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Research Article

Correlates of Knowledge and Practice of Medical Waste Management Among Healthcare Workers in Ethekwini District Public Hospitals, Kwazulu-Natal Province, South Africa

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ABSTRACT

Waste management especially medical waste is essential to preservation of health and integrity of the environment. There are several factors that may influence the adequacy of knowledge and practice regarding waste management. The main purpose of the study was to evaluate factors that influence awareness and practice of medical waste management among healthcare workers. This was a mixed-methods study carried out from October to November 2019 at four public hospitals in EThekwini metropolitan municipality of KwaZulu-Natal province, South Africa, among doctors, nurses, laboratory staff and waste-handlers. Quantitative data were analysed using statistical analysis system (SAS) software. Results showed that respondents' professional category was strongly associated with general knowledge of healthcare waste management, and median scores showed that a higher proportion of nurses had higher scores when compared to laboratory scientists/technicians and medical doctors. Further, general knowledge scores were significantly positively correlated with the practice scores, while waste segregation was significantly, but weakly, associated with training regarding healthcare waste differentiation (p=0.025; V=0.14). Also, knowledge of recommendations in the medical waste management implementation plan was significantly, but weakly associated with waste segregation (p=0.028; V=0.14). Findings revealed a strong correlation between training, availability of waste management related workshops, and proper medical waste management amongst healthcare workers. We conclude that knowledge appeared essential to proper waste segregation and proper medical waste management practice correlates with having the requisite knowledge about waste. We recommend that education and training in waste management be provided to all healthcare workers during formal training in addition to ongoing refresher courses through regular workshops on healthcare waste management.

Keywords: *medical waste, doctors, nurses, healthcare workers, laboratory staff, knowledge, management, waste-handlers, South Africa*

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INTRODUCTION

Waste generated from healthcare facilities is divided into two major categories estimated as 75-90% % of the total waste having characteristics similar to domestic waste while the remainder (10-25%) is infectious or hazardous waste also known as health care risk waste (HCRW) (United States Agency for International Development (USAID) 2014; Chartier *et al*., 2014).

Healthcare or medical waste is the category of waste that is generated in the process of diagnostic and treatment processes by organizations or in a home environment where health care has been provided (Fanning & Lynas, 2014).

With exception of a few specific constituents of liquid waste such as sewage and sullage, blood and other bodily fluids, the major bulk of healthcare waste (HCRW) is a sub-category of solid waste (SW) (Goel, 2017).

Waste management is concerned with the processes involved in minimization, generation and segregation, re-use, recycling, storage, transportation, energy generation and disposal of waste (Bourguignon 2015; Spinazzè *et al*., 2017). There are numerous factors that influence management of waste, which include the following factors, including but not limited to; lack of advanced technology, insufficient or absence of facilities for separation at point of generation, adequate waste management policy and enforcement,

knowledge and awareness (Abel, 2009). In another study, it was established that the socioeconomic status of individuals had a very strong correlation with waste management and utilization of public waste collection services (Ajani, 2008). Such socioeconomic factors include the impacts of gender, age, and educational status on solid waste management and reasons for not using appropriate waste collection services in traditional cities. Age, educational status, and amount charged for waste collection services had been identified as factors influencing solid waste management in highly populated cities (Ajani, 2008).

Waste in general, but especially clinical waste, poses a global challenge in terms of environmental; local, regional and global climate, and public health consequences (Akter, 2000). The deleterious effects of waste or its management are diverse depending on the type of waste (Bourguignon, 2015). The inadequacy in the management of medical waste may occur at any level in the process of waste management. These processes include segregation, storage, collection, transportation and disposal (Fanning & Lynas, 2014). According to various literature the most problematic and yet important component of waste management is that of segregation at the point of generation (USAID 2014; Pandey *et al*., 2016; Yazie *et al*., 2019).

Potential factors that could contribute to poor waste management can be separated into those that are institutional; personnel related, and the country-specific factors. These include awareness regarding healthcare waste; financial limitations; inadequate waste control regime; and availability of appropriately trained personnel (World Health Organization (WHO), 2005). These factors either singularly or in combination may influence the management of healthcare waste and can affect waste handling at any time during the various phases of waste management. Some studies have indicated that knowledge of waste management is essential to good practices (Wafula *et al*., 2019; Rutala *et al*., 1989). However, no single category of workers was consistently knowledgeable in all the aspects required for good practice in waste management in these studies. Moreover, there was a paradoxical relation between knowledge and some aspects of practice as reported by some studies (Pandey, *et al*., 2016; WHO 2005; Hakim *et al*., 2011). Awareness regarding medical waste, has been reported in several studies as being a major contributor to poor medical waste handling practices (WHO 2005; Aksakal *et al*., 2011; Madhukumar & Ramesh, 2012). Therefore, it is plausible to infer that lack of adequate knowledge regarding healthcare waste is an important factor in the poor waste management (Awad & Al Bajari, 2018). It is reported that lack of comprehensive guidelines and legislation on healthcare waste management adversely affects knowledge and awareness among hospital personnel regarding health hazards of infectious waste and their impact on the environment. Nonetheless, even in environments where guidelines exist such as South Africa, studies indicate that they may not be fully adhered to (Department of Environmental Affairs (DEA), 2012). Conversely, proper medical waste segregation is reported to be associated with the use of colour-coding systems as well as the availability of proper receptacles (International Committee of the Red Cross (ICRC), 2011). It is plausible to say that several developing countries offer sub-optimal attention to proper health care waste management despite its potential and the real harm that it poses (Nwachukwu *et al*., 2013).

Compliance with standards such as use of Personal Protective Equipment (PPE) may hamper proper waste handling and increase the risk of injury. As an example, low coverage and use of PPE was reported in a study done in Uganda which was consistent with high rates of Needle Stick Injuries (Ndejjo *et al*., 2015).

In addition, it was reported that insufficient staffing of health facilities affects the adequacy of waste handling (Manyele & Lyasenga, 2010). Finally, the budgetary constraints in developing countries may negatively influence the availability of resources for medical waste management (Stringer, 2011).

MATERIALS AND METHODS

Research design: The study was a non-experimental, cross-sectional study conducted among healthcare workers at four healthcare facilities in eThekwini municipality of KwaZulu-Natal province in the Republic of South Africa.

Objectives of the study: The main aim of the study was to establish the factors influencing the knowledge and practice towards the management of medical waste.

Study Design: The was a mixed methods study utilizing quantitative and qualitative research approaches. The researcher pretested and used a modified WHO health-care waste management-rapid assessment tool for quantitative data collection (WHO, 2005), while an interview guide was used for collecting qualitative data.

Study location: The sample units for the site sample were drawn from the public hospitals in the health district. A total of four hospitals were selected for inclusion in the study from the approved hospitals by the provincial DOH. The inclusion and exclusion criteria were such that the participating hospitals had to be public facilities. These hospitals were in the following categories, namely, regional, specialized and tertiary with a combined bed capacity of 2751 beds. These are high throughput hospitals and the understanding of knowledge and practice towards waste management at these facilities would be considered adequate to inform the research questions and objectives of this study.

Study population and sampling methodology: The study was conducted at four out of eighteen public hospitals situated in eThekwini health district. The participating hospital were selected by simple random sampling from the sample frame of the accessible hospitals within the district. These urban public hospitals are high throughput, therefore, the knowledge and practices of healthcare waste by healthcare workers in these hospitals would give a good idea about how waste is managed in the health district and probably elsewhere in South Africa. The study population comprised four categories of healthcare workers, namely, doctors, nurses, laboratory personnel and waste handlers (WHs).

Sample size calculation: To explore the management of health care waste, assuming 95% confidence and an acceptable margin of error of 3.90%, and maximum variability of 50%. We used a freely available online sample size calculator (Raosoft®), at a margin of error of 3.90, the minimum desirable sample size for participants in the quantitative arm was determined to be 606.

Data collection: Data was collected using and adapted questionnaire from the WHO rapid assessment tool (WHO, 2005) for waste management. We conducted a pilot study of the modified questionnaire involving 12 participants from all the categories of HCWs, namely doctors, nurse, laboratory staff and WHs. The results from this pilot study were not included in the final study but their comments regarding any challenges and experiences in completing the were informative in making minor language and presentation changes to the final questionnaire for face and content validity.

Data analysis and study variables: The statistical analysis for this study was conducted as follows: First, two dependent variables were created from 11 statements on knowledge and 9 on practice to measure their association and correlation with socio-demographic factors of healthcare workers. The median score of responses were calculated for the knowledge and practice variable. The socio-demographic characteristics under consideration for this analysis were the respondents' age, duration of work at current hospital or area of work, professional category, highest level of education (HLOE), and place or area work. Age was categorised into approximate quartiles for further analysis. The two categories of laboratory workers were combined for further analysis due to their small group size. For the WHs' group, HLOE (certificates and diploma) and (primary education or no-education) were grouped into small group sizes. Further, regarding the area of work, each area was analysed separately since multiple areas were selected by respondents. The areas referred to with respect to WHs were the units and wards within the hospital. On the other hand, the area of work with respect to healthcare professionals (HCPs) referred to hospitals and the laboratory-services area.

Ethical considerations

Ethical approval for the study was granted by the ethics committee of the University of KwaZulu-Natal (UKZN) (BREC REF: E678/18), and the KwaZulu-Natal department of health. Further permission was obtained from the eThekwini municipality health district. While each participant gave written informed consented prior to taking part in the study

RESULTS

This was a mixed-methods study, but the results of the qualitative arm of the study are reported elsewhere or in the other papers containing other aspects from this study. The results presented and discussed in this paper are only for the quantitative arm of the study. The response rate of this study was 70.4%, and the demographic characteristics of the study participants are shown in Table 1.

Association between general knowledge median score and demographic variables of HCPs: In this section of the study report, we present the association between knowledge median scores and demographic characteristics of the respondents. The results for knowledge median score are shown in Table 1.

Table 1:
Socio-demographic variables for HCPs knowledge towards waste management

Variable	Category	N	Mean	Std Dev	Median	Inter-Quartile range		Minimum	Maximum	p-value
Age	21-29y	96	59.8	19.0	63.6	45.5	72.7	9.1	100.0	<0.0001
	30-39y	139	69.7	21.2	72.7	54.5	90.9	18.2	100.0	
	40-49y	95	73.6	17.8	72.7	63.6	90.9	27.3	100.0	
	50-65y	64	78.4	18.9	81.8	72.7	90.9	27.3	100.0	
Number of years in current hospital	0-5y	181	63.6	20.4	63.6	45.5	81.8	9.1	100.0	<0.0001
	6-10y	92	71.5	21.3	72.7	54.5	90.9	27.3	100.0	
	11-15y	51	75.4	16.6	72.7	63.6	90.9	27.3	100.0	
	16y+	71	78.0	17.5	81.8	72.7	90.9	27.3	100.0	
Professional category of HCP	Medical Doctor	126	56.1	19.4	54.5	45.5	72.7	9.1	100.0	<0.0001
	Professional Nurse	223	76.3	17.8	81.8	63.6	90.9	27.3	100.0	
	Laboratory Scientist/Technician	45	73.7	17.5	72.7	63.6	90.9	27.3	100.0	
HLOE	Certificate/Diploma	192	76.1	17.4	81.8	63.6	90.9	27.3	100.0	<0.0001
	Bachelor's degree	176	63.5	21.0	63.6	54.5	81.8	9.1	100.0	
	Master's degree	16	61.9	23.8	59.1	45.5	81.8	27.3	100.0	
Area	Regional hospital	229	70.0	21.0	72.7	54.5	90.9	9.1	100.0	0.0039
	Tertiary hospital	93	64.9	19.2	63.6	54.5	81.8	18.2	100.0	
	Specialised hospital	23	79.4	20.6	81.8	72.7	100.0	27.3	100.0	
	Laboratory	46	73.3	18.1	72.7	63.6	90.9	27.3	100.0	

Note: *HLOE = (Highest level of education); HCP = Healthcare professional*

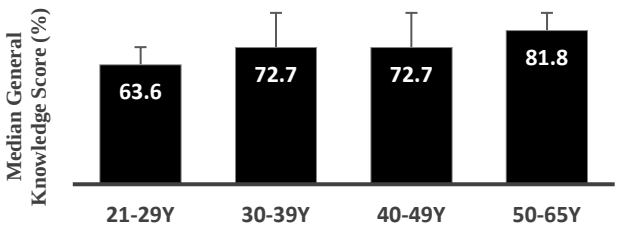

Figure 1:
Association between general knowledge median score and age of HCPs

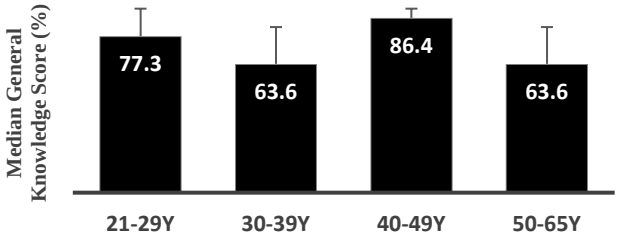

Figure 2:
Association between general knowledge median score and age of waste handlers

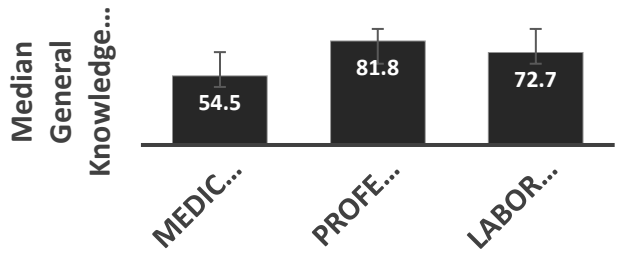

Figure 3:
Respondents' general knowledge median score vs professional category

There was a significant association between the median score and age category ($p<0.0001$). Post-hoc tests showed that the median score increased with increasing age, except that there was no significant difference between the two middle age categories. As shown in Figure 1, there was a strong association between general knowledge score and the age but only among the extreme age ranges with the most knowledgeable 81.8% being 50-60 years of age range, and the least 63.6% in the 21-29 years age range. On the contrary, there was no significant association between the median score and age category ($p=0.070$) as shown in Figure 2. Further, there was a significant association between the median score and time in current hospital or area of work ($p<0.0001$). Post-hoc tests showed that the median score was lower for the 0-5y group when compared to the other groups for HCPs, while there was no significant association between the knowledge median score and duration in current hospital or area of work ($p=0.52$). With respect to the professional category of the respondent, there was a significant association between the median score and the professional category ($p<0.0001$). Post-hoc tests showed that the median score was lower for medical doctors, when compared to the nurses and laboratory staff. A higher proportion of nurses had a higher knowledge score, when compared to laboratory scientists/technicians and medical doctors, with scores of 81.8%, 72.7%, and 54.5%, respectively. For HCPs, there was a significant association between the median score and HLOE ($p<0.0001$), when compared with waste handlers where there was no significant association between the median score and HLOE ($p=0.79$). Post-hoc tests showed that the median score was higher for those with certificates/diplomas, when compared to the other groups. As shown in table 1 respondents with certificates/diplomas as HLOE were more likely 81.8% to be knowledgeable regarding medical waste management, when compared to their counterparts with bachelors and master's degrees, who scored 65.6% and 59.1% respectively. By contrast, there was no marked difference in scores obtained by different levels of education among waste handlers

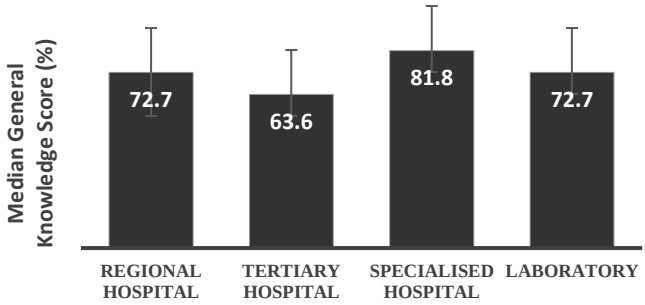

Figure 4:
HCPs general knowledge median score versus hospital or area of work

Regarding hospital of area of work, there was a significant association with the median score ($p=0.0039$) for HCPs. Post-hoc tests showed that the knowledge median score for HCPs was lowest for those working in tertiary hospitals, when compared to all other hospitals and laboratory services as shown in figure 4. Similarly, there was a significant association between the median score and whether WHs worked in the Admin area ($p=0.036$). However, WHs who worked in administrative area were more likely to be less knowledgeable than their counterparts in other areas of work.

Association between practice median score and demographic variables of HCPs: The 8 items of in the "practice of waste management" question batch were combined into a 'practice score', by summing the Likert scale responses out of a possible range of 8-40 and converting this to a percentage.

The results for relationship between socio-demographic variables and practice median score are shown in Table 2. There was a significant association between the median score and age category ($p<0.0001$). Post-hoc tests showed that the median score increased with increasing age, except that there was no significant difference between the two oldest age categories. As depicted in figure 5, practice scores for HCPs seemed to improve with age of respondents but levelled off at 40 years plus. Comparatively, there was no significant association between the median score and age category ($p=0.083$) for waste handlers as shown in figure 6.

Table 2
Analysis of socio-demographic variables for practice regarding waste management

Variable	Category	N	Mean	SD	Median	Interquartile range	Minimum	Maximum	p-value
Age	21-29y	96	57.4	14.4	56.3	46.9	68.8	25.0	96.9	<0.0001
	30-39y	139	62.1	17.4	62.5	46.9	78.1	28.1	93.8	
	40-49y	95	66.8	17.3	68.8	56.3	81.3	25.0	100.0	
	50-65y	64	68.7	16.6	68.8	56.3	81.3	34.4	100.0	
Number of years in current hospital	0-5y	181	60.3	16.8	59.4	46.9	75.0	25.0	100.0	<0.0001
	6-10y	92	59.7	16.5	56.3	46.9	75.0	34.4	100.0	
	11-15y	51	65.8	18.6	65.6	56.3	78.1	25.0	100.0	
	16y+	71	72.6	12.7	71.9	62.5	81.3	37.5	100.0	
Category of HCP	Medical Doctor	126	55.8	13.6	53.1	46.9	65.6	28.1	96.9	<0.0001
	Professional Nurse	223	64.9	17.6	65.6	53.1	78.1	25.0	100.0	
	Laboratory Staff	45	74.6	13.9	78.1	65.6	84.4	46.9	96.9	
HLOE	Certificate/Diploma	192	68.0	17.2	68.8	56.3	81.3	25.0	100.0	<0.0001
	Bachelor's degree	176	57.6	15.8	56.3	46.9	68.8	25.0	100.0	
	Master's degree	16	63.1	12.1	62.5	54.7	71.9	46.9	84.4	
Area	Regional hospital	229	60.0	17.4	59.4	46.9	71.9	25.0	100.0	<0.0001
	Tertiary hospital	93	64.7	14.8	65.6	53.1	75.0	28.1	100.0	
	Specialised hospital	23	67.9	15.6	65.6	53.1	81.3	43.8	93.8	
	Laboratory	46	73.6	14.6	76.6	65.6	84.4	37.5	96.9	

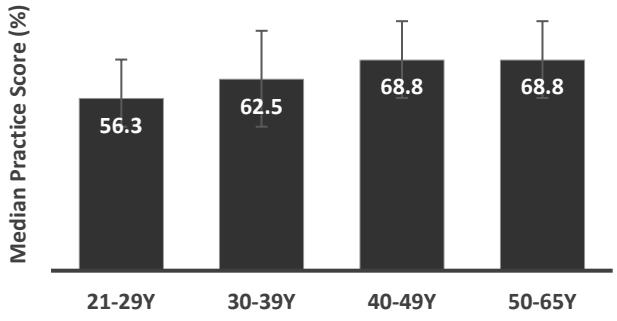

Figure 5:
Respondents' practice median scores versus age

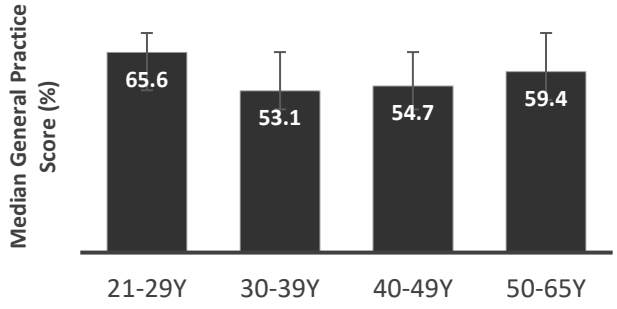

Figure 6:
Practice median score versus age of respondents

There was also a significant association between the median score and time in current hospital (p<0.0001). Post-hoc tests showed that the median score was lower for the 0-5y and 6-10y groups when compared to the other two groups as shown in table 2. Conversely, for waste handlers, there was no significant association between the median score and time in current hospital posts (p=0.079).

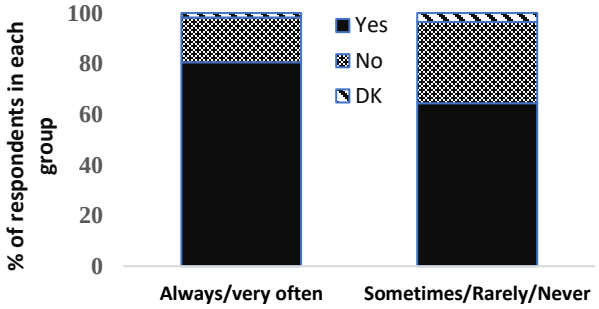

Figure 7:
Respondents' scores for segregation of waste *versus* access to training in waste management

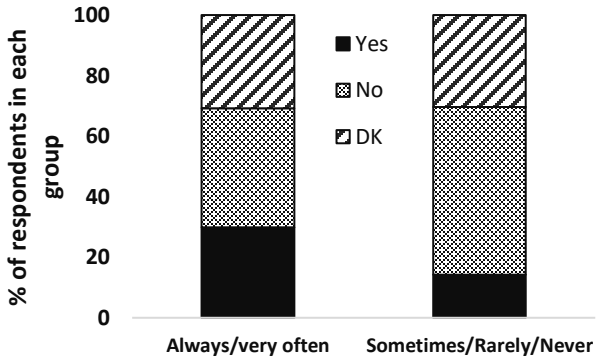

Figure 8:
Waste segregation and knowledge pertaining to waste management

Further, there was a significant association between the median score and HCP category (p<0.0001). Post-hoc tests showed that the median score increased in the order Medical Doctor < Nurse < Laboratory Scientists/Technician. Thus,

Laboratory staff registered higher practice median scores, followed by nurses, and finally medical doctors. With reference to education, there was a significant association between the median score and HLOE (p<0.0001). Post-hoc tests showed that the median score was higher for those with a certificate/diploma when compared to those with a bachelor's degree. On the contrary, for waste handlers, here was no significant association between the median score and HLOE (p=0.69).

Regarding the respondents' area of work, there was a significant association between the practice median score and 'area of work' (p<0.0001). Post-hoc tests showed that the median score was lower for regional hospitals when compared to tertiary hospitals and laboratories. Therefore, laboratory-based healthcare workers registered higher practice median scores than their counterparts in the tertiary and regional hospitals. By contrast for waste handlers, there were no significant associations between the median scores and area of work.

Association between selected general knowledge variables and waste segregation by HCPs: The findings in this section are presented in table 3, figure 7 and 8. We assessed the relationship between segregation of waste and four selected questions from the general knowledge category. We found that waste segregation was significantly, but weakly, associated with training regarding healthcare waste differentiation (p=0.025; V=0.14).

Among those who placed their waste in designated containers always/very often, a higher proportion indicated that they had been trained in this area, compared to those who placed their waste in designated containers only 'sometimes/rarely' or 'never'. Training is therefore likely to influence the HCP's behaviour regarding waste segregation. Further, waste segregation was significantly but weakly associated with knowledge of the recommendations in the waste management implementation plan (p=0.028; V=0.14). Among those who placed their waste in designated containers 'always/very often', a higher proportion indicated that they had knowledge of waste management, when compared to those who placed their waste in designated containers 'sometimes/rarely' or 'never'. However, from our study, waste segregation was not significantly associated with training at school or knowledge of the needle stick-injury reporting policy.

Table 3:
Showing the association between selected general knowledge variables and waste segregation by HCPs

Knowledge variable	Response	Overall	Very often/Always	Sometimes/ Rarely/Never	p-value for in between group test
Question	Category	N (%)	n (%)	n (%)	
Did any of your training at school cover waste management?	Yes	262 (66.3)	226 (66.9)	35 (62.5)	0.78
	No	125 (31.6)	105 (31.1)	20 (35.7)	
	DK	8 (2.0)	7 (2.1)	1 (1.8)	
Have you been trained regarding healthcare waste differentiation?	Yes	308 (78.0)	272 (80.5)	36 (64.3)	0.025 (V=0.14)
	No	78(19.7)	60 (17.8)	18 (32.1)	
	DK	8 (2.0)	6 (1.8)	2 (3.6)	
Does this hospital have a needle stick injury-reporting policy?	Yes	379 (95.9)	324 (95.9)	55 (98.2)	0.84
	No	7 (1.8)	7 (2.1)	0 (0.0)	
	DK	8 (2.0)	7 (2.1)	1 (1.8)	
Do you know the recommendations in the waste management implementation plan?	Yes	109 (27.6)	101 (29.9)	8 (14.3)	0.028 (V=0.14)
	No	164 (41.5)	133 (39.3)	31 (55.4)	
	DK	121(30.6)	104 (30.8)	17 (30.4)	

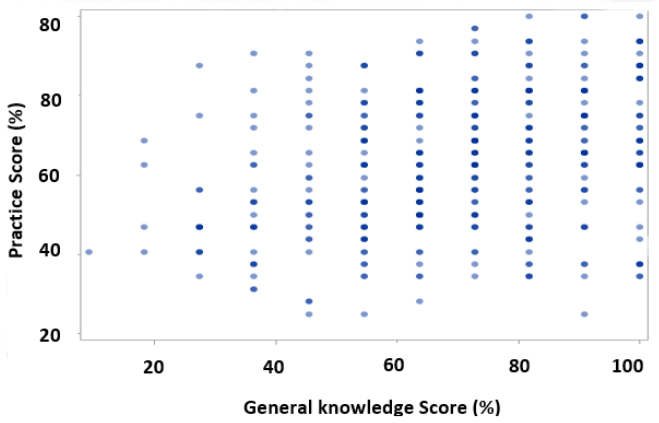

Figure 9:
Scatter graph showing correlation between Practice and general knowledge scores of HCPs

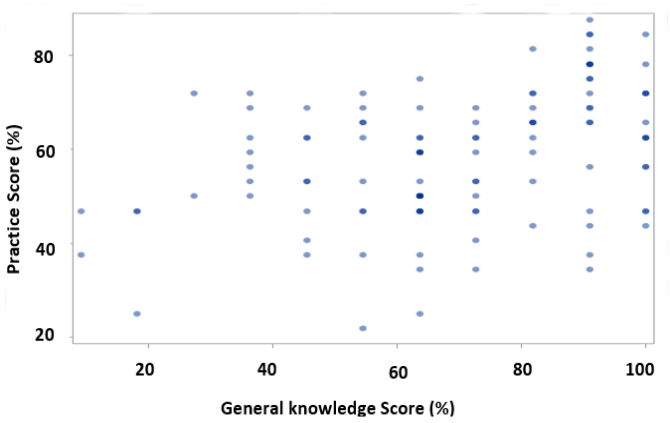

Figure 10:
Scatter graph showing Pearson correlation between practice score and knowledge score for waste handlers

Correlation between knowledge and practice scores: The Spearman correlation coefficients between the knowledge and practice scores (r=0.299 and p=<0.0001), for HCPs are presented in a scatter plot as shown in figure 9. The results show that knowledge significantly positively, but weakly correlated with the practice score. For waste handlers, the Spearman correlation coefficients as shown in figure 10, reveals that the knowledge significantly positively, moderately, correlated with the practice score (r=0.359 and p=<0.0001).

DISCUSSION

Our study reported a response rate of 70.4%, a high rate, although much lower when compared to the response rate of 95.2% reported by Doylo and others in an Ethiopian study (Doylo *et al*., 2018).

Our study showed that respondents' professional category was noted to be strongly associated with general knowledge median scores, whereby a higher proportion of nurses had higher scores when compared to laboratory scientists/technicians and medical doctors. These findings were the opposite to those reported by a Pakistani study, that reported more knowledge in waste management among paramedical staff when compared to physicians and nurses (p=<0.001) (Kumar *et al*., 2018).

We established that respondents' area of work was positively correlated with their knowledge median score. A similar positive correlation between respondents' background and their awareness level was reported by a study by Tejarati and others, (r=0.122, p=0.034), (Tejarati *et al*., 2015). Furthermore, there was a significant association between the median score and time in current hospital or area of work (p<0.0001). Post-hoc tests showed that the median score was lower for the 0-5y group, when compared to the other groups. For HCPs, there was significant association between area of work or hospital, professional category and HLOE. On the other hand, for WHs, there was no significant association between the knowledge median score and HLOE. Practice score are higher for respondents who had been in their current area of work for longer durations. Probably this has something to do with procedural familiarity of their environment and ability to improvise.

Our study revealed that *general knowledge* scores were significantly positively correlated with the *practice* score. The findings are similar to the one conducted by Kumar and others at a Pakistani hospital which showed an almost linear relationship between the knowledge and practice (r=0.541 and p=<0.001) implying that the increase in knowledge of healthcare workers was positively related with their practices in management of healthcare waste (Kumar *et al*., 2018).

We conducted our study amongst HCWs from four throughput hospitals in an urban setting. Their knowledge and practice towards the management of HCW is considered a vital source of information regarding the state of its management in other public hospitals. We were unable to collect data from private waste-contractors which would have added valuable information regarding management of medical waste in this setting.

In conclusion, good practice of waste management begins with having the requisite knowledge about waste. We recommend that education and training in waste management be provided to all healthcare workers during formal training and refresher courses through regular workshops.

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