CHAPTER 7

ASSESSMENT OF SUSTAINABLE HEALTHCARE WASTE MANAGEMENT PRACTICES AMONG HOSPITAL WORKERS IN OWERRI, NIGERIA

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Abstract

Inadequate management and disposal of healthcare waste (HCW) in Nigeria has raised serious concerns due to its pernicious impact on human and environmental safety. The study assesses sustainable HCW management practices among hospital workers within a large hospital in Owerri, Imo State. In doing this, the study predicted the likelihood of being trained on sustainable management of HCW based on workers′ occupation, years of experience and common waste disposal methods. Also, the study measured prevalent HCWs in order to ascertain their main dimensions. Data collection for the study involved cross-sectional survey of workers in the selected hospital. Logistic regression was applied in predicting the likelihood of being trained on sustainable management of HCW, based on three categorical predictors: Occupation, years of experience and common waste disposal methods. Also, principal component analysis (PCA) was applied in ascertaining key dimensions of eight prevalent HCWs. Results indicate that while code-colored bins are not readily available, HCW segregation was significantly related to occupation in the hospital. Regression model for predicting being trained on sustainable HCW management was statistically significant, $\chi 2\ (11) = 21.184$, $p = .032$. PCA of prevalent HCWs in the hospital point towards a two-dimension structure: low risk waste that do not require treatment and special waste needing treatment and cautious management. The study recommends providing multi-purpose HCW treatment systems, which can integrate recycling of general waste and incineration of special waste.

1. Introduction

Any unwanted material that may not be of tangible use to the present owner is usually regarded as waste. On that note, the generation of waste materials is inevitable in any human activity, regardless of spatiotemporal, economic and social intricacies. In hospitals, various categories of waste are produced as workers try to improve health conditions of patients and visitors to the health facility. Due to its hazardous nature, management and disposal of healthcare waste (HCW) should carryout out sustainably, so as to reduce environmental

health and safety impacts . Sustainable management of HCW means that concepts like reduce, reuse, recycling, incineration and life-cycle assessment (LCA) are applied in the collection, segregation, storage, transportation, treatment and disposal of waste materials generated from hospitals . Due to thenature of activities that take place in hospitals, sharps (needles, syringes etc.), used bandages/pads/gloves/plasters/gauze, body tissues, drugs, chemicals, fecal/urinary/blood remains, tubing, plastic/glass bottles and disposable materials/cartons as the predominant waste types generated. Furthermore, HCW generated in hospitals can be categorized as infectious, pathological, radioactive, sharps, pharmaceutical, genotoxic, laboratory, vaccine and general wastes. According to the World Health Organization , over 80% of HCW can be categorized as general waste with less than 20% covering other types of waste which are deemed hazardous to human health and environment. In terms of quantity,annual generation of HCW in Africa is estimated at over 280,000 tons, generated from about 67,000 healthcare centers. . Also, about 5 million human fatalities are attributable to mismanagement of HCW worldwide

Due to its relevance to sustainability, it has been identified that providing adequate training for medical personnel enhances their sustainable waste management practices . Poor training on sustainable HCW management practices means that waste reduction, reuse and recycling may not be widely practiced, leading to most waste materials being disposed in landfills and open dumps . Furthermore, health workers′ gender, level of education and type of occupation can significantly affect their knowledge on sustainable HCW management, especially during a pandemic like COVID-19 .In assessing waste management in several tertiary hospitals in Jos-Nigeria, ascertained that segregation of healthcare was not well-practiced because different categories of waste are usually lumped together and disposed incongruously. Moreover, waste segregation in Nigerian healthcare facilities is hampered by lack of training on sustainable waste management practices, nonexistence of waste separation at source, lack of color coding of waste bins, absence of waste data, among other factors . Evaluation of HCW practices among health workers in Ife-Nigeria and found out that burying, burning (incineration), and communal bin were the predominant waste disposal methods, with most of them preferring burning and burying. Similar practices have been identified in Ghana where assessment of HCW disposal practices in medical facilities identified open dumping, burning and burying

as the main waste disposal method, with about 50% of study respondents disposing HCW in open dumps .

Concerns have been raised on the dangers caused by inadequate management and disposal of HCW in southeast Nigeria . This is because mismanagement of HCW could exacerbate infectious diseases, pollute the natural environment while initiating chronic health disorders and deformities . Also, there are significant potential of harm for hospital workers from contaminated food, water, air, human tissue and sharps which can have serious health implications . Also, the harmful nature of HCW makes the method of disposal very pertinent, especially as it concerns human health and environmental safety. Therefore, this study aims at assessing waste management techniques among hospital workers within a large hospital in Owerri, Imo State. In doing this, the study predicted the likelihood of being trained on sustainable management of HCW based on workers′ occupation, years of experience and common waste disposal methods. Also, the study measured prevalence HCWs in order to ascertain their main dimensions.

2. Methods

The study was carried out in a large hospital located within Owerri municipal area, Imo State, Nigeria. The hospital has a 700-bed capacity, catering for patients in various areas of medicine. First established as a drug dispensary in 1903 during the colonial era, it metamorphosed into a district hospital which later became a general hospital for Owerri city and its environs. In terms of research design, cross-sectional survey was adopted for data collection from workers in the hospital where the study was conducted. On that note, study respondents were working in different sections of the hospital and comprised of the following categories: doctors, laboratory scientists, cleaners, nurses and administrative/clerical workers. Field visitations and interactions with hospital officials indicated that there are about 5000 employees in the medical facility, including contract and casual workers. Random sampling technique was used in determining the sample size of 240 workers, based on sample of proportion representing about 5% of the study population . Out of the sample size of 240 who were given questionnaires in order to provide data for the study, 234valid mail questionnaires were retrieved and used for analysis. In addition, good research ethics were applied in the study; informed and voluntary consent, non-injury and confidentiality were fully observed during data collection. In order to validate

the research questionnaire, a pilot study was carried out so as to experience how respondents felt about the research questions. Also a few corrections were made thereby improving the questionnaire. Data collection took about 2 months to complete.

2.1 Measures

In order to predict the likelihood of workers being trained on sustainable management of healthcare waste (HCW), three categorical predictors were applied as independent variables in model: Occupation (Doctor, Lab scientist, Cleaner, nurse and admin/clerical), years of experience (less than 1 year, 1–5 years, 6–10 years, 11–15 years and more the 15 years) and common waste disposal method (incineration, burying, communal bin). The essence of applying these variables was due to their relevance in sustainable HCW management which has been identified in literature.

In measuring the dimensions of prevalent HCWs, eight constructs of HCW categories (pharmaceutical waste, sharps [needles/syringes/knives] waste, pathological waste, general waste, radioactive waste, genotoxic waste, laboratory waste and vaccine waste) were applied. These constructs were derived from literature where they were identifiedas the main categories of waste generated in medical facilities.

2.2.Data analysis

IBM SPSS version 21.0 software application was applied in coding datasets and also running statistical analysis for the study.

2.2.1. Logistic regression

Binomial logistic regression was used in predicting the likelihood of being trained on sustainable management of HCW. This is because logistic regression has the capacity to predict the outcome of a dichotomous dependent variable by approximating logarithm of the odds (log-odds) of independent variables in the model . In the present study, the question predicted was: *Have you been trained on sustainable management of HCW*? Response: *Yes* (1) or *No* (0). In order to carry out a viable logistic regression, there are several conditions that must be met: mutually exclusive dependent dichotomous variable, one or more mutually exclusive continuous/nominal variables, a sample size of more than 100 and lack of multicollinearity between the independent variables . Logistic regression modelling a

binomial variable Y with two independent variables, X_1 and X_2 will have a logit link function as follows:

$$\text{logit}(Y) = \log_b p/(1-p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \quad (1)$$

Where:

b = base of the logarithm; p = probability of the success for binary response; β_0 = model intercept (constant); β_1 and β_2 = parameters of the model for X_1 and X_2 respectively; ε = errors.

2.2.2 Principal component analysis

Data collected on eight variables of prevalent HCW were analyzed using principal component analysis (PCA), in order to establish their main components and structural dimensions. PCA was applicable because the variables are ordinal in scale, sample size is large (n = 234) and there was tolerable correlation between most variables within the dataset. In terms of sample adequacy, Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was applied where values of 0.6 or more (scores range from 0 to 1) point towards sampling appropriateness. In terms of aptness for dimension reduction, Bartlett's test of Sphericity was valid because it calculates the level of significance (indicating appropriateness) of the dataset for PCA . Components to be retained were determined using a combination of Eigenvalue-one Criterion , Scree plot test and structural interpretability (based on Varimax rotation method) . Results of the PCA's retained component matrix (showing their factor loadings and respective communalities) were then interpreted and discussed.

2.3 Socio-demographics

Socio-demographic information of the study respondents are shown in Table 1.

Table . Socio-demographic data of hospital workers in the study (n = 234)

Respondents' characteristics	*n*	%
1. Gender		
Female	109	46.6
Male	125	53.4
2. Occupation		
Doctor	39	16.7
Lab scientist	57	24.4
Cleaner	73	31.2
Nurse	50	21.4
Administrative/clerical	15	6.4

3. Years of experience

Less than 1 year	36	15.4
1-5 years	52	19.7
6-10 years	79	33.8
11-15 years	52	22.2
More than 15 years	21	9

In terms of gender, about 53% of the study respondents were males. Cleaners were the highest respondents at 31.2%. This was followed by lab scientists and nurses at 24.4% and 21.4%, respectively. Doctors comprised 16.7% of the study respondents while administrative/clerical workers comprised the least percentage of respondents at 6.4%. In terms of years of experience, 6–10 years had the most percentage of respondents at 33.8%. Workers with 11–15 years′ experience comprised about 22% of the study respondents while 1–5 years category covered 19.7%. Workers with less than 1 year experience covered 15.4% while more than 15 years comprised 9% of the study respondents.

Results

Table 2 shows results on cross-tabulation between respondents′ occupation and the extent they use code-colored waste bins. The results indicate that most of the respondents (over 70%) do not use code-colored waste bins at all, with cleaners and nurses having the highest frequencies under this category with 22.2% and 18.4% respectively. However, association between extent of respondents′ use of code-colored waste bins and their occupation was not statistically significant, p = .252.

Table 1. Use of code-coloured waste bins among hospital workers studied

		Occupation					p-value
		Doctors	Lab scientists	Cleaners	Nurses	Admin./clerical	
Use of code - colored waste bins	Not at all	24 (10.3%)	40 (17.1%)	52 (22.2%)	43 (18.4%)	12 (5.1%)	.252
	Not often	12 (5.1%)	9 (3.8%)	14 (6.0%)	4 (1.7%)	1 (0.4%)	
	Often	3 (1.3%)	7 (3.0%)	7 (3.0%)	2 (0.9%)	2 (0.9%)	
	Very often	-	1 (0.4%)	-	1 (0.4%)	-	

Results in Table 3 shows cross-tabulation between respondents' extent of healthcare waste (HCW) segregation and their occupation. The results indicate that more than half (about 60%) of the study respondents segregate their HCWs, often and very often, with cleaners having the highest percentage (24.4%). Furthermore, the relationship between the extent respondents segregate waste and their occupation, was statistically significant, p = .032.

Table 1. HCW segregation among hospital workers studied

		Occupation					p-value
		Doctors	Lab scientists	Cleaners	Nurses	Admin./clerical	
Waste Segregation	Not at all	12 (5.1%)	15 (6.4%)	7 (3.0%)	13 (5.6%)	3 (1.3%)	.031
	Not often	7 (3.0%)	13 (5.6%)	9 (3.8%)	13 (5.6%)	2 (0.9%)	
	Often	14 (6.0%)	23 (9.8%)	33 (14.1%)	17 (7.3%)	6 (2.6%)	
	Very often	6 (2.6%)	6 (2.6%)	24 (10.3%)	7 (3.0%)	4 (1.7%)	

Likelihood of being trained on sustainable HCW management

In predicting whether or not workers have been trained on sustainable HCW management, respondents' occupation, years of experience and waste disposal methods were applied as independent variables in a logistic regression. In the first place, the variables used in the model all had responses that were mutually exclusive. In testing for multicollinearity among the categorical independent variables, Variance inflation factor (VIF) and coefficients of tolerance of the variables are shown in Table 4.

Table 4. Collinearity statistics for categories of the model predictors

Categorical predictors	Collinearity statistics	
	Tolerance	VIF
Occupation	.996	1.004
Experience	.995	1.005
Waste disposal method	.997	1.003

Source: Author

Collinearity statistics for the three categorical predictors show that tolerance values are all above 0.9 while VIF values are under 1.6, indicating that there are no multicollinearity issues among the variables. Overall model fitness of the logistic regression in Table 5 shows that the model was statistically significant, $\chi 2$ (11) = 21.184, p = .032. Furthermore, the logistic regression model was not a poor fit as shown by the Hosmer and Lemeshow Test which was statistically non-significant, $\chi 2$ (8) = 4.117, p < .846.

Table5. Logistic regression fitting information

	Chi-square	df	p-value
Overall model fitness	21.184	11	.032
Hosmer and Lemeshow Test	4.117	8	.846

Source: Author

Classification table for the regression model shown in Table 6 indicates that 65% of the cases were accurately classified at a probability cut off of .500. The results show that 82.1% of workers who have been trained on sustainable HCW management were accurately predicted by the model while 37.1% of workers who have not been trained on sustainable HCW management were also accurately predicted by the model.

Table 6. Classification table for outcome variable of the logistic regression

			Outcome variable		
			Training on HCW management techniques		Percentage Correct
			No	Yes	
Training on HCW management techniques		No	33	56	37.1
		Yes	26	119	82.1
Overall Percentage					65.0

Cut off is .500
Source: Author

Parameter estimates of the logistic regression model in Table 7 indicate that only the reference category under "occupation" was statistically significant in predicting the likelihood of workers being trained on sustainable HCW management (Admin/clerical: Wald $\chi 2$ (4) = 8.046, p = .011). Also, only one category under "years of experience" was statistically significant (11–15 years: Wald $\chi 2$ (1) = 1.039, p = .038) in the model; the log odd coefficient value (B column) was positive implying an increasing log odd. In addition, only the communal bin category under "Disposal method" was statistically significant, Wald $\chi 2$ (1) = 2.134, p = .044.

Table 7. Parameter estimates of the Logistic regression

	B	S.E.	Wald	Df	Sig.	Exp(B)	95%C.I.for EXP(B)	
							Lower	Upper
Occupation [Ref.: Admin/Clerical]			8.046	4	*.011			
Doctor	.093	.647	.021	1	.886	1.097	.309	3.899
Lab Scientist	-.731	.615	1.409	1	.235	.482	.144	1.609
Cleaner	.303	.623	.237	1	.627	1.354	.399	4.595
Nurse	.118	.625	.035	1	.851	1.125	.331	3.825
Years of Experience [Ref.: < 1 year]			4.822	4	.306			
1 – 5 years	.216	.641	.113	1	.736	1.241	.353	4.357
6 – 10 years	.094	.598	.025	1	.875	1.099	.341	3.544
11 – 15 years	1.544	.534	1.039	1	*.038	3.580	1.804	9.652
More than 15 years	-.553	.560	.976	1	.323	.575	.192	1.723
Disposal method [Ref.: Open dump]			6.589	3	.086			
Incineration	-.383	.412	.864	1	.353	.682	.304	1.529
Burying	-.080	.508	.025	1	.875	.923	.341	2.500
Communal bin	.531	.363	2.134	1	*.044	1.700	.834	3.467
Constant	.688	.731	.885	1	.347	1.990		

Ref. = Reference category for each independent variable in the model; * = statistically significant.Source: Author

Based on parameter estimate results in Table 7, the odds of workers with 11−15 years′ experience being trained on sustainable HCW management is 3.580 (95% CI,1.804 to 9.652) times more than those with 1 year experience. Under HCW disposal methods, the odds of workers who mainly dispose HCW in communal bins being trained on sustainable HCW management is 1.7 (95% CI, .834 to 3.467) times more than those who mainly dispose HCW in open dumps.

Dimensions of prevalent HCWs

In identifying the main dimensions of prevalent HCWs in the hospital studied, PCA was applied on eight HCW variables (Pharmaceutics, Sharps, Pathological, General, Radioactive, Genotoxic, Laboratory and Vaccine wastes). These variables were applied in the PCA due to their relevance in literature .

Table 8. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			**.667**
Bartlett's Test of Sphericity	Approx. Chi Square	-	155.732
	Df		28
	Sig.		**.000**

Source: Author

A sample size of 234 was deemed appropriate for the PCA; overall Kaiser−Meyer-Olkin (KMO) measure of sampling adequacy was 0.667 while individual KMO values ranged between 0.502 and 0.734. Furthermore, Bartlett′s test of sphericity in Table 8 was statistically significant, $\chi 2$ (28) = 155.732, $p < .001$, which justified carrying out PCA.

Table 9. Components with extracted loadings in the PCA

Component	Extraction Sums of Squared Loadings		
	Eigenvalue	% of Variance	Cumulative %
1	**2.106**	**26.321**	**26.321**
2	**1.243**	**15.540**	**41.860**
3	.981	12.264	54.125
4	.918	11.472	65.597
5	.787	9.832	75.428
6	.768	9.598	85.026
7	.647	8.093	93.119
8	.551	6.881	100.000

Source: Author

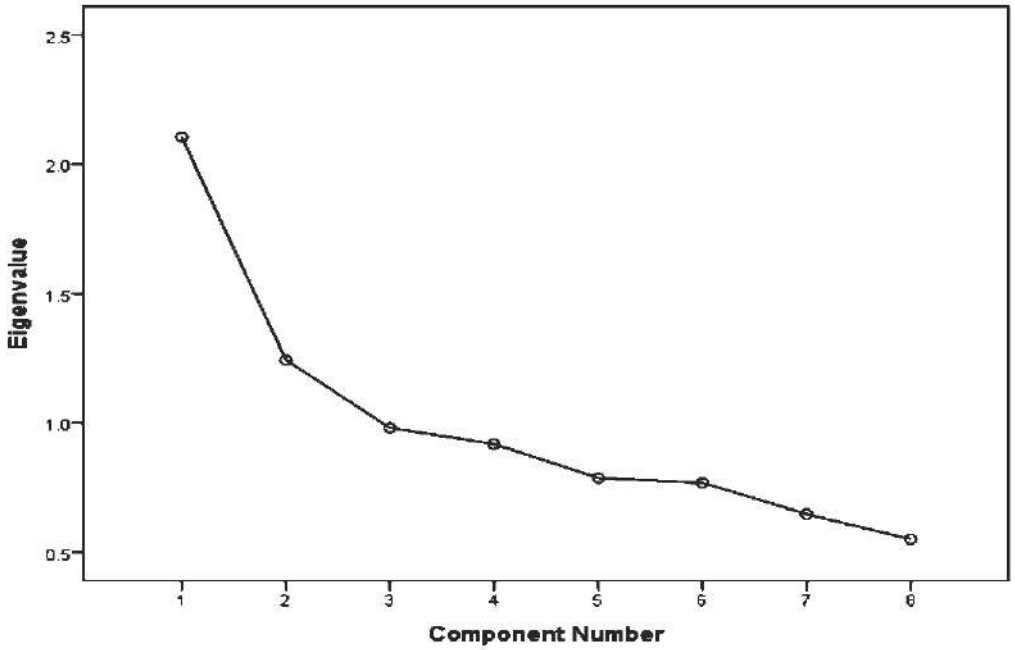

Figure 1. Scree plot test for the PCA(Source: Author)

According to extraction loadings of the PCA shown in Table 9, only the first two components had eigenvalues more than one (41.86% cumulative of total variance explained), pointing towards retaining two components. Also, the scree plot (see Figure 1) supports the viability of retaining two components given that the line deflects at the second component. On that note, two components were retained; component loadings (emboldened) and their respective communalities are shown in Table 10. This is because the rotated component matrix, facilitated by Varimax rotation gave the simple structure required for interpreting the PCA. According to Table 10, Pharmaceutics, Sharps, Pathological and General wastes are strongly loaded to component 1, with respective values of .716, .691, .576 and .498. Similarly, Radioactive, Genotoxic, Laboratory and Vaccine wastes are strongly loaded to component 2, with respective values of .482, .278, .808 and .662.

Table10. Rotated Component Matrix with communalities for the PCA

Variables (waste type)	Component loadings		Communalities
	1	2	
Pharmaceutics	**.716**	-.022	.514
Sharps	**.691**	-.018	.478
Pathological	**.576**	.260	.400
General	**.498**	.342	.365
Radioactive	-.184	**.482**	.266
Genotoxic	.397	**.278**	.235
Laboratory	.-.007	**.808**	.653
Vaccine	.021	**.662**	.438

Source: Author

Discussion

Study results show that most of the respondents (over 70%) do not use code–colored waste bins at all. This may be attributable to unavailability of these bins in this hospital, as well as poor training on sustainable healthcare waste (HCW) management, which has been identified in literature . Furthermore, unavailability of color–coded bins may be the reason for the non–significant relationship between occupation and use of code–colored waste bins. Results also show that more than half (about 60%) of the study respondents segregate their HCWs, which was statistically significant in relation with occupation. Segregation of waste is importance to sustainable HCW management as posited by .

Regression results on predicting whether or not workers have been trained on sustainable HCW management based on respondents′ occupation, years of experience and waste disposal methods was statistically significant, indicating that the variables are a good fit in the model. This is in line with ′s logistic model for predicting waste management practices. Furthermore, non–significance of the Hosmer and Lemeshow Test, as well as accuracy prediction in the classification table also points toward the viable of the regression model as posited by . Model parameter estimates indicates that “occupation" was statistically significant implying that being trained on sustainable HCW management may depend on designation in the hospital. This is in line with the findings of Shekoohiyan et al. (2022) on knowledge variation on sustainable HCW management. Also, “11–15 years” under years of experience was statistically significant. This is because the odds of workers with 11–15 years′ experience being trained on sustainable HCW management is 3.580 times more than those with 1 year experience, as shown in Table 5. This finding could also indicate that imbibing sustainable HCW management practices increases with higher experience in the hospital. Furthermore, communal bin disposal of HCW was the only statistically significant category under disposal method, indicating that waste disposal may be lacking in terms of sustainable practices. Alharbi et al. (2021) also identified HCW disposal in open dumps among health workers in Saudi Arabia, attributable to poor sustainable waste training and lack of regulatory frameworks. In addition, results indicate that the odds of workers who mainly dispose HCW in communal bins being trained on sustainable HCW management is 1.7 times more than those who mainly dispose HCW in open dumps. This finding is in line with Ngwuluka et al. (2009), Afolabi et al.

(2018) and Egbenyah et al. (2021) on incongruous HCW disposal in Nigeria and Ghana, where hospital workers do not treat nor segregate waste materials which may be burned, buried or eventually disposed in open dumps.

PCA results indicate that there are two dimensions of prevalent HCWs in the hospital studied, as explicated by the two components retained. The four variables that are strongly load to component 1 (Pharmaceutical, Sharps, Pathological and General wastes) are mainly HCW that do not require too much treatment before disposal. This finding is line with World Health Organization findings that majority of waste generated in hospitals (about 80%) are not very toxic in terms of handling and storage (WHO, 2018). However, these waste categories have been identified as also being detrimental to human health due to possible of contamination of environmental parameters like air, water and soil (Doylo et al., 2019). Component 2 of the PCA also has four variables that are strongly to it (Radioactive, Genotoxic, Laboratory and Vaccine wastes). The four HCWs under this dimension may be described as those require special handling and treatment before disposal. Therefore, management of HCW under this dimension should consider their hazardous nature, in order to reduce environmental and human health impacts. This aligns with Ezedike et al. (2020) and Alharbi et al. (2021) on the need for sustainable management of waste of different sources and streams. Therefore, it is not unexpected that Luo et al. (2021) identified the necessity training hospital workers on sustainable waste management techniques, due poor waste segregation and indiscriminate HCW disposal in Nigeria (Ngwuluka et al. 2009; Oli et al., 2016).

Conclusion

The study has assessed sustainable healthcare waste (HCW) management practices among hospital workers in Owerri, Imo State, by predicting the likelihood of being trained on sustainable management and also determining the dimensions of prevalent HCWs. Results indicate that code-colored bins are not available in the hospital studied. Furthermore, many workers in the healthcare facility studied segregate HCW generated, depending on occupation in the hospital. Furthermore, regression model for predicting being trained on sustainable HCW management was statistically significant, indicating that occupation, experience and waste disposal method were

fitting variables in the model. Also, PCA of eight variables on prevalent HCWs in the hospital studied pointed towards a two-dimension structure: low risk waste that do not require treatment and special waste needing treatment and cautious management.

Based on the study's key findings, it recommended that code-colored waste bins are provided in various sections of the hospital. This will go a long way in ensuring that waste is separated at source, thereby fostering sustainable HCW management. More training activities using a more practical approach to sustainable HCW management should be provided. This is because practical trainings are more explicit in imbibing the principles of sustainable HCW management. Also, more effort should be made in providing multi-purpose HCW treatment systems in large hospitals. These treatment systems can integrate recycling of general waste and incineration of special waste which may be hazardous when disposed in communal bins and dump sites.

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