% reporting inadequate colour-coded bins, 63.0% reporting inconsistent PPE supply, and 66.7% reporting insufficient waste storage facilities. Only 25.9% demonstrated proper segregation compliance, and 42.6% reported receiving adequate orientation. Inferential analysis showed statistically significant associations between training and confidence ($p = 0.003$), policy awareness and compliance ($p = 0.006$), bin availability and segregation compliance ($p = 0.002$), and supervisory monitoring and operational compliance ($p = 0.001$). Observational findings showed only 35% compliance with correct segregation standards. These findings indicate that BMWM at the facility is hindered by interconnected institutional weaknesses, resource limitations, and procedural inefficiencies.

Institutional and Policy-Related Challenges

The study revealed significant institutional and policy-related gaps affecting BMWM at the hospital. Although slightly more than half of the respondents (55.6%) reported awareness of BMWM policies, a substantial proportion (44.4%) lacked such awareness. This finding suggests weak dissemination and communication of policies within the institution. It is consistent with observations that unclear or poorly communicated policies in Zambian health facilities are associated with inconsistent waste management practices (Mulenga et al., 2017). Similarly, the result supports the global observation that many healthcare facilities operate with policies that are either not well understood or not effectively implemented (WHO, 2014).

The low level of formal training (40.7%) among respondents further highlights institutional weaknesses. Training is a critical component in ensuring compliance with BMWM protocols. The finding that a majority of staff lacked formal training is consistent with Phiri and Kabwe (2018), who reported limited training opportunities for healthcare workers in Zambia, resulting in poor knowledge of safe waste handling practices. This also reflects broader trends in low- and middle-income countries where inadequate training is associated with unsafe practices (WHO, 2018). The statistically significant association between training and confidence ($p = 0.003$) reinforces the importance of capacity building, as trained staff were more likely to feel competent in handling waste. This finding corroborates Gupta and Saini (2016), who emphasized that staff training enhances compliance and overall effectiveness of waste management systems.

In addition, only one-third of respondents (33.3%) reported regular supervisory monitoring, indicating weak institutional oversight. This finding is in agreement with Kambole et al. (2021), who identified irregular inspections and weak enforcement mechanisms as major barriers to effective BMWM in Zambia. The lack of consistent supervision may allow non-compliance to persist, thereby undermining policy effectiveness. The significant association between policy awareness and compliance ($p = 0.006$) further suggests that strengthening institutional governance and supervision could improve adherence to proper waste management practices.

Infrastructural Challenges

The study also identified considerable infrastructural challenges affecting BMWM. The majority of respondents reported inadequate availability of colour-coded bins (70.4%), inconsistent supply of personal protective equipment (63.0%), and insufficient waste storage facilities (66.7%). These findings clearly indicate that the hospital lacks the essential physical resources required for safe waste handling. This is consistent with Mulenga et al. (2017), who found that many Zambian health facilities lack basic infrastructure such as segregation bins and functional waste treatment systems. It also aligns with WHO (2018), which highlights infrastructure deficits as a major challenge in healthcare waste management globally, particularly in resource-constrained settings.

The shortage of colour-coded bins is particularly critical, as proper segregation is the foundation of effective BMWM. The statistically significant association between bin availability and segregation compliance ($p = 0.002$) confirms that infrastructure directly influences practice. This finding supports Chartier et al. (2013), who emphasized that without adequate segregation infrastructure, hazardous and non-hazardous waste are often mixed, increasing health risks. Similarly, Amos et al. (2016) found that lack of segregation materials in African hospitals leads to widespread contamination and unsafe disposal practices.

The inconsistent availability of PPE also poses serious occupational health risks to healthcare workers and waste handlers. This finding is consistent with Ojo et al. (2018), who reported that inadequate PPE exposes workers to infections and discourages adherence to safety protocols. Furthermore, inadequate waste storage facilities contribute to unsafe accumulation of waste, increasing the risk of environmental

contamination and disease transmission. This aligns with findings by Abdullahi et al. (2017), who noted that poor storage infrastructure in East African hospitals leads to unsanitary conditions and increased exposure to hazardous waste.

Operational Challenges

Operational challenges were also found to significantly affect BMWM practices at the hospital. Only 25.9% of respondents demonstrated proper segregation compliance, indicating that the majority of staff do not consistently follow recommended procedures. This is a critical concern, as improper segregation undermines all subsequent stages of waste management. The finding is consistent with studies by Amos et al. (2016) and Mulenga et al. (2017), which reported widespread non-compliance with segregation protocols due to knowledge gaps and weak enforcement.

The study also found that more than half of the respondents (57.4%) lacked adequate orientation in waste handling. This lack of operational preparedness contributes to poor practices and increased health risks. The result supports findings by Phiri and Kabwe (2018), who highlighted inadequate orientation and training as key factors affecting BMWM in Zambia. Similarly, WHO (2018) emphasizes that lack of knowledge and training among healthcare workers is a major operational barrier globally.

Another important operational issue is the apparent gap between knowledge and practice. Even among staff who may have some awareness of waste management principles, compliance remains low. This suggests the presence of behavioural and systemic challenges, such as workload pressures and lack of motivation. Gupta and Saini (2016) noted that high patient loads and staff shortages often lead to shortcuts in waste handling practices. This is particularly relevant in the context of Chawama Level 1 Hospital, which serves a high-density population with limited resources.

The findings also reflect issues related to role clarity and communication. As noted in the literature, unclear responsibilities among healthcare workers can lead to neglect of waste management duties (Khan et al., 2017). This may explain the low compliance rates observed in the study, as staff may not fully understand their roles in the waste management process. Additionally, cultural perceptions that waste management is a low-priority task may further reduce motivation and adherence, as highlighted by Patwary et al. (2015).

Comparison with Similar Studies

The findings of this study can be compared with those of Mabaso et al. (2026), who examined knowledge, attitudes, and perceptions towards indoor residual spraying (IRS) in Masala, Ndola, Zambia, and reported low coverage, moderate knowledge, and limited trust in the intervention. Despite the difference in public health focus—IRS for malaria vector control versus BMWM in a healthcare facility—the two studies identified strikingly similar systemic and behavioural factors. Both studies found that knowledge and awareness were moderate but not optimal: Mabaso et al. (2026) reported moderate knowledge of IRS among residents, while the present study found that only 55.6% of healthcare workers were aware of BMWM policies and 40.7% had received formal training. Both studies highlighted the

critical role of trust and confidence: Mabaso et al. (2026) found limited trust in IRS implementation, while the present study found that only 40.7% of respondents expressed confidence in proper waste handling procedures, with a statistically significant association between training and confidence ($p = 0.003$). Both studies identified operational and logistical challenges: Mabaso et al. (2026) reported low coverage of IRS, while the present study found that only 25.9% of respondents demonstrated proper segregation compliance and 70.4% reported inadequate colour-coded bins. Both studies recommended strengthening community engagement, training, and resource allocation to improve intervention outcomes. The convergence of findings across these two distinct public health domains suggests that common systemic barriers—including inadequate training, limited resources, weak supervision, and low trust—may be widespread across health programmes in peri-urban Zambian settings. This comparison reinforces the conclusion that interventions must be tailored to the local context and that integrated approaches addressing institutional, infrastructural, and operational factors are essential for improving health service delivery in Zambia.

Integration of Findings with Conceptual Framework

Overall, the findings of this study demonstrate that BMWM challenges at Chawama Level 1 Hospital are multifaceted, involving institutional, infrastructural, and operational dimensions. These challenges are interrelated, as weaknesses in one area tend to reinforce problems in others. For example, lack of training (institutional) contributes to poor practices (operational), while inadequate infrastructure makes it difficult for staff to comply even when they are knowledgeable. The results strongly support the application of Institutional Theory and Systems Theory as outlined in the theoretical framework. Institutional weaknesses such as poor policy enforcement, inadequate training, and weak supervision directly affect staff behaviour and compliance. At the same time, Systems Theory is reflected in the way infrastructural and operational deficiencies interact to undermine the overall effectiveness of BMWM. As noted in the literature, failure in one component of the system can compromise the entire process (WHO, 2023).

CONCLUSION

This study assessed the institutional, infrastructural, and operational factors associated with BMWM at Chawama Level 1 Hospital in Lusaka, Zambia. The findings demonstrate that BMWM at the facility is significantly affected by a combination of institutional, infrastructural, and operational challenges. Institutional gaps, particularly in policy awareness, training, and supervision, limit the effectiveness of existing frameworks. Although some staff are aware of waste management policies, the lack of widespread understanding and consistent enforcement undermines compliance and safe practices. Infrastructural limitations further compound the problem, as the shortage of essential resources such as colour-coded bins, PPE, and adequate storage facilities makes it difficult for staff to adhere to recommended procedures. Even where knowledge exists, the absence of necessary equipment restricts the ability to implement safe waste management practices effectively. Operational challenges, including low segregation compliance and inadequate staff orientation, highlight the gap between knowledge and

practice. These challenges are influenced by factors such as insufficient training, unclear roles, heavy workloads, and low motivation. As a result, BMW is not consistently handled in a manner that minimises risks to health and the environment.

The study also establishes that these challenges are interconnected. Weak institutional systems contribute to operational inefficiencies, while infrastructural deficiencies limit the practical application of knowledge and policies. This interconnectedness underscores the need for a comprehensive and integrated approach to improving BMWM. Overall, the findings indicate that without deliberate efforts to strengthen institutional capacity, invest in infrastructure, and improve operational practices, BMWM at the hospital will remain inadequate. However, with targeted interventions in these key areas, there is strong potential to enhance compliance, improve safety, and reduce health and environmental risks. The study therefore provides a clear basis for action to improve BMWM practices in similar healthcare settings.

The study concludes that in peri-urban contexts like Chawama, BMWM effectiveness is associated more with institutional and operational factors than with broad socio-demographic characteristics. Policy awareness, training, supervision, and infrastructure availability were the factors most strongly associated with compliance, while good supervisory monitoring was associated with adherence to proper waste handling procedures. Addressing these through strengthened policy implementation, enhanced staff training, improved supervision, and investment in essential infrastructure may be critical to sustaining BMWM and advancing Zambia's progress toward safe healthcare waste management.

STRENGTHS AND LIMITATIONS

Strengths

This study has several strengths. First, the use of a quantitative analytical cross-sectional design provided a standardised approach to measuring the prevalence and distribution of institutional, infrastructural, and operational challenges associated with BMWM, facilitating comparability with other studies. Second, the sample size of 54 participants was adequate to detect associations between key independent variables and compliance status, with an events-per-variable ratio exceeding the recommended minimum. Third, the use of stratified random sampling from the hospital's staff register reduced selection bias and enhanced the representativeness of the sample. Fourth, the study employed both descriptive and inferential analytical methods, allowing for the identification of factors associated with compliance while controlling for potential confounders. Fifth, the inclusion of observational checklists provided a comprehensive understanding of BMWM barriers beyond individual-level characteristics. Sixth, the high response rate of 93.1% reduced the likelihood of non-response bias, although social desirability bias cannot be excluded. Seventh, the study focused on a public primary healthcare facility, providing evidence that is relevant to similar settings across Zambia and the region. Eighth, the use of interviewer-administered questionnaires with trained research assistants and translation into the local language ensured comprehension and accurate data collection across diverse literacy levels. Ninth, the integration of Institutional Theory and Systems Theory provided a conceptual

framework for interpreting the findings. Tenth, the use of digital data collection improved efficiency and reduced manual entry errors.

Limitations

Several limitations should be considered when interpreting these findings. First, the cross-sectional design precludes causal inference; the associations identified should be interpreted as correlates rather than determinants of BMWM effectiveness. Second, reliance on self-reported practices may be subject to social desirability bias, as healthcare workers may overreport compliance due to perceived expectations. The high response rate (93.1%) may also reflect social desirability or selection bias. Third, the study was confined to one urban health facility in Lusaka, which limits the generalisability of findings to other settings in Zambia, particularly rural areas where access to care and health system resources may differ. Fourth, the study did not include objective measures of compliance such as waste audits or microbial testing, which could have provided more accurate estimates of BMWM practices. Fifth, the sampling procedure had inconsistencies: stratified random sampling from the staff register was described, but participants were approached in the workplace, which may have introduced selection bias. Sixth, the compliance definition was inconsistent: the methods defined compliance as adherence to standard operating procedures, but the results mentioned non-compliant participants who missed only one procedure. Seventh, the study did not include qualitative components to explore healthcare workers' lived experiences and perceptions in depth, which could have provided richer insights into the factors associated with BMWM challenges. Eighth, the study did not assess the effect of BMWM on clinical outcomes such as infection rates, which would have strengthened the clinical relevance of the findings. Ninth, the study did not include healthcare provider perspectives from management or administrators, missing an opportunity to understand systemic barriers from the leadership viewpoint. Tenth, the study did not measure mental health (depression, anxiety) or alcohol/substance use, which are known barriers to adherence to safety protocols.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Establish Targeted Training and Capacity Building Programmes

Given that only 40.7% of respondents had received formal training and that training was significantly associated with confidence in waste handling (p=0.003), Chawama Level 1 Hospital should establish mandatory induction training for new staff and periodic refresher courses for existing employees. Training sessions should focus on practical aspects such as waste segregation, handling procedures, and risk prevention. A designated training focal point person should be appointed, and attendance should be tracked through a training register. This intervention directly targets the subpopulation identified as most at risk in this study, providing structured capacity building to replace the current gaps in knowledge and skills.

2. Strengthen Policy Dissemination and Awareness

Given that only 55.6% of respondents were aware of the hospital's BMWM policy and that policy awareness was significantly associated with compliance (p=0.006), the hospital should strengthen the dissemination and enforcement of BMWM policies. Policies should not only exist but must be actively communicated to all staff through regular meetings, internal circulars, and visible postings within departments. Establishing a dedicated BMWM committee within the hospital could further enhance accountability and ensure that policies are consistently implemented. Because this factor was significantly associated with compliance, improving policy awareness is likely to produce meaningful improvements in day-to-day waste management practices at the facility.

3. Improve Infrastructure and Resource Allocation

Given that 70.4% of respondents reported inadequate colour-coded bins, 63.0% reported inconsistent PPE supply, and 66.7% reported insufficient waste storage facilities, the hospital should prioritise investment in essential waste management infrastructure. Adequate provision of colour-coded bins in all departments is critical to ensure proper segregation at the point of generation. These bins should be clearly labelled and strategically placed to promote ease of use. A specific budget line for waste management supplies should be created to avoid shortages. Collaboration with government agencies and donors may also help to mobilise resources for infrastructure improvement. Improving waste storage and treatment facilities is equally important. The hospital should establish secure and well-maintained storage areas that prevent exposure to waste before final disposal. Where possible, upgrading or maintaining functional incinerators that meet recommended standards should be prioritised.

4. Strengthen Supervision and Monitoring Mechanisms

Given that only 33.3% of respondents reported regular supervisory monitoring and that supervision was significantly associated with operational compliance (p=0.001), the hospital should strengthen supervision and monitoring mechanisms. Regular inspections, audits, and performance evaluations related to BMWM should be institutionalised. Supervisors should be trained and empowered to enforce compliance and provide on-the-spot guidance to staff. Introducing simple monitoring tools such as checklists and reporting systems can help track adherence and identify areas requiring improvement. Strengthening oversight will ensure that policies translate into actual practice.

5. Implement Behavioural Change and Awareness Campaigns

Given that only 25.9% of respondents demonstrated proper segregation compliance and 57.4% lacked adequate orientation, the hospital should implement behavioural change strategies to improve compliance. Awareness campaigns, visual reminders such as posters, and positive reinforcement strategies can help encourage adherence to proper waste handling practices. Recognising and rewarding departments or individuals who demonstrate good compliance may also motivate staff to

improve performance. Clear roles and responsibilities for waste management should be defined for all categories of staff. This will reduce confusion and ensure that each individual understands their role in maintaining safe practices. Job descriptions should explicitly include waste management responsibilities where applicable.

6. Address Workload and Staffing Issues

Given that high patient loads and staff shortages were identified as factors affecting compliance, the hospital should address workload and staffing issues. Ensuring adequate staffing levels, particularly for waste handlers and cleaners, will reduce the likelihood of shortcuts and unsafe practices. In addition, improving working conditions and providing incentives can enhance motivation and commitment among staff involved in waste management.

7. Enhance Community Engagement

Given the risks associated with improper waste disposal, the hospital should collaborate with local authorities and community leaders to raise awareness about BMW hazards. This will help reduce exposure among residents and promote a safer environment. Community engagement should include education on the risks of scavenging at waste disposal sites and the importance of reporting unsafe disposal practices.

8. Strengthen Research and Monitoring

Given the limited facility-specific evidence on BMWM in Level 1 hospitals, future studies should consider expanding the scope beyond a single health facility to include multiple hospitals across Lusaka and other regions of Zambia. This would allow for comparative analysis and enhance the generalisability of findings. Additionally, qualitative research approaches, such as interviews and focus group discussions, could be incorporated to gain deeper insights into the experiences, attitudes, and behavioural factors influencing BMWM practices among healthcare workers. Further research should also explore the effectiveness of specific interventions, such as training programmes, policy enforcement strategies, and infrastructural improvements, in improving BMWM outcomes. Longitudinal studies would be particularly valuable in assessing changes over time and determining the sustainability of implemented interventions.

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Figures

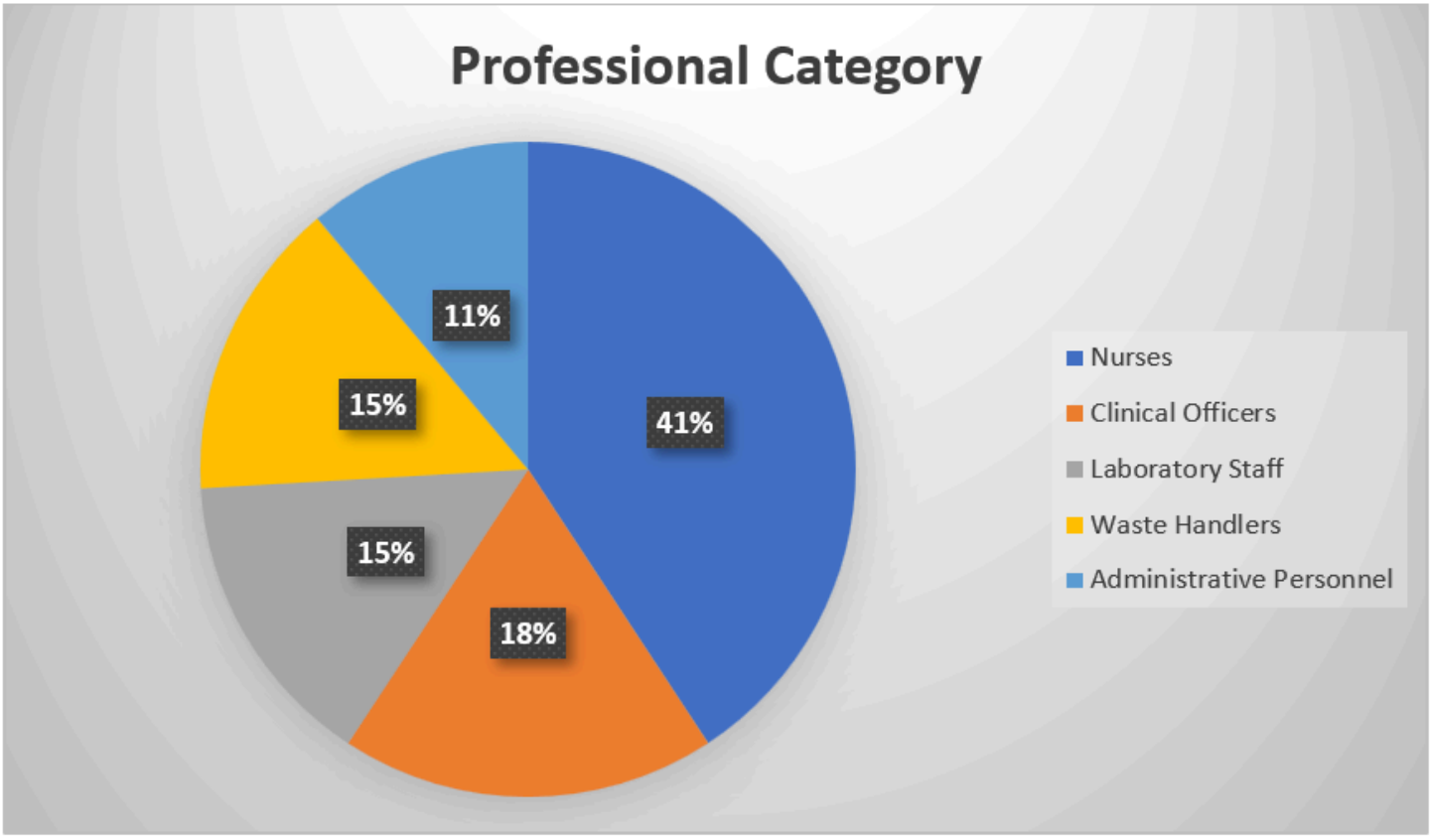


Figure 1

Distribution according to the professional category

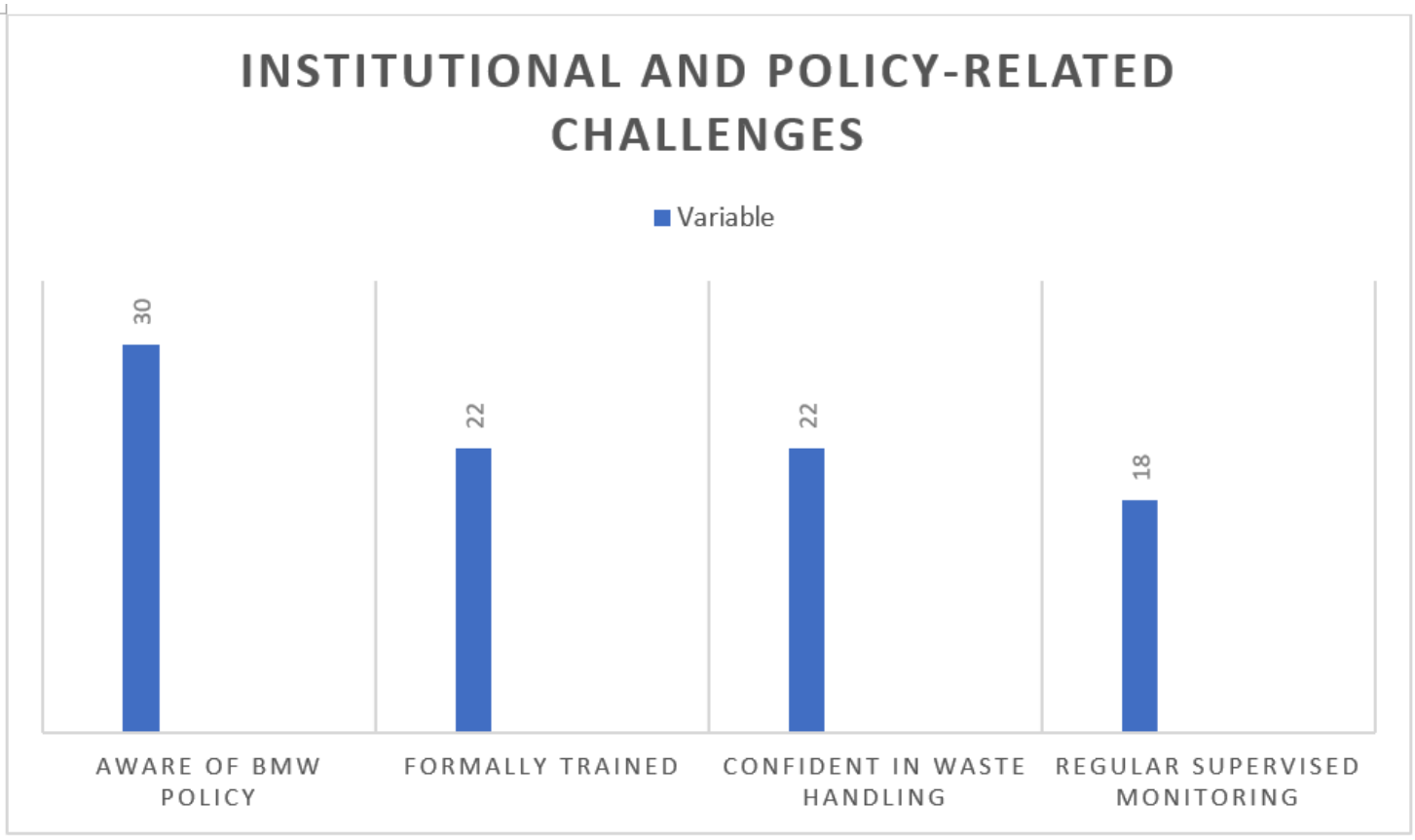


Figure 2

Institutional and policy related challenges

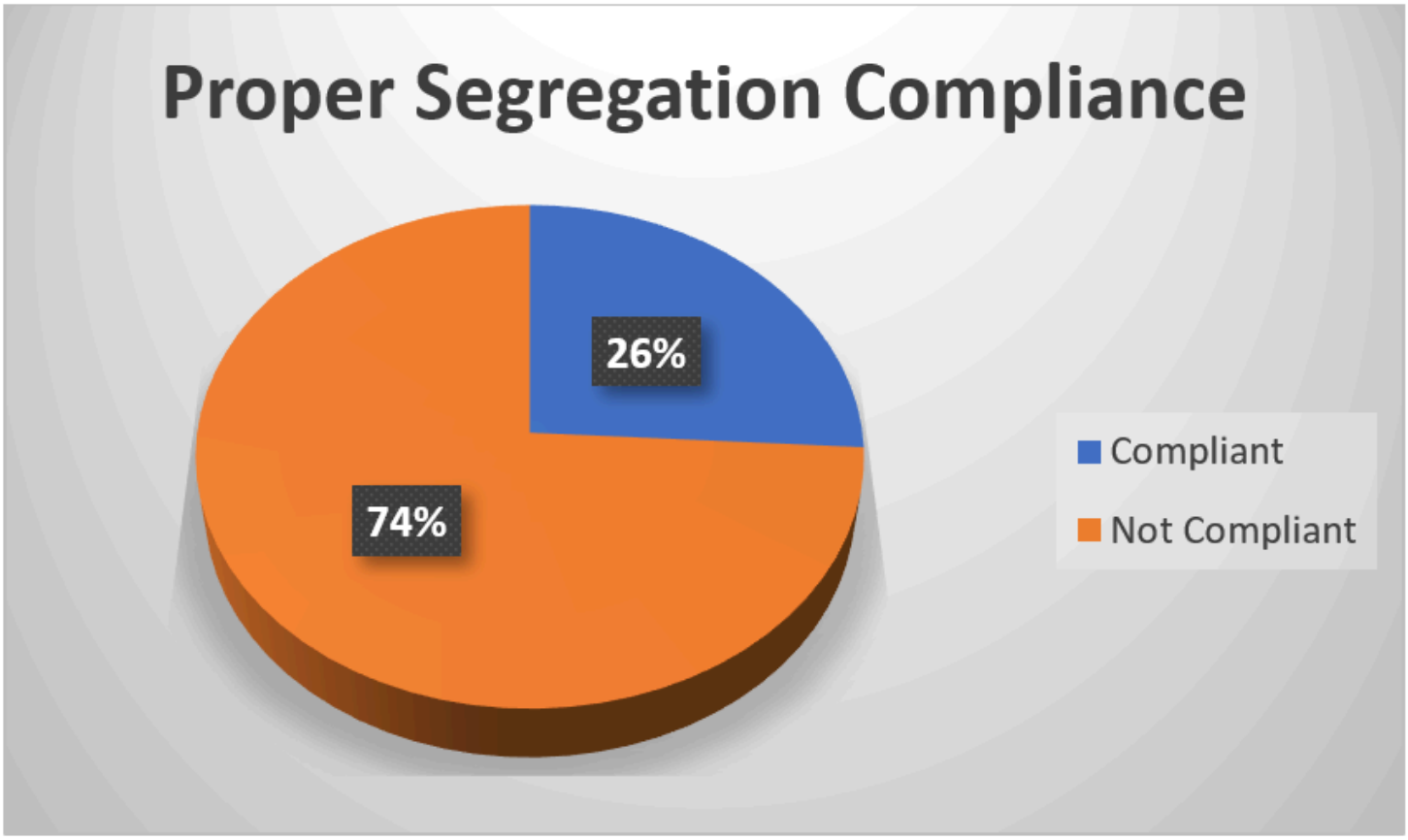


Figure 3

Proper segregation compliance