

## Original Article

# Assessing Knowledge, Attitudes, and Practices of Healthcare Workers Regarding Medical Waste Management at a Tertiary Hospital in Botswana: A Cross-Sectional Quantitative Study

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### ABSTRACT

**Background:** Medical waste management (MWM) is of concern to the medical and general community. Adequate knowledge regarding management of healthcare waste is an important precursor to the synthesis of appropriate attitudes and practices of proper handling and disposal of medical waste by healthcare workers (HCWs). **Aims and Objectives:** This study was designed to investigate knowledge, attitudes, and practices of doctors, nurses, laboratory technicians, and housekeeping staff, regarding MWM at a tertiary hospital in Gaborone, Botswana. **Materials and Methods:** This was a cross-sectional quantitative study using a self-administered questionnaire involving 703 participants. Data were analyzed using SAS software. Descriptive statistics were used to summarize the data. Responses for attitude of respondents were analyzed using nonparametric tests. **Results:** The completion rate for this study was 90% with (632/703) questionnaires analyzed. Majority of respondents were nurses 60% (422/703), followed by housekeeping staff 24.3% (171/703), doctors 10.95% (77/703), and laboratory technicians 4.7% (33/703). The study showed that 66.9% (423/632) of respondents had some training in MWM, and 90.5% (572/632) claimed to have knowledge regarding the consequences of poor MWM, particularly health risks. There was a significant agreement among the respondents that segregation of medical waste should be done at the point of generation (mean score = 4.43 out of 5). Majority of respondents reported that the healthcare facility had a color-coding system (mean score = 4.59) and identified “lack of knowledge of the dangers of improper waste management by HCWs” as the major obstacle to MWM. **Conclusion:** This study showed that MWM practice at this facility was above average, although improvements were required in accessing waste disposal points and availability of personal protective equipment. Ongoing training should be provided to HCWs on MWM, with more attention to knowledge of regulatory requirements, and involvement of HCWs in development of MWM policies to enhance compliance.

**KEYWORDS:** Africa, biohazards, color-coding, developing countries, ethics, healthcare laws, hospitals, medical errors, regulation, risk management

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## INTRODUCTION


Medical waste is defined as “Any waste which is generated in the diagnosis, treatment or immunization of human beings or animals or in research” in a place where healthcare is provided.<sup>[1]</sup> It includes all the materials used while administering

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treatment to patients as well as all items contaminated by hazardous fluids, for example, blood, urine, feces, and other body fluids. Medical waste poses an important global challenge because of potential hazards to the environment and public health. Healthcare workers (HCWs) are exceptionally at a high risk to potential contamination from medical waste by the nature of their work and proximity to this kind of waste. While healthcare wastes are generated during all processes of provision of healthcare services, the quantities of waste produced vary with the type of health facility, the level of services offered; and the economic status of a given country. As an example, a general medical practice facility would not generate the same medical waste quantities as does a day surgery; likewise, an eye hospital may not generate as much hazardous waste as an obstetric practice.<sup>[2]</sup> Globally, it is estimated that 7–10 billion tons of waste are generated per annum, out of this only 2 billion tons are municipal solid waste, of which medical waste contribute but a small fraction.<sup>[3]</sup> It is estimated that 75%–95% of bio-medical waste are non-hazardous, whereas 10%–25% are hazardous waste.<sup>[2]</sup> However, when both types of medical waste are mixed together, then all types of medical waste may become harmful and detrimental to humans, animals, and the environment. Unfortunately, reports suggest that almost 80% of medical waste are mixed with general waste, especially in developing countries.<sup>[3]</sup> Proper and adequate management of medical waste is, therefore, of great importance during healthcare service delivery. In the course of providing healthcare services (preventative, promotive or curative), it is inevitable that medical waste will be generated. When waste is not handled in the correct manner, it may lead to serious health consequences for both humans,<sup>[3,4]</sup> animals, and may have a significant negative impact on the environment.<sup>[5,6]</sup> Further, the rapid environmental degradation associated with global warming and climate change is a critical challenge to the global community.<sup>[7]</sup> Therefore, waste disposal is a major concern in most communities especially in developing countries that lack environmental awareness education programs.<sup>[2-4,8]</sup> It has been suggested that minority populations and people in poverty are exposed to environmental health hazards at a disproportionately high rate when compared to affluent communities.<sup>[9]</sup>

### Classification and management of medical waste

Medical waste is generally subdivided into general waste and hazardous waste. General waste from healthcare facilities is considered safe for disposal via the general municipal waste stream. On the other hand, hazardous waste stream requires special handling given its potential to affect public health and

the environment.<sup>[5]</sup> For waste segregation to be done adequately, proper receptacles (containers) must be available and accessible to the waste generators. These must be of correct specification including labeling. The World Health Organization (WHO)<sup>[10]</sup> recommends that best practices require that visible posters indicating the kind of waste to be disposed should be placed on adjacent walls, such reminders reinforce behavior of proper waste segregation. Further, it is recommended that for segregation to be successful, containers of sufficient sizes be provided to avoid unpredictable fill-ups before collection and disposal of waste. There are specifications for appropriate healthcare waste receptacles according to the type of waste that they are intended to hold including the recommended color. The color-coding system that is internationally accepted is as follows: yellow – sharps; red – anatomical and infectious materials; dark green – pharmaceutical and chemical; and black – domestic waste, as shown in Figure 1.<sup>[11]</sup>

In addition, other forms of medical waste are not color coded but are by law required to carry specific symbols denoting or identifying the waste involved such as radioactive and chemical wastes.<sup>[12]</sup> Arguably, medical waste is a global concern because the hazards of poor management of waste may have far-reaching consequences on health and the environment.<sup>[13]</sup>

### Disposal of medical waste

Disposal of healthcare waste in general may involve one of the following methods, the choice depending on the category of waste and probably cost and availability of the technology. These include incineration, landfill disposal, or deep burial.<sup>[14]</sup> There could be exceptions and special cases, for example, waste containing recognizable body parts or foetal materials such as placentae, religious and cultural preferences should be considered and such waste should be disposed using acceptable and sensitive modalities.<sup>[15]</sup>

### Waste management and safety at the workplace

As noted in the foregoing text, injuries may result at the workplace because of exposure to waste. The International Labor Organization (ILO)<sup>[16]</sup> estimates that globally, up to 2.2 million people die from occupation-related disease and injuries and 170 million experiences nonfatal albeit serious injuries. Further, 5%–7% of deaths in established economies are a result of occupational related diseases.<sup>[16]</sup> The economic cost to companies and individual workers is staggering; mostly in terms of absenteeism, health and treatment costs, compensation, and legal costs. It is recommended that a safety culture should be created at the work place to prevent injuries; which would involve training and behavioral changes; aimed at prevention of exposures

at the workplace.<sup>[16]</sup> The resultant effect translates to good waste management practices such as efficient segregation of waste and use of personal protective equipment at work.

### Potential impact of improper disposal of medical waste in Botswana and other developing countries

Among the major diseases that afflict Botswana is tuberculosis (TB), and this is exacerbated by the synergy provided by the dual infection with HIV/AIDS. In addition, there is a high burden of HIV/HBV coinfection. The attendant immunosuppression resulting from HIV infection increases the viral replication of HBV as well as enabling transmissibility of HBV. This also increases the risk of acute HBV infection progressing to the chronic state and subsequent latent infections.<sup>[17]</sup> With the growing population and the inevitable increasing number of patients and the medical waste they generate, waste management and especially medical wastes need attention and action. Waste, especially medical waste is particularly important because improper handling can be a risk to both healthcare providers and the general population alike because of exposure to infectious and or contaminated objects.<sup>[4,18,19]</sup> Besides the increasingly health risks, improper waste management may contaminate the pristine water sources in Botswana, which is already a water scarce country.<sup>[20]</sup> Therefore, the government has instituted strict measures, which govern the management of waste disposal.<sup>[20]</sup>

### Ethical and legal implications of healthcare waste management

According to the Health Professions Council of South Africa (HPCSA),<sup>[21]</sup> healthcare waste may be defined as

Any undesirable or superfluous by product, emission, residue, or remainder generated in the course of health care by healthcare professionals, healthcare facilities, and other nonhealthcare professionals, which is discarded, accumulated, and stored with the purpose of eventually discarding it or is stored with the purpose of recycling, reusing, or extracting a usable product from such matter.<sup>[21]</sup>

Waste management refers to the processes involved from the point of generation to disposal or reuse of generated waste. Proper handling of biohazardous waste must meet minimum requirements for disposal which include<sup>[10]</sup>

- i. Segregation from other waste
- ii. Securely packaged
- iii. Labeling indicating source, type of waste, and the nature of treatment required
- iv. Transportation by appropriately trained personnel
- v. Treatment and elimination of the biohazard; and
- vi. Documentation and records.

Management of healthcare waste then, like all other forms of waste, must conform to the waste hierarchy as illustrated in Figure 2.<sup>[22]</sup>

### Ethical dilemmas regarding medical waste

The moral and legal concerns of waste management are diverse; they range from breach of privacy and confidentiality, through duty of care to matters concerned with negligence, compensation, and restorative justice.<sup>[23]</sup> Several legislations are in force in most countries that are enacted for the purpose of ensuring environmental integrity, proper waste handling, and human health and well-being. These include acts of parliament and other legal instruments.<sup>[10-12,14-16,19-21]</sup> Furthermore, international ethical instruments, such as the UNESCO *Universal Declaration on Bioethics and Human Rights*,<sup>[24]</sup> have identified fifteen core principles of bioethics, which include “protecting future generations” and “protection of the environment, the biosphere, and biodiversity.”<sup>[23,24]</sup> Therefore, doctors and other healthcare professionals have a moral and ethical obligation to act in a value- and duty-based manner to assist in the proper disposal of medical waste as part of virtue ethics and duty-based ethical obligations.<sup>[23-25]</sup>

### Duty of care

The duty of care holds important responsibility on the healthcare waste generator. This obligation holds the waste generator responsible for the welfare of HCWs, patients, visitors to healthcare facilities, the public, and environment.<sup>[10]</sup> It is, therefore, the duty of the generator of healthcare waste to ensure that waste is properly handled from generation up to disposal. Various process and activities, such as proper labeling of receptacles and adequate segregation, proper storage, and ultimately disposal, must be conducted in a manner that meets ethical and legal requirements. This process is enhanced by color coding of the receptacles.<sup>[10-11,26]</sup> Although waste management involves, minimization of waste and proper segregation, collection, storage, transportation, disposal, and record keeping. The duty of care entails much more, including the provision of appropriate education, training, and the commitment of the HCWs and healthcare managers within an effective policy and legislative framework.<sup>[12]</sup> Properly segregated waste minimizes potential injuries that otherwise result from inadvertent mix-up and erroneous handling.<sup>[2]</sup> Furthermore, segregation ensures cost effectiveness in the waste handling process, therefore, preventing resource wastage. Regarding responsibility toward the workers, the employer has a duty toward their safety and must provide adequate personal protective equipment and should provide vaccination against blood borne infections such as hepatitis B virus.<sup>[27]</sup> A good example to illustrate the

consequences of potential dereliction of duty in handling waste disposal is the 2000 incident as reported by Nwachukwu and others,<sup>[28]</sup> in which 6 Russian children contracted small pox (though a mild form) after coming in contact with discarded vaccine ampoules at a garbage dump in Vladivostok, Russia.<sup>[27]</sup> Such an environment is a danger and not conducive to healthy well-being. The South Africa Medical Research Council (SAMRC) states that “unnecessary or avoidable exposure to such hazards is ethically unacceptable.”<sup>[29]</sup> From the foregoing discussion, it is vital that HCWs are aware of the required ethical and legal standards and that an understanding of their role in the management of medical waste is made clear.

### Risk management implications of healthcare waste management

Risk management is derived from law and professional standards and is expressed through institutional policies and standard operational procedures.<sup>[23]</sup> When legal and risk management issues arise in the delivery of healthcare, there may also be ethical concerns. Conversely, what is originally identified as an ethical problem may raise legal and risk management issues.<sup>[23,30]</sup> The risk management implications of improper healthcare waste management or the failure to handle medical waste properly could lead to medical errors and allegations of negligence. For example, improper handling of healthcare waste could lead to each of three classifiable types of medical error as outlined below.<sup>[23,30]</sup>

- Errors of omission*, for example, where medical waste is not disposed at all or aggregated with regular waste leading to infectious disease or nosocomial infection or infection amongst HCWs or to environmental pollution
- Errors of commission*, for example, where waste is disposed into the wrong containers, resulting ultimately in improper disposal and the attendant consequences, for example failure to incinerate or autoclave infectious materials that ought to be incinerated or autoclaved before proper disposal
- Errors of unawareness*, for example, where HCWs are improperly trained regarding the proper method of disposing medical waste, leading to attendant consequences and the need for sanctions and vicarious liability against the employers and employees for failure to obey laws or regulations regarding waste management.<sup>[23,30]</sup>

## MATERIALS AND METHODS

### Research design

This study was a descriptive cross-sectional study conducted at a single tertiary government healthcare facility in Gaborone, Botswana.

### Study location

The study was conducted at the biggest hospital in the country with 500 beds capacity and the national referral hospital. It also acts as the main referral hospital for local healthcare clinics and has the only 24-hour emergency medical services in Gaborone, which is also the nation's capital city. It provides services for all the clinical disciplines. Nationally, the facility has the largest numbers of HCWs per each of the four categories of participants in the study.

### Objectives

The aim of this study was to assess the knowledge, attitudes, and practice among four categories of HCWs, namely doctors, professional nurses, laboratory technicians, and housekeeping staff with regard to waste management. The study site was purposively selected.

### Study population and sampling methodology

For each respondent group (doctors, nurses, laboratory technicians, and housekeepers), a sample size was estimated separately, since these groups were the primary strata. Sample size calculations were done in G\*Power based on the estimation of a 50% proportion, at a 5% significance level and 5% precision.<sup>[31]</sup> The formula used to estimate the sample size for each group was

$$n = (z^2 r (1 - r) N) / (Ne^2 + z^2 r (1 - r)),$$

where  $n$  = calculated sample size,  $N$  = population size,  $z$  = critical value at the chosen significance level,  $r$  = proportion to be estimated, and  $e$  = precision.

Thus, for example, for the category of doctors:  $N=46$ ,  $z = 1.96$ ,  $r = 0.50$  (50%), and  $e = 0.05$  (5%), and  $n$  is, thus, 41.096, which is rounded to 42. Response rates for surveys of this kind are estimated at about 50%. The calculated sample sizes were, therefore, doubled to estimate the number of respondents to be approached to participate in this study. The calculated sample sizes, as well as the actual number of respondents approached, per group are shown in Table 1. Given the low number of doctors and laboratory technicians, all available doctors and technicians were approached to participate in the study. Likewise, because of the response rate estimation, all the housekeepers were approached to participate. As for the nursing professionals, 79% (=470/598) were approached to participate in the study.

The target number of participants in each group was estimated as follows: 90 doctors, 469 professional nurses, 256 housekeepers, and 46 laboratory technicians.

However, the study recruited following number of participants for each category of HCWs: 80 doctors, 432 professional nurses, 40 laboratory technicians, and 198 housekeeping personnel.

### Study instrument and data collection

The data collection instrument was a semistructured questionnaire, comprised of three sections, namely, -knowledge of waste management section, which comprised 11 questions aimed at establishing the respondents' understanding of waste management techniques and methods of waste disposal in the hospital. The second section was about attitudes toward waste management consisting of nine questions that investigated the respondents' attitudes toward waste disposal strategies. The third section on practice of waste management was subdivided into four subsections, namely, -general inquiry about the practice, challenges in the process of segregation and management of medical waste, and obstacles to waste management; possible solutions for restructuring of waste management; and the type of waste handled. Finally, biographical information covered the respondents' biographical data, including age, gender, educational background, duration of employment at the hospital, and area of the hospital where they worked.

### Inclusion criteria

The following were the inclusion criteria for this study.

- i. Participants had to be employed by the hospital under study
- ii. Willingness to participate in the study after signing the consent form
- iii. Be literate in English language.

### Exclusion criteria

The following HCWs were excluded from the study:

- i. All professional HCWs not permanently employed by the hospital.
- ii. Any staff members who were not willing to sign the consent to participate.

### Data analysis

Data were collected using a self-administered questionnaire. The questionnaire was pretested to ascertain ease of understanding and to determine if it was worded to elicit all the materials of interest for this research study. Therefore, this process was concerned with assessing content validity of the questionnaire. Participants for the pretesting stage were drawn from the heads of department at the study hospital which included doctors and nurse practitioners. Pretesting of the questionnaire was conducted at the same hospital as the study; however, those involved in the pretesting phase were not allowed to participate in the actual study. Findings from this process showed that all respondents were satisfied and that the questionnaire was adequate for the purpose of the study.

The final version of the questionnaire consisted of following four sections: knowledge of waste management, attitudes toward waste management, practice of waste management, and biological information. Collection of data took place from January 13 to February 10, 2014. The data collected were analyzed using SAS software G\*Power 3.1.<sup>[31]</sup> The results are presented in percentages, medians, and means.

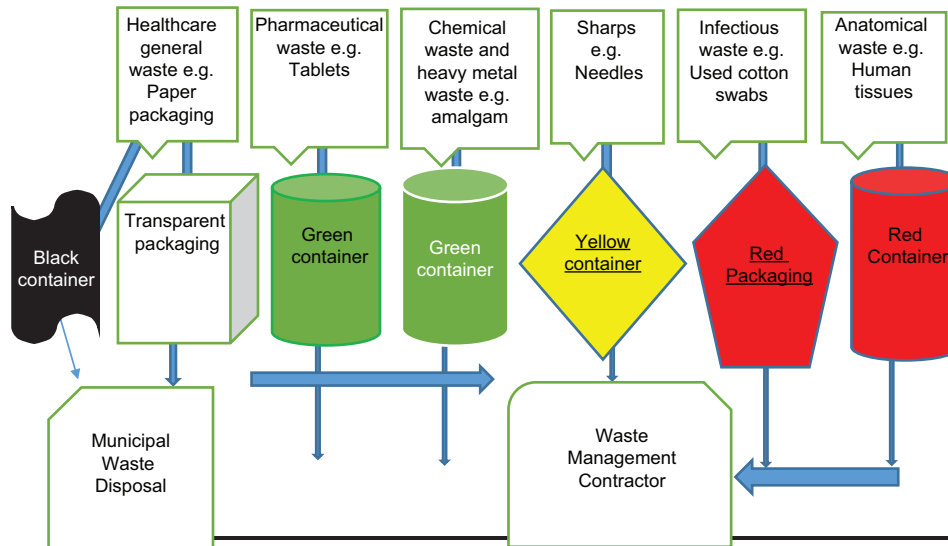
### Ethical considerations

Before commencing the study, ethical clearance was sought from the College of Human Sciences Higher Degrees Committee of the University of South Africa (UNISA) and granted. Further permission was obtained from the Botswana Ministry of Health and the hospital under study. Thereafter, each participant was ascertained to be of age of consent according to the laws of Botswana, which is 18 years of age. They were then required to sign an informed consent form before completing the questionnaire. In addition, the principal investigator (PI, BM) held various meetings at departmental levels with the potential respondents where he discussed the aspects of the study. Voluntary participation and the right of the respondents to enrol or withdraw from the study were emphasized. The researcher explained to all potential respondents that if they agreed to participation in the study, they would have to sign the consent form in the presence of the researcher or his assistants before they could take the questionnaire to complete at their own convenience, within a set period. Three weeks was suggested as adequate, but most questionnaires were returned within a few days. Confidentiality was maintained by ensuring anonymity since there were no identifiers obtained from the research respondents. The completed and collected questionnaires were kept under lock and key.

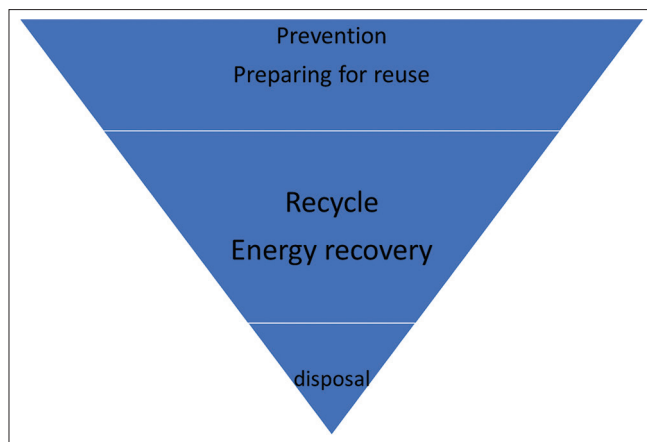
## RESULTS

### Demographic characteristics of the study population

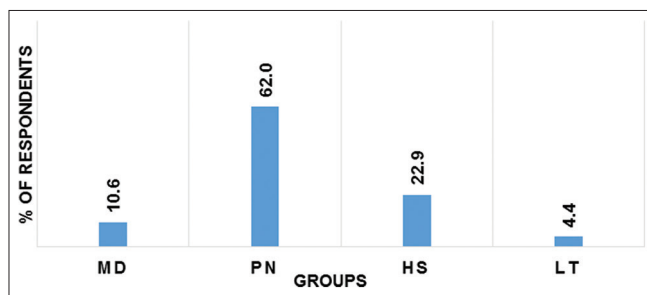
Overall, 703 respondents participated in the study. Majority of these respondents were nurses 60% (422/703), followed by housekeeping staff 24.3% (171/703), doctors 10.95% (77/703), and laboratory technician 4.7% (33/703) as shown in Figure 3. However, only 90% (632/703) of the completed questionnaires were deemed acceptable for analysis. Further, these results showed that female respondents were the majority with 71.5% (452/632), whereas males were 28.5% (180/632). Majority of respondents from each category of HCWs were aged between 25 and 34 years (62.5%) ( $n = 395/632$ ) as shown in Figure 4. Doctors were predominantly in age



**Figure 1:** Flowchart for proper segregation and disposal of healthcare waste. Adapted from SANS



**Figure 2:** Hierarchy of waste management



**Figure 3:** Distribution of participants in each category of HCWs. MD=Medical doctors; PN=Professional nurses; HS=Housekeeping staff; LT=Laboratory technicians

group 25-34 years. Whereas for the nurses, laboratory technicians, and housekeeping staff, the distribution was predominantly within the 25–34 age bracket as follows, 60.7% (238/392), 67.9% (19/28), and 68.2% (99/145), respectively. Only 58.2% (39/67) of doctors were within the 25- to 34-year age bracket [Figure 4]. Regarding the duration of work at the healthcare facility, the majority of

respondents 93.6% (592/632) had worked at the hospital for <10 years, whereas the remaining 6.4% (40/632) reported having worked at the hospital for ≥11 years, as shown in Figure 5. With regards to education, 56% (354/632) of all respondents had diplomas, mainly professional nurses and laboratory technicians, as shown in Figure 6. The majority of doctors 80.6% (54/67) had a bachelor’s degree, whereas most nurses 85.2% (334/392) had only diploma level education and none of the housekeeping staff had attained a diploma level education.

**Knowledge regarding medical waste management**

Table 1 reveals the knowledge of the study participants regarding waste management. Results showed that a majority of doctors 83.6% (56/67) had some training in waste management, followed by nurses with 69.4% (272/392). All the categories of HCWs had poor knowledge regarding presence of recycling services in the hospital, the worst being doctors with 13% (9/67). Approximately half of the participants 49.8% (315/632) stated that HCWs received training in medical waste management (MWM).

**Attitude toward waste management**

Analysis of the responses for attitudes of respondents was at 95% confidence interval using a nonparametric test equivalent to one-way analysis of variance (ANOVA). Thus, the outcome was presented in terms of medians rather than means. This was due to the fact that the negative skewness of the data results obtained from the assumptions of the one-way ANOVA for the between-group tests were not being met. In other words, the population under study was found to be nonsymmetric; therefore, it was preferable to use a nonparametric equivalent to one-way ANOVA (the

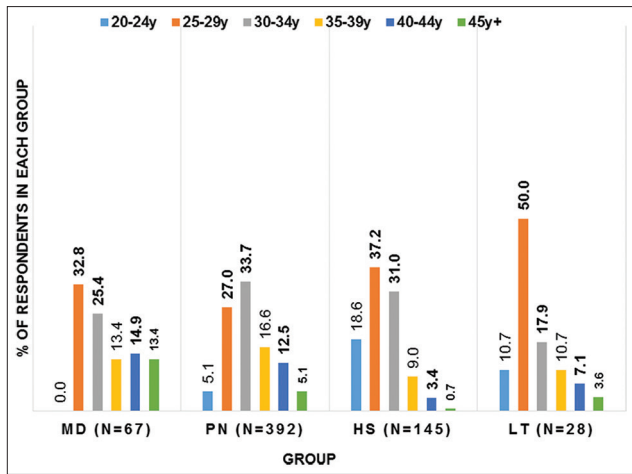


Figure 4: Age brackets distribution within categories of healthcare workers

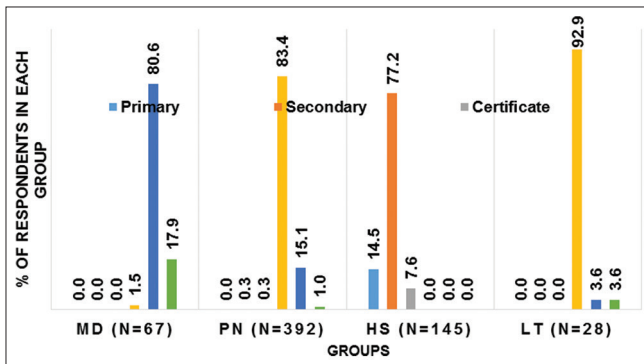


Figure 6: Educational level of participants by professional group

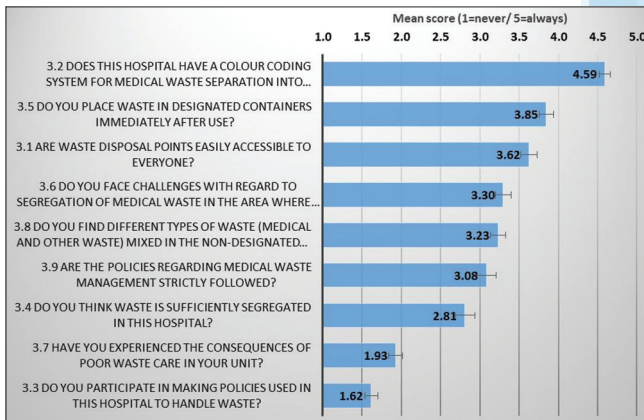


Figure 8: Mean scores of responses regarding practice of medical waste management (n = 632)

Kruskal–Wallis test), based on advice from an expert statistician. Results regarding attitude toward medical waste are shown in Figure 7. The best overall scoring item was in favor of segregation of waste being done at the point of generation, with a median score of 4.43. On the other hand, the item inquiring about whether waste was separated according to the policies of the hospital resulted in a median score of 2.76 out of 5.

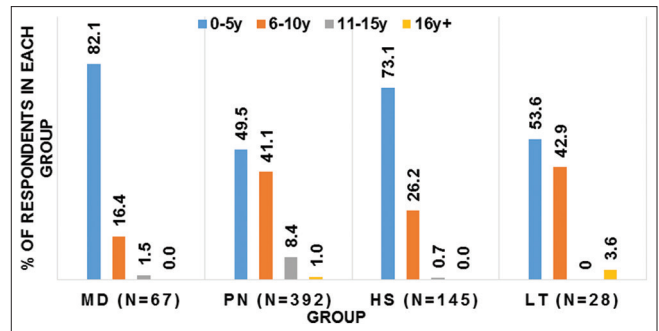


Figure 5: Graph showing the duration of work at the health facility

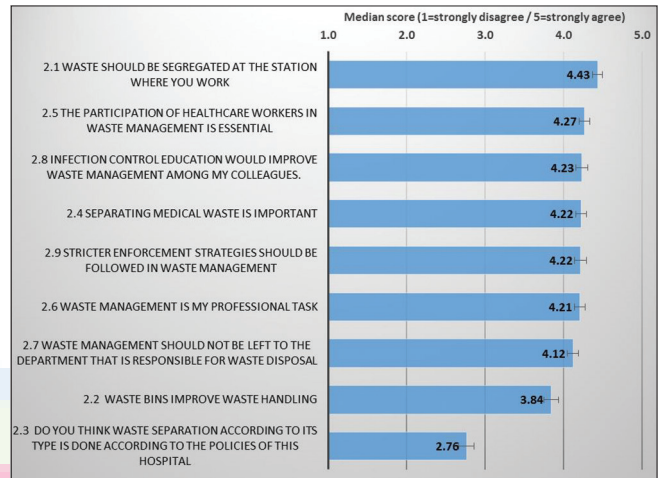


Figure 7: Mean scores regarding attitudes to medical waste (n = 632)

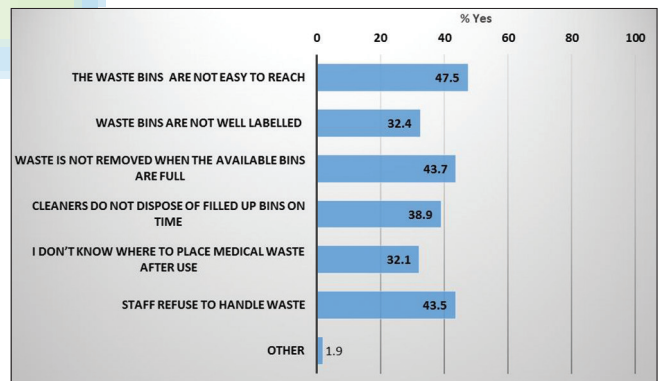


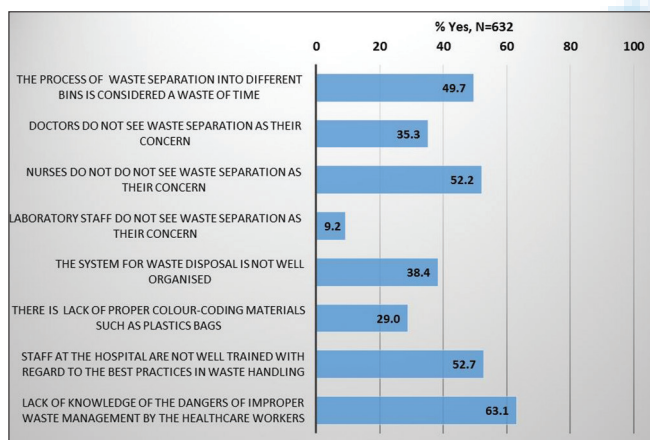
Figure 9: Challenges faced by respondents regarding medical waste management

### Practice of waste management

Regarding practice of waste management, participants were asked questions in three parts. Each of these parts had a distinct set of questions with a unique format of answers. The results of the first part of this section were presented in terms of mean scores as shown in Figure 8. This illustrates the overall mean score for each of the different statements that were presented to the respondents. The error bars denote the 95% confidence interval for the mean. We found

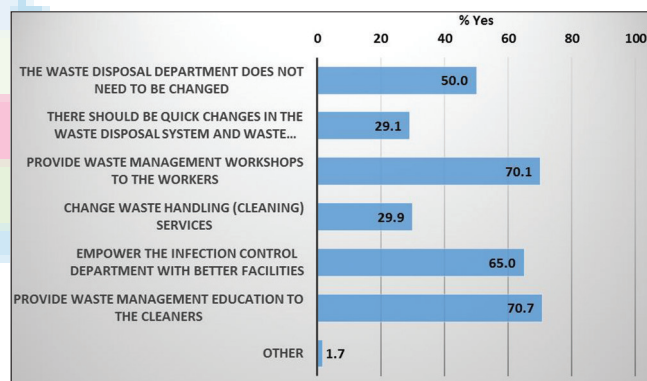
**Table 1: Knowledge of healthcare workers regarding medical waste management**

Variable	Doctors, % (n=67)	Nurses, % (n=392)	Housekeeping staff, % (n=145)	Laboratory technicians, % (n=28)
Did any of your training cover waste management?	83.6 (56/67)	69.4 (272/392)	54.5 (79/145)	57.1 (16/28)
Do you know the category of waste that is called medical waste?	97.0 (65/67)	95.9 (376/392)	91.0 (132/145)	78.6 (22/28)
Is it possible for you to tell the difference between the different categories of medical waste?	91.0 (61/67)	96.9 (380/392)	90.3 (131/145)	100.0 (28/28)
Have you been trained with regard to waste differentiation?	74.6 (50/67)	87.2 (342/392)	66.2 (96/145)	82.1 (23/88)
Do you know about the policies in this hospital about reporting needle stick injuries?	92.5 (62/67)	96.2 (377/392)	82.8 (120/145)	82.1 (23/28)
Is there an infection control department in this hospital that deals with waste management?	80.6 (54/67)	93.1 (365/392)	91.0 (132/145)	89.3 (25/28)
Are you aware if recycling of medical waste is done at this hospital?	19.4 (13/67)	49.5 (194/392)	29.0 (42/145)	17.9 (5/28)
Do you think that if waste is not properly handled it can be a risk to healthcare workers and patients?	94.0 (63/67)	94.4 (370/392)	82.1 (119/145)	71.4 (20/28)
Do you know what happens to waste after it is picked up from the station where you work?	47.8 (32/67)	80.6 (316/392)	79.3 (115/145)	57.1 (16/28)
Do you always know what type of waste you are dealing with?	77.6 (52/67)	81.6 (320/392)	82.1 (119/145)	75.0 (21/28)
Are staff given training workshops regarding waste management?	40.3 (27/67)	53.1 (208/392)	50.3 (73/145)	25.0 (7/28)



**Figure 10:** Barriers to medical waste management reported by respondents (n = 632)

that respondents generally agreed that there was a color coding system, waste was placed in designated containers immediately after use, and waste disposal points were accessible, “very often.” Respondents indicated that challenges were faced with respect to segregation of medical waste; often, different types of waste were found mixed. Institutional policies were seldom followed, and waste was adequately segregated, “sometimes.” Finally, participants indicated that they had experienced the consequences of poor waste management and participated in making waste handling policies, “rarely.” Surprisingly, participation in process of formulating waste management policies in the hospital scored worst. Consequently, such policies may



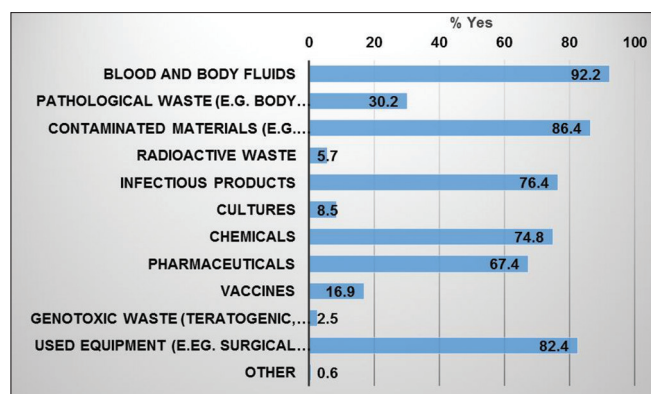
**Figure 11:** Respondents agreeing to suggested solutions for restructuring medical waste management (%)

be viewed as alien by these HCWs, and therefore not followed as required.

### Challenges to waste management

The second part of the section on the practice of waste management required participants to select from a set of challenges; those that they encountered at their workstations. It is notable that there were no challenges that stood out; all the items received a moderate level of support (30%–50%). The challenge with the highest support was that regarding the ease of access to waste bins with 47% (300/632) score. This was followed by “waste is not removed when the available bins are full” with 43.7% (276/632), whereas the lowest support was for the “other” response with 1.9% (12/632).





**Figure 12:** Types of medical waste generated by respondents (%)

### Barriers or obstacles to medical waste handling

The most common obstacles reported was “lack of knowledge and training” identified by 63.1% (399/632) respondents; followed by the fact that majority of nurses do not see waste separation as their area of concern according to 52.2% (330/632) of nurses. The least of the recorded obstacles was that of laboratory technicians’ view of waste separation at 9.2 (58/632). Responses indicating inadequacy of appropriate color coding was 29.0% (183/632). Obstacles to waste management reported are shown in Figure 9.

### Potential solutions toward restructuring waste management practice

Overall, the percentage of respondents who agreed with each of the different statements regarding restructuring of waste management practices is shown in Figure 10. The most popular solutions were providing better education (to workers and cleaners), chosen by 70.7% (447/632); and empowering the infection control department with better facilities, selected by 65% (411/632) respondents.

### Types of medical waste generated or handled at the healthcare facility

This study considered 11 different kinds of medical waste, which were listed so that HCWs could select as many as possible of those that they either handled or generated in the process of conducting their work are depicted in Figure 11. The most handled/generated of medical waste was blood and body fluids as reported by 92.2% (582/100) of participants, whereas the least handled/waste type was genotoxic waste with 2.5% (16/632). Majority of doctors 98.5% (66/67) reported handling and/or generating blood/body fluids during their practice. Conversely, only 7.5% (5/67) of doctors reported handling or generating genotoxic medical waste. Most nurses 97.7 (383/392) reported handling blood and body fluids, whereas only 2% (40/392) reported handling genotoxic waste.

Similarly, blood and fluids was the type of waste most handled by housekeeping staff and laboratory technicians at 73.8% (107/145) and 96.4% (26/28), respectively. The percentage of respondents who handled or generated different types of medical waste are shown in Figure 12.

## DISCUSSION

This study aimed to study the knowledge, attitude, and practices of HCWs at a tertiary hospital in Gaborone, Botswana, regarding management of medical waste. Findings revealed that there were differences in knowledge, attitudes, and practice of waste management among the four categories of HCWs at the hospital under study. There were deficiencies in the knowledge levels of waste management among all the categories of HCWs in this study. The agreement observed with regard to possible remedial importance of educating HCWs in waste management in this study was consistent with the 70% ( $n = 89$ ) overall agreement found in another study from the United Kingdom.<sup>[32]</sup> The results from our own studies did not reveal a statistically significant association between postbasic training and performance of members of each category of HCWs. However, there was a strong relationship between the performance of each group of HCWs and the demographic characteristics of the respondents. For example, there was a strong relationship between highest level of education and location of basic training for doctors, when compared with nurses and laboratory technicians, in favor of those that had obtained their postbasic training outside Botswana.

### Knowledge of waste management

Regarding knowledge of waste management, high scores were recorded by most HCWs regarding knowledge of the basics of MWM and handling aspects, such as the categorization of different types of waste, policies on needle-stick injury, existence of infection control department within the hospital, and the health risks associated with poor waste handling. However, previous training, availability of training, and awareness of recycling of medical waste scored lowest. About half, 49.8% (315/632) of participants stated that they received some training in MWM. This was much higher than the findings of another study done in India,<sup>[33]</sup> which reported that only 16.3% of participants had received any training in MWM. Further, an intermediate score was observed regarding aspects of knowledge concerning waste differentiation and training and disposal of waste after collection. Most nurses 96.2% (377/392) reported knowledge of needle-stick injury reporting policies, which is consistent with the findings of an Indian study

where 88.6% of nurses were also aware of needle-stick injury reporting policies.<sup>[34]</sup> However, our findings are in contrast with those reported from a study done in South Africa, which found that only 47.2% of HCWs had adequate knowledge of correct disposal of healthcare waste and only 36.0% employed appropriate disposal practices of medical waste.<sup>[35]</sup>

### Attitude and practice regarding waste management

Attitude toward waste management among respondents: Most respondents agreed that medical waste should be segregated at the point where it is generated. This was consistent with the results from a study in India,<sup>[33]</sup> where 96.9% of respondents agreed that waste should be segregated. Pertaining to the practice of waste management, the study established presence of high level of agreement that there was a colour-coding system in the hospital under study. Nonetheless, segregation of medical waste was problematic with mixing of the different types of waste. Segregation was found to be high in Indian studies conducted by Chudasama *et al.*<sup>[36]</sup> and Charania and Ingle,<sup>[37]</sup> who found that the correct response was as high as 86.9% and 82.4% respectively. In addition, adherence to MWM policies in this study was found to be poor, and HCWs were rarely included in the development of waste handling policies. There was evidence that the different departments involved in medical practice do not synergise with each other towards proper MWM. For example, waste was often found mixed up, although the institution has a colour coding system, and placement of waste is not in proper receptacles “all the time or always.” This is similar to another study from South-Eastern Nigeria, where Anozie and others reported that 98.1% of hospitals in this region practiced indiscriminate waste disposal, with only 40% of healthcare managers reporting having received any training on MWM.<sup>[38]</sup> However, in a study done in Chennai India, 28% of respondents did not adhere to disposal of waste into appropriately color-coded receptacles.<sup>[37]</sup> Respondents reported several challenges to proper practice of MWM. Half of the participants reported inadequacy or inappropriate receptacles. The next most reported challenge was absence of protective gear, such as heavy-duty gloves for the cleaners, followed by doctors’ failure to dispose of waste after medical procedures.<sup>[36,37]</sup>

### Obstacles to proper MWM

The most recognized obstacle to MWM in this study was the “lack of knowledge of the dangers of improper waste management by the HCWs” with a 63.1% (399/632) “yes” response. Doctors contributed the highest response of 67.2% (425/632), whereas the housekeeping

personnel had the lowest at 53.8% (340/632). The least scoring obstacle was “laboratory staff do not see waste separation as their concern” with 9.2% (58/632) responding affirmatively. It should be noted that this might be explained by the low numbers of HCWs in this category, as well as the fact that laboratory staff do not share workstations with most respondents from the other categories of HCWs in this study.

### Solutions for restructuring

This subsection provided six pre-stated choices, whereas the seventh option required respondents to suggest a solution. There was an overall 50%/50% response for the item “the waste disposal department does not have to be changed.” The highest “yes” responses was from housekeeping personnel with 57.2% (361/632), and the lowest from doctors with 35.8%. The most agreed-upon solution was “provide waste management education to the cleaners” scoring 70.7% (447/632), followed by 71.6% (452/632) for “provide waste management workshops to the workers.” This likely implied some degree of the self-assessment by the HCWs concerning their preparation regarding proper waste management practices. Only 1.7% (11/632) of respondents gave responses in the subsection to suggest a solution for restructuring the waste management at the hospital. The highest scoring of the seven was “encourage HCWs to view waste as their concern” with 27.3%.

## CONCLUSIONS AND RECOMMENDATIONS

This study was done at a selected tertiary hospital in Gaborone, Botswana, and was conducted among doctors, nurses, laboratory technicians, and housekeeping personnel. It was a prospective, descriptive and cross-sectional study using a self-administered questionnaire. The objective of the study was to establish the level of HCWs knowledge, attitudes, and practices regarding MWM. Results showed that there were gaps in knowledge and practice of MWM by respondents across all categories of HCWs. Inadequacy of knowledge was reported as the most common obstacle to MWM. We would like to recommend that all categories of HCWs practising in Africa should have ongoing training on proper MWM. Further, university and college educated HCWs, such as doctors and nurses should have at least one lecture included in the medical and nursing curricula regarding MWM, and a session on proper waste management should be included at all induction or orientation programmes for all categories of HCWs, before assumption of duty.

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### Conflicts of interest

There are no conflicts of interest.

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