



# **Biomedical Waste Management: What do Medical Doctors and Nurses in a Nigerian Tertiary Healthcare Facility Know?**

**Queencallista N. Sidney-Nnebue<sup>a</sup>, Chinomnso C. Nnebue<sup>b,c\*</sup>, Daniel C. Anh<sup>d</sup>, Onyinye M. Azi<sup>d</sup>, Chika D. Asobie<sup>d</sup> and Callista C. Anyanwu<sup>d</sup>**

<sup>a</sup> Physical Planning Unit, Nnamdi Azikiwe University, Awka, Nigeria.

<sup>b</sup> Department of Community Medicine, Madonna University, Elele, Nigeria.

<sup>c</sup> Department of Community Medicine, Nnamdi Azikiwe University, Awka, Nigeria.

<sup>d</sup> Department of HIV Care and Department of Community Medicine, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria.

## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

## **Article Information**

### **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/85649>

**Original Research Article**

**Received 14 March 2022**

**Accepted 26 April 2022**

**Published 27 May 2022**

## **ABSTRACT**

**Background:** Health care service providers aim at managing diseases and health related conditions. In this quest, they albeit inevitably generate wastes, some of which have potentials of causing harm to them, co-workers, clients, patients and the public.

**Objective:** To assess the awareness and knowledge of biomedical waste management among doctors and nurses at a tertiary healthcare facility in Owerri, Nigeria.

**Materials and Methods:** This was a facility-based cross sectional survey of 287 health care service providers (108 Medical Doctors and 179 Nurses). Enrollment was via multistage sampling technique. Data were obtained using self-administered semi-structured questionnaires, and analysed using statistical package for social sciences software version 22. Chi-square test was used to determine statistical significance and at p value  $\leq 0.05$ .

**Results:** Majority, 273 (95.1%) respondents reported awareness of BWM. The commonest source of information on BWM was 235 (86.1%) from undergraduate training. Also, 160 (55.8%) of them had good knowledge scores on BWM, 103 (35.9%) had been trained on BWM, while knowledge

\*Corresponding author: E-mail: nnebnons@yahoo.com, cc.nnebue@unizik.edu.ng;

grade significantly vary with ever trained on BWM ( $p=0.001$ ). Occupation was significantly associated with awareness that BW minimization is a role for Medical Doctors and Nurses.

**Conclusions:** This study found apparently high awareness of BWM and fair level of knowledge. Awareness on BW minimization as a role for Medical Doctors and Nurses is associated with occupation and so do knowledge grade and ever trained on BWM. There is need for regular, comprehensive but occupation specific training on BWM.

**Keywords:** *Health care waste; biomedical; Owerri Nigeria; awareness; knowledge.*

## 1. INTRODUCTION

"Biomedical (Health care or Medical) waste is the total waste stream from a health care facility that comprises potential infectious waste and non-infectious waste materials" [1]. "It is a subset of wastes generated in health care facilities such as hospitals, physicians' offices, dental practices, blood banks, veterinary hospital/clinics, as well as medical research facilities and laboratories [2]. Biomedical wastes (BWs) are prone to contamination by infectious substances such as blood, body fluids, and are thus regarded as regulated wastes" [2].

The World Health Organization (WHO) report in 2011 revealed that low income countries such as Nigeria, generate an average of 0.2kg per bed per day [3]. Dudi, et al., in 2015 reported that the amount of waste generated in low income countries ranges from one (1) to two (2) kg/patient/day [4]. Even though BWs are generated in the process of managing diseases and health related conditions albeit inexorably, BWs are a special group of wastes because they contain substances that may be deleterious, and can cause ill health to people exposed to it [5]. "Of the total amount of wastes generated via health care activities, about 85% is general, non-hazardous waste such as papers, nylons, packaging materials, dust. The remaining 15% is considered hazardous, and may be infectious, toxic or radioactive" [3]. The scenario above seems better than the true picture in our clime, as Ogbonna et al., in a study of tertiary hospitals in Port Harcourt Nigeria, posited that hazardous wastes make up 21.3% of BWs [6].

Biomedical waste management (BWM) comprises steps such as waste minimization, segregation, codification, handling, treatment, and disposal [1]. Medical doctors and Nurses play key roles in BWM and basically at the level of minimization of waste generation and waste segregation. Worldwide BWM presents an increasing concern to health authorities and the

public [7]. In low-income countries, BW is often not minimised or segregated into hazardous and non-hazardous, thus increasing the bulk of hazardous wastes [3]. In Zimbabwe, Taru and Kuvarega, observed that biomedical wastes are still not properly handled, but are rather disposed of together with domestic wastes, thus escalating the frequency of potential public health risks, nuisance, disease and economic burden [8]. Awodele, et al., in 2016, posited that BWs remains a significant challenge, particularly in most health care facilities of the low income countries where it is impeded by factors such as poor knowledge of BWM and inadequate training of staff on BWM [9].

Currently, there is paucity of literature in support of the existence of effective BWM system in Nigeria [10,11]. The occupational safety of healthcare workers handling waste is rather taken for granted. Also, there is paucity of studies done in the past to assess the knowledge on BWM among Medical doctors and Nurses in Nigeria. This study will gauge the level of knowledge on BWM among the study group, bridge the gaps if any, provide contributions to scientific studies as well as equip them with the requisite knowledge towards ensuring safety in their places of work and safety to the public. It will provide policy makers and stakeholders with good science and evidence-based information that will positively impact on formulation of appropriate policies on BWM, vis a vis safety and infection control. It is thus needful to assess the awareness and knowledge of BWM among Medical doctors and Nurses at a tertiary healthcare facility in Owerri, Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Study Design

This was a facility-based cross-sectional descriptive study conducted in April 2018 to June, 2018.

## 2.2. Description of Study Area

The study setting was the Federal Medical Centre (FMC) Owerri, located in Owerri Municipal, one of the three local government areas (LGA) that constitute Owerri the Capital of Imo State in South East Nigeria. The LGA had an area of 8km<sup>2</sup> and a population of 127,213 [12]. The FMC Owerri was established in 1903 as a hospital for treatment of soldiers, police officers and other colonial officers. It was formally renamed Federal Medical Centre (FMC) Owerri on the 1st of January 1995 [13]. The FMC Owerri is a 700 bed capacity referral center that offers comprehensive and specialist health care in Internal Medicine, Surgery, Paediatrics, Obstetrics and Gynecology to the areas under its catchment [11]. The center serves as a facility for postgraduate training of Medical doctors and personnel in medical allied sciences [12].

## 2.3 Study Participants

This consists of: Medical doctors and Nurses at the employ of the FMC Owerri, Nigeria.

### 2.3.1 Inclusion criterion

Medical doctors and Nurses who had worked at the FMC Owerri, Nigeria for at least three (3) months prior to the study. This will help ensure that knowledge and practices reported could be attributed to the BWM culture in the study setting.

### 2.3.2 Exclusion criteria

The study did not include Medical doctors and Nurses at the employ of the FMC Owerri, Nigeria, who were on casual appointment, absent from duty within the period of the study and or were present but declined consent.

## 2.4 Variables

These consist of: a) socio-demographic variables of respondents such as age, gender, religion, etc., b) awareness of BWM, c) knowledge of BWM, d) ever trained on BWM.

## 2.5 Data sources/Measurement

Frequencies of the variables were determined by univariate analysis, while bivariate analysis, using chi-square test was employed in testing associations between variables.

## 2.6 Bias

This study is based on self-reporting. Thus, some of the questions could be sensitive in nature. As a result, there could be reporting errors (under-reporting and over-reporting).

## 2.7 Study Size

### 2.7.1 Sample size determination

The sample size was determined using the sample size formula for cross sectional surveys in populations greater than 10,000 (Cochran) stated thus [14]:  $n = Z^2 pq/d^2$ , where n= minimum sample size; Z=standard normal deviate at 95% confidence interval set at 1.96; p=prevalence in a previous study; q=1 -p; d=degree of precision (0.05); Therefore, with proportion of health care workers that practice health care waste management as reported by Malebatja, at 49.6% = 0.496 [15], n = 384. Since the formula above holds when population is more than 10,000, for population less than 10,000, we applied the formula below [16,17]:  $nf = \frac{n}{1 + \frac{n}{N}}$ , where, nf = The

desired sample size when the population is less than 10,000, n = The desired sample size when the population is more than 10,000, The target study population, N is 1106 [12], nf = 285. Assuming 10% of the sample size was added to cover for attrition [16], the estimated sample size was approximately 313 [18].

### 2.7.2 Sampling technique

The study participants were selected in two stages. In the first stage, stratified sampling technique was used to group the participants according to occupation into Doctors and Nurses. From the 1106 subjects that make up the target population, 423 (38.2%) are Doctors and 683 (61.83%) are nurses [19]. Hence the study sample size of 313 was proportionately split into 120 doctors and 193 Nurses. In the second stage, the staff register was used as the sampling frame and 313 participants were chosen by simple random sampling technique using balloting (i.e. 120 doctors and 193 Nurses).

## 2.8 Data Collection Technique

Data collection in this study was done using semi-structured questionnaires. The questionnaires consist of 5 sections made up of 29 questions. All questions were written in English language and pre-tested on similar set of

respondents in Madonna University Teaching Hospital Elele, Nigeria. This was done, to check for the reliability, validity, appropriateness of format, wording and time needed to fill the questionnaire. Thereafter the instruments were reviewed by colleagues, necessary adjustments were effected and before the questionnaire were administered to the study participants. To ensure data quality, training of data collection team and field monitoring of data collection were done. Post data collection team meeting was held daily to share experiences and solve field problems

## 2.9 Quantitative Variables

Continuous variables were displayed as means  $\pm$  standard deviation (SD).

## 2.10 Statistical Methods

The data were edited and entered into the computer, cleaned, with range and consistency checks. Analyses of data were carried out using International Business Machine/statistical package for social sciences (IBM/ SPSS) Windows version 22.0 [17]. Descriptive data were presented as simple frequencies and percentages. Tests of statistical significance were carried out using Chi square tests and p values  $\leq 0.05$  were considered significant. Ten [10] knowledge items, were used with a total scale score of [10] points each, where (0-5= poor; 6-7= fair; 8 - 10=good.

## 3. RESULTS

Out of 313 questionnaires that were administered, 287 were returned and were analysed giving a response rate of 91.7%. Table 1 shows the socio- demographic characteristics of respondents, made up of 108 (37.7%) Medical Doctors and 179 (62.3%) Nurses. The modal age group 99 (34.3%) was 25-29 years. Majority, 200 (69.7%) were females, 123 (42.3%) were never married, 279 (97.2%) were Christians, 248 (86.4%) were of the Ibo ethnic extraction, while 223 (77.7%) had worked for <10 years.

Table 2 shows the awareness of BWM among respondents. Two hundred and seventy three (95.1%) respondents reported awareness of BWM. The sources of information on BWM reported by the 273 respondents that are aware, include: 235 (86.1%) from undergraduate training, 98 (35.9%) from postgraduate training, 95 (35.9%) from social media. One hundred and eighty eight (65.5%) and 140 (48.8%) of

respondents reported awareness that BW minimization and segregation as roles for health care service providers respectively. Table 3 highlights the level of knowledge and the ever trained on BWM among respondents. One hundred and sixty (55.8%) respondents had good level of knowledge on BWM, while 103 (35.9%) had been trained on BWM.

Table 4 shows the relationship between knowledge grade and ever trained on BWM among respondents. There was a statistically significant association between level of knowledge and ever trained on BWM respondents ( $\chi^2=11.278$ ,  $p=0.001$ ).

Table 5 shows the relationship among occupation of respondents and awareness cum knowledge grade on BWM. There was a statistically significant association between occupation and awareness of BW minimization as a role for health care service providers ( $\chi^2=3.928$ ,  $p=0.048$ ).

## 4. DISCUSSION

This cross-sectional descriptive study assesses the awareness and knowledge of BWM among doctors and nurses at a tertiary healthcare facility in Owerri, Nigeria. The current research reveals an apparently high level of awareness of BWM, to the tune of 95.1% of participants that reported so. This finding agrees with that of a 2014 study by Adogu, et al., though among health workers in a secondary health facility in Onitsha, a big commercial city in the neighbouring Anambra State [20]. The index study reports undergraduate training, postgraduate training, then social media, as the commonest sources of information on BWM. There is no report in literature to corroborate or negate this report. Despite being poorly researched to date, it is important that these citations on the sources of information on BWM need to be validated. The authors then posit there is need for further studies in this regard.

The present study investigated the role of health care providers in the minimization of generation of BW as well as in waste segregation at the point of its generation using colour coding. The report has it that 65.5% and 48.8% of participants report awareness that BW minimization and segregation are roles for health care service providers respectively. Adogu, et al., Ezeoke, et al., as well as Malini, et al., concurs with this finding [20,21,22].

**Table 1. Socio- demographic characteristics of respondents**

<b>Characteristics</b>	<b>Frequency N=287</b>	<b>Percentage (%)</b>
<b>Occupation</b>		
Medical Doctors	108	37.7
Nurses	179	62.3
<b>Age at last birthday (in years)</b>		
20-24	17	5.9
25-29	99	34.5
30-34	83	28.9
35-39	47	16.4
≥40	41	14.3
<b>Gender</b>		
Male	87	30.3
Female	200	69.7
<b>Marital status</b>		
Never married	123	42.9
Currently married	163	56.8
Divorced	3	1.1
<b>Religion</b>		
Christianity	279	97.2
Islam	6	2.1
African Traditional religion	2	0.7
<b>Ethnicity</b>		
Ibo	248	86.4
Hausa.	5	1.7
Yoruba.	20	7
Others*	14	4.9
<b>Duration of service as a doctor or nurse (years)</b>		
<10	223	77.7
10-20	62	21.6
21-30	2	0.7

\* Others- Ijaw, Ikwerre, Isoko, Ogoni, Tiv,

**Table 2. Awareness of biomedical waste management among respondents**

<b>Variables</b>	<b>Frequency (N=287)</b>	<b>Percentage (%)</b>
<b>Have heard of BWM</b>		
Yes	273	95.1
No	14	4.9
Total	287	100
<b>Sources of information on BWM (n=273)*</b>		
Undergraduate Training	235	86.1
Postgraduate Training	98	35.9
Social media	95	34.8
Electronic media	74	27.1
Print media	65	23.8
BWM training pre- employment	62	22.7
Periodic BWM training post- employment	53	19.4
<b>Aware that BW minimization is a role for HCSPs</b>		
Yes	188	65.5
No	99	34.5
Total	287	100
<b>Aware that BW segregation is a role for HCSPs</b>		
Yes	140	48.8
No	147	51.2
Total	287	100

\* Multiple responses

BW- biomedical waste;

BWM- biomedical waste management

HCSPs- health care service providers.

**Table 3. The level of knowledge and the ever trained on biomedical waste management among respondents**

<b>Variables</b>	<b>Frequency (N)</b>	<b>Percentage (%)</b>
<b>Knowledge Grade</b>		
Poor (Have heard of BWM)	24	8.4
Poor (Have not heard of BWM)	14	4.9
Poor (Subtotal)	38	13.2
Fair	89	31
Good	160	55.8
Total	287	100
<b>Ever trained on BWM</b>		
Yes	103	35.9
No	184	64.1
Total	287	100

BWM- biomedical waste management

**Table 4. Relationship between knowledge grade and ever trained on biomedical waste management among respondents**

<b>Variables</b>	<b>Knowledge Grade</b>				<b>Test statistic</b>	<b>p value</b>
	<b>Poor (%)</b>	<b>Fair (%)</b>	<b>Good (%)</b>	<b>Total (%)</b>		
<b>Ever trained on BWM</b>						
Yes	12 (4.2)	20 (7)	71 (24.7)	103 (35.9)		
No	26 (9)	69 (24)	89 (31.1)	184 (64.1)	11.278	0.001*

\* Statistically significant association =  $p \leq 0.05$ ,  $\chi^2$ - Chi square test

BWM- biomedical waste management

**Table 5. Relationship among occupation and awareness cum knowledge grade on biomedical waste management among respondents**

<b>Occupation</b>		<b>Doctors</b>	<b>Nurses</b>	<b>Total</b>	<b>Test statistic</b>	<b>p value</b>
<b>Variables</b>		(N/%)	(N/%)	(N/%)	( $\chi^2$ )	
<b>Awareness on BWM</b>						
<b>Aware that BW minimization is a role for HCSPs</b>						
Yes		63 (22)	125 (43.6)	188 (65.5)		
No		45 (15.7)	54 (18.8)	99 (34.5)	3.928	0.048 *
Total		108 (37.6)	179 (63.4)	287 (100)		
<b>Aware that BW segregation is a role for HCSPs</b>						
Yes		46 (16)	94 (32.8)	140 (48.8)		
No		62 (21.6)	85 (29.6)	147 (51.2)	0.245	0.104
Total		108 (37.6)	179 (63.4)	287 (100)		
<b>Knowledge Grade</b>						
Poor		15 (5.2)	23 (8)	38 (13.2)		
Fair		35 (12.2)	54 (18.8)	89 (31)	0.293	0.589
Good		58 (20.2)	102 (35.5)	160 (55.8)		
Total		108 (37.6)	179 (63.4)	287 (100)		

\* Statistically significant association =  $p \leq 0.05$ ,  $\chi^2$ - Chi square test.

BW- biomedical waste; BWM- biomedical waste management

HCSPs- health care service providers

The present research highlights that 55.8% of participants had good level of knowledge on BWM. This finding is consistent with findings elsewhere, though there were variations in

proportions, ranging from 51%-94%, [20,21,22]. These variations could be explained in the light of differences in methodologies such as study

settings, study subjects, sampling procedures and data collection techniques.

This study reports that only 35.9% had been trained on BWM. This agrees with the finding by Adogu and others, who posits that majority of the participants they studied had not received training on the subject [20]. Njiru and colleagues, in Kenya as well as Hakim and others, in Egypt also reports similar ranges in the proportion of participants that had ever received some form of training on the topic under discuss [23,24,25].

On the relationship between knowledge grade and ever trained on BWM, the present study finds that level of knowledge vary significantly with ever trained on the subject. A study elsewhere, reports poor knowledge score on BWM among doctors and nurses, and associated same with the 56% coverage of training on BWM [26].

The current study shows a statistically significant association between occupation and awareness that BW minimization is a role for health care service providers. However, there was no significant variation between occupation and awareness that BW segregation as a role for health care service providers. Studies elsewhere by other authors agree with the disparity in awareness with respect to occupation and segregation [22,26]. While Pullishery and others, in Mangalore reports higher awareness among nurses [26]. Malini, et al., in Puducherry, documents higher scores among doctors [22]. However, the index survey is cross sectional in nature and could not report the direction of relationships even where one exists. There is need for further studies along this line.

## 5. LIMITATIONS OF THE STUDY

This study is of cross-sectional design and data collected via the fact that self-reporting and the data is therefore subject to reporting errors. The biases would have been minimized by self-administration of survey tool and anonymity in data collection.

## 6. CONCLUSIONS AND RECOMMENDATIONS/FUTURE DIRECTIONS

This study found apparently high awareness of BWM, but does not translate to fair level of knowledge on BWM reported. Knowledge grade vary significantly with ever trained on BWM. And

so does occupation vary with awareness of BW minimization as a role for health care service providers. There is need for concerted and cohesive efforts by all relevant stakeholders, towards the provision of comprehensive but occupation targeted, sustained training programs. This will help maintain awareness, impart adequate knowledge and equip these Medical doctors and Nurses with requisite skills to manage BMW.

## ETHICAL CONSIDERATION AND CONSENT

Approval was obtained from the appropriate authorities in the institution of study. Written consent of the respondents was also solicited and obtained for the conduct and publication of this research study. Study participants were free to refuse or withdraw from the study at any time without any penalty. All authors hereby declare that the study has been examined and approved by the Department of Community Medicine Madonna University ethics committee, Elele, Nigeria and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. World Health Organization. Management of solid health-care waste at primary health-care centres: A decision-making guide; 2005. Available:[http://www.who.int/water\\_sanitation\\_health/publications/manhcwm.pdf](http://www.who.int/water_sanitation_health/publications/manhcwm.pdf). Accessed on: 11/12/17.
2. Environmental Protection Agency. Medical Waste; 2017. Available:<http://www.epa.gov/rcra/medical-waste>. Accessed on 11/12/17.
3. World Health Organization. Waste from health care activities; 2011. Available:<http://www.who.int/mediacentre/factsheets/fs253/en/>. Accessed on 11/12/17.
4. Dudi M, Sharma R, Sharma S, Jain M. Assessment of the knowledge, attitude and practices regarding biomedical waste management amongst paramedical staff in

- a tertiary level health care facility. International Journal of Medical Science and Public Health. 2016;5(4):615-619.
5. Rutala WA, Odette RL, Samsa GP. Management of infectious waste by US hospitals. Jama. 1989 Sep 22;262(12): 1635-1640.
  6. Ogbonna DN, Chindah A, Ubani N. Waste management options for health care waste in Nigeria; A case Study of Port-Harcourt Hospitals. Journal of Public Health and Epidemiology. 2012;4(6):156-159.
  7. Helal NA, Edger J, Hawkins L. Factors affecting health and safety, particularly sharps injuries, in medical waste handlers in hospitals in the rapidly developing desert emirate of Abu-Dhabi; a questionnaire study. InBMC Proceedings. 2011;5:215-216.
  8. Tara P, Kuwarega A. solid waste management, The case study of Parirenyatwa hospital Zimbabwe, Rev Biomed. 2005;16:153-158
  9. Awodele O, Adewoye AA, Oparah AC. Assessment of medical waste management in seven hospitals in Lagos, Nigeria. BMC public health. 2016;16(1):269-273. Available:<https://www.channelstv.com/2014/03/01/earthfile-nigerias-health-care-waste-managment-policy/> updated on March 1st 2014.  
Accessed on 16th November 2017
  10. Nwachukwu NC, Anayo OF, Ugbogu OC. Health care waste management public health benefits, and the need for effective environmental regulatory surveillance in Federal Republic of Nigeria. 2012. DOI: 10.57772/53196. Available:<https://www.researchgate.net/publication/236842418>. Accessed on 1<sup>st</sup> December 2017.
  11. Owerri Municipal. Available:<http://www.wikipedia.org/wiki/owerrimunicipal>. [Accessed on 31 January 2015]
  12. Agunwa CC. Practice of universal precautions among doctors and nurses of Federal Medical Center Owerri, Imo State, South-East Nigeria. University of Nigeria Virtual Library. Available:<http://www.unn.edu.ng/publications/files/17958>. Accessed on 2<sup>nd</sup> December 2017.
  13. Cochran WG Sampling Technique Iowa State University Press. 1997;3:27.
  14. Malebtja SM. Knowledge and practices of health care workers on medical waste disposal at George Masebe Hospital, Waterberg district Limpopo Province, South Africa. Submitted in the faculty of Health Science Department of Public Health University of Limpopo; 2016. Available:[http://ul.netd.ac.za/bitstream/handle/10386/1745/malebatja\\_sm\\_2016%20.pdf?sequence=1&isAllowed=y](http://ul.netd.ac.za/bitstream/handle/10386/1745/malebatja_sm_2016%20.pdf?sequence=1&isAllowed=y). Accessed on 30<sup>th</sup> November.
  15. Araoye MO. Research methodology with statistics for health sciences. Nathadex publishers Ilorin. 2004;115-121.
  16. Statistical Package for Social Sciences (IBM SPSS) 22.0 version. Armonk NY: IBM United States. IBM Corp; 2013.
  17. Sidney-Nnebue QN, Garba AO, Fadiora GE, Etim FC, Ezenagu AN, Nnebue CC. Towards sustainable development: Exploring the knowledge of environmental impact assessment among undergraduates in a Nigerian University. Environment. 1(5):10.
  18. Bowler's proportional allocation formula. In. Pandey R, Verma MR. Samples allocation in different strata for impact evaluation of developmental programme. Rev. Bras. Biom. São Paulo, 2008;26(4):103-12.
  19. Adogu OU, Ubajaka CE, Nebuwa JE. Knowledge and practice of medical waste management among health workers in a Nigerian Hospital. Asian Journal of Science and Technology. 2014;5(12):833-838.
  20. Ezeoke EU, Babatunde I, Ndu AC. Investigating knowledge, attitude and health care waste management by health care workers in a Nigerian tertiary health institution. Global Journalist Health Science. 2017;9(4):222-232.
  21. Malini A, Eshwar B. Knowledge, attitude and practice of biomedical waste management among health care personnel in a tertiary care hospital in Puducherry. International Journal of Biomedical Research. 2015;6(03):172-176.
  22. Njiru MW, Mutai C, Gikunji JK. Awareness and practice on biomedical waste management among health care personnel in Kenyatta National Hospital. Last African Medical Journal 2013;90(2):52-58.
  23. Muthoni MS, Nyerere KA, Ngugi CW. Assessment of level of knowledge in medical waste management in selected

- hospitals in Kenya. *Applied Microbiology.* Open Access. 2016;2(4):1000124.
24. Hakim SA, Mohsen A, Bakr I. Knowledge, attitudes and practices of health-care personnel towards waste disposal management at Ain Shams University Hospital, Cairo Eastern Mediterranean Health Journal. 2014;20(5):347-354.
25. Pullishery F, Panchmal GS, Siddique S, Abraham A. Awareness knowledge and practices on biochemical waste management among health care professionals in Mangalore. A cross sectional study. *International Archives of Integrated Medicine.* 2016;3(1):29-35
26. Azuike EC, Adinma ED, Nwabueze SA, Azuike ED, Mbanuzuru VA, Epundu UU, et al. Healthcare waste management: what do the health workers in a Nigerian tertiary hospital know and practice. *Science Journal of Public Health.* 2015;3(1):114-118.

© 2022 Sidney-Nnebue et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**Peer-review history:**

*The peer review history for this paper can be accessed here:*

<https://www.sdiarticle5.com/review-history/85649>