Nigerian Research Journal of Engineering and Environmental Sciences 6(1) 2021 pp. 160-168

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

Quantity of Healthcare Waste Generated by Health Facilities in Urban Bauchi, Bauchi State, Nigeria

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ARTICLE INFORMATION

Article history:
Received 29 Mar, 2021
Revised 28 May, 2021
Accepted 29 May, 2021
Available online 30 Jun, 2021

Keywords:
Medical waste management
Healthcare facilities
Health care waste
Hospital waste
Waste generation
Bauchi

ABSTRACT

The basis for effective medical waste management strategy is the availability of sufficient and accurate data on the waste generated. This study aimed to determine the quantity of waste generated by healthcare facilities in urban Bauchi. Stratified random sampling technique was used, in which the area was divided into ten (10) strata which represent the ten (10) administrative wards of urban Bauchi namely, Dan Iya, Birshi, Makama A, Dan Amar A, Dan Amar B, Makama B, Tirwun, Dan Kade, Dawaki and Hardo wards respectively. Among each ward, one (1) hospital was purposively selected and labelled as A, B, C, D, E, F, G, H, I and J, to preserve their identity. Weighing balance was used to determine the quantity of each type of waste generated per day in each hospital. The total quantity of waste generated were weighed together each day for a week prior to disposal at dumpsites. The results show that, the average quantity of healthcare waste generated per day at hospital A, B, C, D, E, F, G, H, I and J are 200.8 kg, 30.4 kg, 15.2 kg, 11.1 kg, 10.7 kg, 8.5 kg, 14.9 kg, 3.6 kg, 8.8 kg and 21.8 kg respectively. The average waste generation rate for all the sampled hospitals was calculated as 32.6 kg/day and 0.6 kg/bed/day. It is recommended that proper documentation pertaining to the quantity of waste generated in the hospitals need to be improved.

1. INTRODUCTION

Medical wastes are all types of wastes produced by health facilities such as general hospitals, medical centers and dispensaries. It represents small number of total residues generated in a community. However, such residues can potentially transmit diseases and present an additional risk to the staff of healthcare facilities, patients and the community at large, if not managed properly (Cheng *et al.,* 2009). Such waste includes soiled cotton, bandages, hypodermic needles, syringes, tubing such as intravenous sets, and urinary catheters among others. As an emerging issue, medical waste management is affected by a lack of training, awareness,

and financial resources to support solutions (Babanyara *et al.,* 2013). Proper collection and disposal of this waste is of great importance as it can impact negatively on both public and environmental health (Derso *et al.,* 2018).

The World Health Organization (WHO) reported that about 15% of total waste generated in the healthcare facilities are hazardous and must be properly segregated at the point of generation to prevent the whole healthcare waste (HCW) becoming 100% hazardous (WHO 2014). It was estimated that each year, there are about 8 to 16 million new cases of Hepatitis B virus (HBV), 2.3 to 4.7 million cases of Hepatitis C virus (HCV) and 80,000 to 160,000 cases of human immune deficiency virus (HIV) due to unsafe injections disposal and mostly due to very poor waste management systems (Awodele *et al.,* 2016). Moreover, most hospital do not have incinerators and even those that do are not designed for the disposal of large quantities of waste and consequently have become overloaded, causing air pollution in surrounding area. Thus, poor waste management practices pose a huge risk to the health of the public, patients, professionals and contribute to environmental degradation (Srivastav *et al*., 2012).

Adogu *et al.* (2014) assessed the knowledge and practice of medical waste management among healthcare workers in Anambra state, Nigeria and reported that due to lack of quantification of HCW, there was no waste reduction plan in the selected hospitals. This lack of plan for HCW management eventually leads to inadequate waste segregation at point of use, collection, storage and final disposal. To develop any effective management plan, there is the need for adequate information and statistics on the subject. Hence, this study aims to contribute by assessing the quantity of HCW generated by health facilities in urban Bauchi, for proper documentation and planning.

2. MATERIALS AND METHODS

2.1. Study Area

Bauchi is the capital of Bauchi State in North Eastern Nigeria. Located between Latitudes $10^0$16' 30" – $10^0$21' 0" North and Longitudes $9^0$48' 0" and 9^0 52'30" East (Gani *et al.,* 2012), Bauchi covers a total land area of 3,687 square kilometers (Ogwuche, 2013). It is on the northern edge of the Jos plateau, at an elevation of 616 m above sea level. The topography of Bauchi metropolis is relatively flat in the center (Usman and Mohammed, 2012).

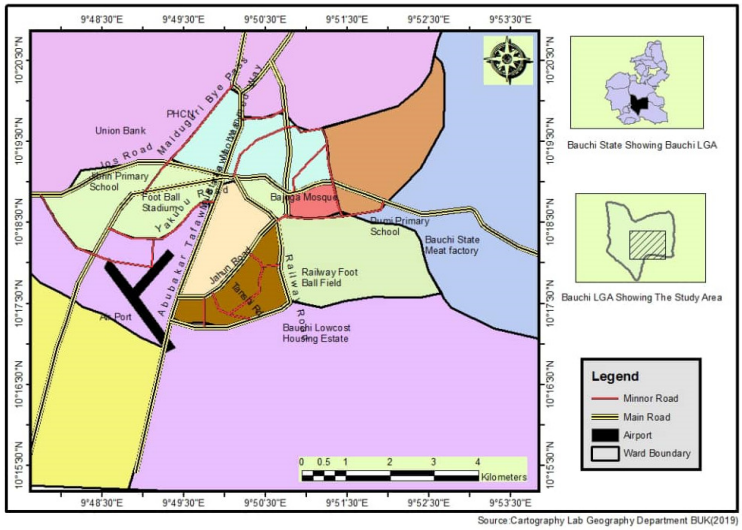

Figure 1: Map of the study area

Bauchi town (Figure 1) consists of ten administrative wards and comprises old town in the center, surrounded by the town wall which is the high density area, and from outside are the medium and low density areas surrounding the old town. However, apart from the old town, most of the other areas were laid out with a proper town plan and basic infrastructure, such as paved-roads, pipe borne water and good drainage system in some areas (Usman and Mohammed 2012). Based on a reconnaissance survey conducted in this research, urban Bauchi comprises of 52 health care centers which consist of 17 private health centers, 29 primary health cares (PHC) and 4 public hospitals.

2.2. Methods

Stratified random sampling technique was used to group the population into ten (10) strata which represent the ten (10) administrative wards of urban Bauchi namely, Birshi, Makama A, Makama B, Tirwin, Dan Kade, Dawaki, Dan Amar A, Dan Amar B, Hardo and Dan iya ward respectively (Bello *et al*., 2007). Ten (10) hospital were selected randomly among the ten administrative wards. The sample size was obtained based on Krejcie and Morgan table (Krejcie and Morgan, 1970). Weight measuring scale was used to determine the quantity of waste generated per kg per day in each of the sampled hospital. The total quantity of waste generated were weighed together each day prior to disposal at dumpsites and recorded for one week. Calculations of average quantity of waste per bed per day were carried out by dividing the total quantity of waste by the number of beds in each hospital. Table 1 presents the population distribution of the waste handlers, the sample size and the hospital category. Also, in order to protect their confidentiality, the names of the selected hospitals are coded in this article. The names are tagged as A, B, C, D, E, F, G, H, I and J.

Table 1: Population sampling

Ward	Hospital	Category	Sample population	Sample size
Dan Iya	A	Public	145	91
Birshi	B	Public	17	11
Makama A	C	Public	26	16
Dan Amar A	D	Public	15	9
Dan Amar B	E	Public	10	6
Makama B	F	Private	3	2
Tirwin	G	Private	4	3
Dan Kade	H	Private	8	5
Dawaki	I	Private	5	3
Hardo	J	Private	3	2
Total	10		236	148

3. RESULTS AND DISCUSSION

The quantity of health care waste (HCW) produced daily was computed according to the departments or units in the facilities. As shown in Table 2, the quantity of HCW generated at hospital A was 200.8 kg per day, with 354 beds capacity while the quantity of HCW per bed per day was 0.6 kg. Obstetrics & gynecology unit (labor room, post-natal, post-operative, antenatal, gynae clinic etc.) generates the highest quantity of wastes with 33.3 kg, followed by Laboratory with 31 kg, then male and female medical wards 23.8 kg and male and female surgical wards 22.3 kg. It is also revealed that Clinical Pharmacology generates the least quantity of waste with 1.9 kg. This can be attributed to the difference in medical specialty offered in the wards, as obstetrics and gynecology ward in the hospital uses large quantity of disposable materials in the care process that is associated with increased waste generation. These results are consistent with those reported in the work of Abdulla *et al.* (2008) which reported HCW generation rates that ranged between 0.6 to 2.6 kg/bed/day with weighted standard of 0.83 kg/bed/day in Jordan.

Table 3 shows the average quantity of HCW generated at hospital B per day as 30.4 kg, with 54 beds capacity, while the quantity of HCW per bed per day was 0.54 kg. It also shows that the hospital laboratory generates the highest quantity of wastes with 14 kg per day, which could be attributed to the prevalence of infectious

waste in the unit such as used test kits, used swabs, sputum, stool, blood serums among others. In contrast, Consultation units generate the smallest quantity of waste with 0.8 kg per day due to the flash nature of services that take place in the unit. Similar result was recorded in the work of Qdaiss *et al.* (2007) in which the quantity of HCW documented in one of the public hospitals in Jordan is 0.66 kg per bed per day. This variation in waste generation among hospitals may be attributed to numerous reasons such as hospital specialization, proportion of disposable items used in health care activities and efficiency of segregation of hazardous medical from non-hazardous medical waste stream.

Table 2: Mean quantity of healthcare waste at hospital A

S/N	Department/unit	Number of beds	Quantity (kg/day)
1	Laboratory	1	31
2	Clinical pharmacology	0	1.9
3	Physiotherapy	4	2.7
4	Pediatrics	41	21.6
5	Obstetrics & gynecology	78	33.3
6	Accident and Emergency	26	14.4
7	Female & male medical ward	59	23.8
8	Female & male surgical ward	83	22.3
9	General outpatient department	1	9.2
10	Ear, nose & throat	8	2.7
11	Eye clinic	7	1.2
12	Theater	6	5.8
13	Amenity	9	20.1
14	Psychiatric	20	4.7
15	Mortuary	11	3.1
	Total	354	200.8
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{200.8}{354} = 0.6$ kg			

Table 3: Mean quantity of healthcare waste at Hospital B

S/N	Department/units	Number of bed	Quantity (kg/day)
1	Laboratory	2	14.1
2	Pharmacy	1	2.3
3	Consultation room	1	0.8
4	Leprosy male ward	14	3.0
5	Leprosy female wards	11	4.7
6	Male chest unit	9	2.4
7	Female chest unit	16	3.1
	Total	54	30.4
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{30.4}{54} = 0.5$ kg			

The average quantity of HCW generated at Hospital C was 15.2 kg per day, with bed capacity of 28, as shown in Table 4. The average waste per bed per day was 0.5 kg. The least generating units in the hospital were the consultation unit with 0.4 kg per day, followed by pharmacy unit with 0.5 kg. This could be attributed to the nature of services they deliver with low usage of disposable materials. The leading generating units are the laboratory with 3.7 kg, followed by female ward with 3.3 kg, then pediatric unit with 2.8 kg and delivery suite with 2.1 kg per day. This was due to the mass number of patients it accommodates, the prevalence of infectious waste such as the used hand gloves, used catheter, syringe & needles, and breakable ampoules.

Table 5 shows the total quantity of HCW generated at hospital D as 11.1 kg per day, with 15 beds capacity, while the average quantity of HCW at the hospital per bed per day was 0.7 kg. General female ward produced

the largest quantity of the waste at the hospital with 3.5kg per day for its frequent accommodation of high number of patient as well as frequent use of disposable materials. Pharmacy unit generate the least quantity of the waste with 0.3 kg per day, which could be due to the nature of services it offers with no patient accommodation.

Table 4: Mean quantity of healthcare waste at Hospital C

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Pediatric	4	2.8
2	Female ward	9	3.3
3	Theatre	1	1.4
4	Post operation room	5	1.0
5	Laboratory	1	3.7
6	Pharmacy	0	0.5
7	Consultation room	1	0.4
8	Delivery suite	7	2.1
	Total	28	15.2
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{15.2}{28} = 0.5$ kg			

Table 5: Mean quantity of healthcare waste at hospital D

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Labor room	4	2.6
2	Laboratory	1	1.4
3	Immunization	0	0.5
4	Pharmacy	0	0.3
5	General female ward	6	3.5
6	General male ward	4	2
7	Consultation room	0	0.8
	Total	15	11.1
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{11.1}{15} = 0.7$ kg			

The average quantity of HCW generated at hospital E was 10.7 kg per day (Table 6), with 14 beds capacity, while the quantity of HCW at the hospital per bed per day was 0.8 kg. However, General female ward generates the largest quantity of the waste with 2.8 kg per day due to the high flow of patient in the ward, while pharmacy unit generate the least quantity of the waste with 0.3 kg per day due to its low accommodation of patient.

Table 6: Mean quantity of healthcare waste at primary healthcare E

S/N	Department/Unit	Number of bed	Weight (kg/day)
1	Labor room	4	2.5
2	Laboratory	1	1.8
3	Immunization	0	1.5
4	Pharmacy	0	0.3
5	General female ward	4	2.8
6	General male ward	4	1.3
7	Consultation room	1	0.5
	Total	14	10.7
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{10.7}{14} = 0.8\ kg$			

Table 7 reveals that hospital F generates a total of 8.5 kg of waste per day with 15 bed capacity. The average waste generated per bed per day is 0.6 kg. The Table further shows that general ward generates the maximum

quantity of waste per day with 4.1 kg due to the enormous accommodation of patients with high mixture of infectious and general waste generation. Consultation unit generate the lowest amount of HCW of 0.3 kg per day.

Table 7: Mean quantity of healthcare waste at hospital F

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Theater	1	1.7
2	Consultation room	1	0.3
3	General ward	12	4.1
4	Laboratory	1	2
5	Pharmacy	0	0.4
	Total	15	8.5
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{8.5}{15} = 0.6$ kg			

Hospital G generates a total quantity of 14.9 kg of waste per day with 26 bed capacity, as presented in Table 8. The total waste generated per bed per day was 0.6 kg. Female ward and subsequently laboratory unit generate the highest quantity of waste with an average of 5.4 kg and 4.7 kg respectively. This can be attributed to frequent specimen taken to the laboratory and bulk of general waste from the female ward. This is followed by male ward with 3 kg, consultation room 0.7 kg, injection room and pharmacy unit 0.4 kg each and immunization room with the least quantity of 0.3 kg per day. Table 9 shows the total quantity of HCW generated at hospital H per day as 3.6 kg, with 3 beds capacity the average quantity of the HCW per bed per day was 1.2 kg. The result further reveals that the hospital's Maternity ward generates the highest quantity of the waste with 1.9 kg. This could be because the unit deals with frequent flow of patient as well as infectious waste such as blood, amniotic fluids, used sanitary pads, placentas, retained product, used catheters among others. In contrast, family planning unit generates the least quantity of the waste with 0.2 kg per day. Hospital I generates an average quantity of 8.8 kg of HCW per day, with 10 bed capacity, while the total HCW per bed per day was 0.9 kg, as revealed in Table 10. It also shows that Labor room generate the highest quantity of waste with 2.4 kg, followed by pediatric unit with the quantity of 2.2 kg of waste per day. This is likely because of high patient accommodation in the units, whereas consultation room generate the least quantity of waste per day with 0.3 kg per day due to its low usage of disposable items. Similar result was reported in the work of Qdais *et al.* (2007) in which 0.84 kg/bed/day was recorded in Abu Obaidah hospital in Jordan. Table 11 reveals that Hospital J generates a total quantity of 21.8 kg of waste per day, with 30 beds capacity. The average total waste generated per bed per day was 0.7 kg. The least waste generating unit was the X-ray room with 0.3 kg of waste per day, while the highest waste generating unit was the female ward with 6.3 kg, followed by laboratory with 4.7 kg, then maternity with 4 kg, male ward with 3.6 kg, theater room with 2 kg, consultation room with 0.5 kg and scanning unit with 0.4kg. This is also attributed to the high disposable materials used in the unit, patient flow and high number of specimen taken. The result is in line with the work of Kagonji and Manyele, (2011) in which an average of 0.79 kg per bed per day was recorded in Tanzanian district hospitals.

Table 8: Mean quantity of healthcare waste at health clinic G

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Laboratory	1	4.7
2	Consultation room	1	0.7
3	Injection room	1	0.4
4	Female ward	17	5.4
5	Male ward	6	3
6	Pharmacy	0	0.4
7	Immunization room	0	0.3
	Total	26	14.9

Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{14.9}{26} = 0.6$ kg

Table 9: Mean quantity of healthcare waste at clinic H

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Maternity	3	1.9
2	Laboratory	0	0.5
3	Out-patient department	0	0.4
4	Routine immunization	0	0.3
5	Family planning	0	0.2
6	Pharmacy	0	0.3
	Total	3	3.6
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{3.6}{3} = 1.2$ kg			

Table 10: Mean quantity of healthcare waste at hospital I

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Pediatric	4	2.2
2	Laboratory	0	1.9
3	Labor room	3	2.4
4	Pharmacy	0	0.4
5	Treatment room	1	0.5
6	Consultation room	1	0.3
7	Theater room	1	1.1
	Total	10	8.8
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{8.8}{10} = 0.9$kg			

Table 11: Mean Quantity of Healthcare Waste at J

S/N	Department/Unit	Number of bed	Quantity (kg/day)
1	Scanning room	3	0.4
2	X ray room	1	0.3
3	Theater room	1	2
4	Female ward	12	6.3
5	Male ward	9	3.6
6	Maternity	2	4
7	Laboratory	1	4.7
8	Consultation room	1	0.5
	Total	30	21.8
Quantity of HCW per bed per day = $\frac{Total\ Quantity\ of\ HCW}{Number\ of\ Bed} = \frac{21.8}{30} = 0.7$ kg			

The average waste generated per day and kg/bed/day for all sampled Hospitals is summarised in Table 12. The average waste generation rate in all the sampled hospitals is 32.6 kg/day and 0.6 kg/bed/day. This rate is lower than 0.934 kg/bed/day reported in Sylhet City (Bangladesh), 1.2 kg/bed/day in Dhaka (Bangladesh), 4.5 kg/bed/day in USA, and 2.5 kg/bed/day in France (Rahman *et al.*, 1999), but consistent with a study on medical waste generation of 0.573 kg/bed/day in Lagos (Longe and Williams, 2006). This can be attributed to variations in geographical location, living habits and standards, accessibility of different treatment facilities, and perhaps the ways in which solid wastes are categorized in different countries. Jang (2011) added that geographic location, the amount of disposable or reusable medical devices and the degree of regulation enforcement at national and local levels also influence generation rate of medical waste. Nemathaga *et al.* (2008) reported that the clinical waste generation rate for more-developed countries is

generally higher than what is generated in less-developed countries. Canada and USA were reported to have a high generation rate that ranges from 4.3-5.8 kg per bed per day.

Table 12: Mean quantity of healthcare waste generated in sampled hospitals

S/N	Hospitals / Clinics	Category of hospitals	Number of bed	Average HCW generated per day (kg)	HCW generated kg/day/bed
1	I	Private	10	8.8	0.9
2	C	Public	28	15.2	0.5
3	F	Private	15	8.5	0.6
4	G	Private	26	14.9	0.6
5	J	Private	30	21.8	0.7
6	H	Private	3	3.6	1.2
7	A	Public	364	200.8	0.6
8	D	Public	15	11.1	0.7
9	E	Public	14	10.7	0.8
10	B	Public	54	30.4	0.56

Mean of quantity of healthcare Waste: 32.6 kg/day and 0.6 kg/bed/day

4. CONCLUSION

It is concluded that the most significant factors associated to quantity of medical waste were type and size of the healthcare facility, number of patients who visit the healthcare facility and the type of services provided by the facilities. Also, waste in most of the surveyed hospital were not measured and documented. Therefore, the study recommends that proper documentation on quantity of medical waste generated per day/week/month/year should be done in order to serve as guide for effective and efficient medical waste planning. Health facilities should make sure that collected medical wastes within their environment of work are properly segregated before disposal to reduce nosocomial infections and other risks to human health and environment.

5. ETHICAL CONSIDERATION AND PARTICIPANTS CONSENT

Ethical approval for this study was obtained from Bauchi State Ministry of Health and the Bauchi State health research Ethics Committee (BASHREC). The procedures were explained to the participants and then their permission to participate in the study was obtained. The participants that declined being part of the study were excluded. Confidentiality was ensured by excluding all the names of the sampled hospitals.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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