Chapter 9

Characterisation of Dental Waste in Tertiary Dental Hospitals: A Third World Example

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Additional information is available at the end of the chapter

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1. Introduction

Dental (Medical) waste has been defined as all wastes generated from health care or health related facilities. The waste generated from the dental hospital are of various materials, sizes, shades and shapes and are therefore regarded as heterogeneous [1]. There are dental liquid wastes such as X-ray (developer and fixer) wastes and other chemicals and drugs generated within the dental or medical facilities in general. The waste can also be in form of solid generated from the diagnosis, investigations and treatment of human beings and or in animal trials [2,3]. The solid waste generated from the dental hospital can be broadly categorised into two, namely; infectious and non-infectious wastes. The mode of treatment of these waste differ sharply for the safety of man and his environment. Generators of medical/dental wastes are defined as those producing more than 23 kg of regulated medical/dental waste per month [4]. For generators who manage their waste by shipping to offsite disposal facilities, they are supposed to separate, package, label, mark, and track the waste according to regulations [2, 5]. In Nigeria, generators have, for long time, assumed treatment methods based on techniques suitable for treatment of municipal solid waste.

Infectious wastes include blood on swabs or dressings and used sharps (needles, probes, endodontic reamers and files etc.) are considered non-hazardous waste. This can be mixed with routine rubbish if such are properly treated to become non-infectious. Any untreated waste should be properly labelled and handled by a waste hauler [6]. Contaminated sharps must be placed in a puncture-resistant rigid container and treated prior to disposal. It is also must be submitted that untreated containers of sharps cannot be compacted.

Dental waste can lead to infection and or transmission of infectious diseases. This is done because of the micro-organisms content namely bacteria, fungi and viruses. These micro-organisms can cause disease or mirage of health related conditions [7]. The level of infectiousness of any agent will grossly depend on the dose of micro-organism introduced in to the body, portal of entry (intravenous, aerosol, oral-faecal etc.), virulence factor of the micro-organism (production of enzymes, waste products and other toxins capable of damaging host tissues) and the state of host immune resistance. The quantity of infectious waste generated in health care facility is in the range of 10 to 25% of the total generation [8, 9, 10, 11].

Dental waste has been demonstrated to contribute significantly to pollution of the environment if poorly treated [12] and that it can lead to cross-infection risks [13] such as deadly HIV and Hepatitis among others [14]. Heavy metals such as Chromium, Cadmium and Amalgam are frequently generated from the dental hospitals and are known to be hazardous. These metals have been known to cause diseases in humans such as liver, kidney and respiratory damage by Chromium while cadmium may cause kidney disorders and lung cancer [15].

Dental treatment involves the use of consumables such as gloves, face masks, rubber dams, protective cellophane and other chlorine containing items which are disposed off by incineration. The process of incineration leads to release of dioxin, Hydrogen Chloride (HCl) and Chlorofluorocarbon (CFC) which has been implicated in reproductive defects, neurological problems, cancer formation, hormonal and immune disorders [16]. Also, food remains and glass wares should be sort out of dental waste because they adversely affect the performance of incinerator. Although, dental waste do not generally contain food remains to any large extent as this is not a common practice within the clinics, but more of plastics (Polyvinyl Chloride PVC, Polyethylene, (PE), polypropylene (PPE). This can be mixed with routine rubbish if such are properly treated to become non-infectious. Any untreated waste should be properly labelled and handled by a waste hauler [6]. Contaminated sharps must be placed in a puncture-resistant rigid container and treated prior to disposal.

The proper and standardized management of dental waste will assist in controlling health risks among humans and safe environment. These are the main reasons for proper managing of dental waste.i.e. to render such non-infectious /hazardous. It is the sole responsibility of generators of (dental) waste to dispose them adequately and so it is for the handlers as well. The standard practice for dental waste are: designation and identification, segregation, packaging, storage, transport and handling, treatment techniques, disposal of treated waste, contingency planning and continued staff training [2,17]. The cost of mishandling of dental waste is another question that must be answered by dental waste generator. Their goal would be to minimize such cost to the lowest possible.

There is a sharp difference in the way dental waste should be handled compared with that of Municipal waste. The traditional way of handling Municipal waste are such as landfilling, composting, recycle and waste-to-energy technologies (WTE); but these cannot be applied directly to dental waste except recycling and WTE system. Dental waste will require special treatment due to infectious nature and common incineration (as is the case with municipal wastes). This cannot be performed except staff of such device are properly trained. During the process of incineration, dioxins and furans can be controlled or reduced by the incineration

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temperature. However, under start-up conditions, dioxins and furans can be stopped from entering the atmosphere by use of wet scrubbers [4]. Dental wastes consist of extracted teeth and other human parts which are usually loaded with micro-organisms and hence Dental waste must be rendered non-infectious before disposal which is regarded as the process of waste treatment. If this is not achieved the dispersal of dangerous infectious materials will ensue. Waste treatment is determined by waste type and the type of treatment appropriate for it. Incineration is just appropriate for dental waste. The volume and weight of incinerated dental waste is reduced to above 90% making the eventual disposal of a less problem when compared with other methods. Incineration is the best technology to date yet it has its own short comings such as high capital and running cost, operating charges, sterilisation efficacy, maintenance and operator skills, control of air and water emissions. Lastly, it cannot take care of radioactive materials from X-ray rooms. Management of dental waste can be done by treatment first, recovery of useful materials such as Mercury, Silver and other metals, modification of characteristics of the waste, making exposure free of harm and environmental friendly. Basically there are two types of incineration namely large and small scale systems. The large scale systems utilises any of the followings: fluidized bed combustors [18], starved and excess air incineration and rotary kilns; while the small scale systems uses chambers which can be single or double chambers. Incineration can be used to heat water for the use of both the patients and hospital. Dental local anaesthetic cartridges, ampoules, glass wares that are not combustible can be treated with steam autoclaving, microwave irradiation, chemical treatment and radiofrequency irradiation [2].

Van Veen [5] was of the opinion that medical waste must be monitored so that the where about of such is known at all times, this can be achieved by proper controls put in place. The control can be done through policy and adequate empowerment for the policy to work. Only by this, will our environment be free and fear of harm from medical wastes. At this point, little is known about policy and implementation of medical waste in Nigeria as compared to that of advanced countries. Even if the policy is there little is known about the implementation and it's monitoring. "Regulation myopia" which means failure to look beyond the immediate issue to see the full effects of the regulatory actions [4] must be avoided when policy on waste management are put in operation. There are various current ways to manage dental waste, this include reduction of waste generated, this is done by eliminating or substituting substances that increase or expose individuals to health risks e.g. use of digital X-rays compared to the conventional film, developer/fixer combination [12]. Another way is to segregate and recycle useful materials from the dental waste such as mercury from amalgam, Silver from fixer/developer. Noncombustible items in dental waste should not be fed into incinerators and waste-to-energy system (WTE). This is because they give rise to continuous smoke which will hinder complete combustion of the waste components. To recycle dental hospital waste poses some challenges of harm to handlers of such unlike the municipal waste. This is why dental (like the medical) recyclables are highly discriminated at [4]. Hence there is a need to prove to the general recycling market that dental waste has great prospect.

Previous studies in Africa have reported non-conformity to standard ways of disposing of dental (medical) waste [19,3,13,12]. The majority of studies carried out on dental waste centred

on knowledge, attitude and practice of Dental Health Care Workers [19], infection control [20, 21], composition of dental waste [22] and management of mercury and dental amalgam [23]. This study therefore aims at sorting, characterizing and quantifying wastes generated in selected eight clinics of a Dental Hospital in third world nation. This is with a view to providing information on waste classification in dental hospitals in developing nations. It is expected that such information will aid sustainable dental waste disposal in the study area and beyond.

2. Materials and methods

Waste generation and management were monitored daily for a month at the eight dental clinics of Obafemi Awolowo University (OAU), Ile-Ife, Nigeria. The choice of dental Hospital OAU Ile-Ife for this study is influenced by some factors. First, it serves as the referral centre for dental patients from Osun, Ekiti, Ondo and part of Kwara states, in southern part of Nigeria. Other dental tertiary hospitals in the region lack such regional coverage. In addition, it's the only one located in the sub-urban area peculiar to the third world environment.

Wastes at the source were characterised, classified by the authors into the two main categories by weight and by volume infectious and non-infectious. Waste collection polythene bags were placed in each of the two waste baskets (one for infectious and the other for non-infectious) in all the eight clinics and the X-ray room of Obafemi Awolowo University Dental Hospital for collection of waste from each unit. On many occasions there was a necessity for sorting of the wastes into the two categories. The sorting was done with the use of disposable gloves and facemasks and duck lip forceps by the authors, this sorting method was similar to that used by [13]. Measurement of solid wastes was carried out using a weighing scale of sensitivity of 0.01g weight. The breath, height and length of the tied solid waste inside waste disposal bags were measured in metres. The measurement was done by the principal investigator and two other assistants at the close of each clinic day and before the waste were carried away by haulers. Statistical information on the waste generations and classifications were determined through number of patients and measurement of necessary parameters.

2.1. Results and discussion

Results from study are discussed in the following categories: characterisation, generation and application of the results.

Characterisation: It is well known that the wastes generated from the treatment of patients suffering from infectious diseases may spread infection either through direct contact or indirectly through the environment. In Nigeria the management of these infectious waste materials is regulated under Decree 42 of November 1998 [2]. It was reported that injections undertaken with contaminated syringes caused about 23 million infections of Hepatitis B, Hepatitis B and HIV worldwide [2]. Report from Tanzania, was that during immunization campaigns the medical waste management staff needs to take an extra care and the wastes generated during such campaigns have different classes depending on the mode of classification [1]. The classification of sharps and softs on weight and volume bases shows that sharps

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are still a small portion of the waste, which requires special care compared to the softs [2]. Tables 1 and 2 show the typical waste composition from the clinics and the characterisation of the waste studied based on the weight and volume, respectively.

Clinic	Mass of the waste per patient (g)				Volume of the waste per patient (cm^3)				Density of the waste per patient (g/cm^3)			
	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation	Mean
Oral Diagnosis	119.50	1.00	30.33	22.39	20254.00	6.00	4468.57	1568.72	0.1667	0.0005	0.0506	0.0213
Conservative	113.00	0.00	34.21	29.53	3300.00	0.00	947.21	728.26	2.0000	0.0000	0.4444	0.1149
Periodontology	104.00	0.20	28.44	43.33	4620.00	1.20	1081.25	1266.42	0.0355	0.0012	0.0109	0.0131
Paedodontics	173.33	0.00	48.07	51.35	9240.00	0.00	2389.19	1774.59	0.0833	0.0000	0.0233	0.0183
Orthodontics	64.86	0.00	20.44	33.63	3736.86	0.00	890.76	956.82	0.0833	0.0000	0.0252	0.0190
X-RAY	129.00	0.00	29.94	18.69	2372.53	0.00	553.05	423.47	0.1128	0.0000	0.0338	0.0163
Prosthetics	150.00	0.00	45.91	52.28	6562.50	0.00	1499.00	1000.76	3.0588	0.0000	0.6782	0.1804
Oral Surgery	112.00	0.00	24.13	32.55	3480.00	0.00	996.21	1043.18	6.2381	0.0000	1.3919	0.3255

Table 1. Statistical information on infectious waste generation

Clinic	Mass of the waste per patient (g)				Volume of the waste per patient (cm^3)				Density of the waste per patient (g/cm^3)			
	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation	Mean	Maximum	Minimum	Standard Deviation	Mean
Oral Diagnosis	72.50	0.00	15.72	7.15	7245.00	0.00	1589.82	593.73	0.166667	0.000000	0.050847	0.018091
Conservative	40.00	0.00	12.27	16.11	3045.00	0.00	870.46	832.61	2.750000	0.000000	0.612814	0.148557
Periodontology	47.50	0.01	13.77	21.37	6375.00	1.20	1548.16	1915.26	0.033333	0.000654	0.009942	0.007505
Paedodontics	50.00	0.01	15.34	25.39	7245.00	3.00	2016.11	2529.82	0.083333	0.000700	0.024514	0.013248
Orthodontics	68.00	0.01	18.26	25.49	10657.50	3.00	2541.14	2627.27	0.083333	0.001308	0.024607	0.011846
X-RAY	120.00	0.00	27.20	13.59	3990.00	0.00	1030.05	616.96	0.083333	0.000000	0.025575	0.011189
Prosthetics	110.00	0.00	25.19	13.39	2800.00	0.00	830.34	546.47	2.291667	0.000000	0.509659	0.129943
Oral Surgery	62.00	0.00	17.05	17.34	4914.00	0.00	1087.43	1105.23	0.083333	0.000000	0.025008	0.010657

Table 2. Statistical information on non- infectious waste generation

The Oral surgery clinic was the highest generator of infectious waste (density= 1.392) while Prosthetic clinic was in the same category for non-infectious waste (density=0.130). The amount of waste generated from the Oral Surgery clinic was not unexpected in view of the procedures involved in tooth extraction, biopsies and other surgery routines. From the tables it can be seen that waste generation and characterisation are functions of clinics and number of patients. Table 3 presents statistical data on the patients per clinic.

Clinic	Oral Diagnosis	Conservative	Periodontology	Paedodontics	Orthodontics	X-RAY	Prosthetics	Oral Surgery
Maximum (Number of patients)	30	24	25	10	10	31	25	18
Minimum (Number of patients)	1	0	1	1	2	0	0	0
Standard Deviation	8.48	7.10	5.33	2.45	2.58	10.73	5.93	5.55
Mean	12.4	7.4	6.1	3.9	4.35	11.7	5.55	8.9

Table 3. Statistical data on the patients

From the tables maximum waste per patient for infectious waste was 173.33g/ day and maximum volume per patient was 20254.00 cm^3 / day. For non-infectious waste maximum mass per patient is 120.00 g/day and volume per patient is 10657.50 cm^3 with maximum patient per clinic of 31 per day. The dental wastes are managed as the municipal wastes in the present study similar to the findings of [1,12] which was contrary to international standard practice.

Application of the results: The current waste management techniques consist of generation, storage, transporting and final disposal, which indicates that there is a need of having treatment facilities for infectious and non- infectious wastes individually. For infectious waste proposed waste treatment period is weekly (5 working days in a week) using locally developed facilities as Figure 1, 2 or Figure 3.

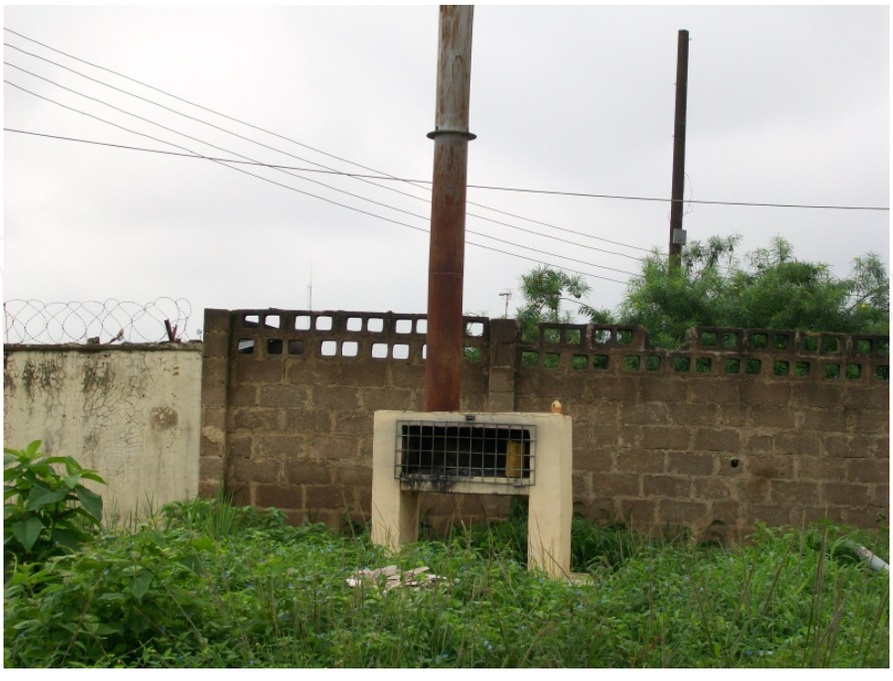

Figure 1. Locally developed incinerator using concrete

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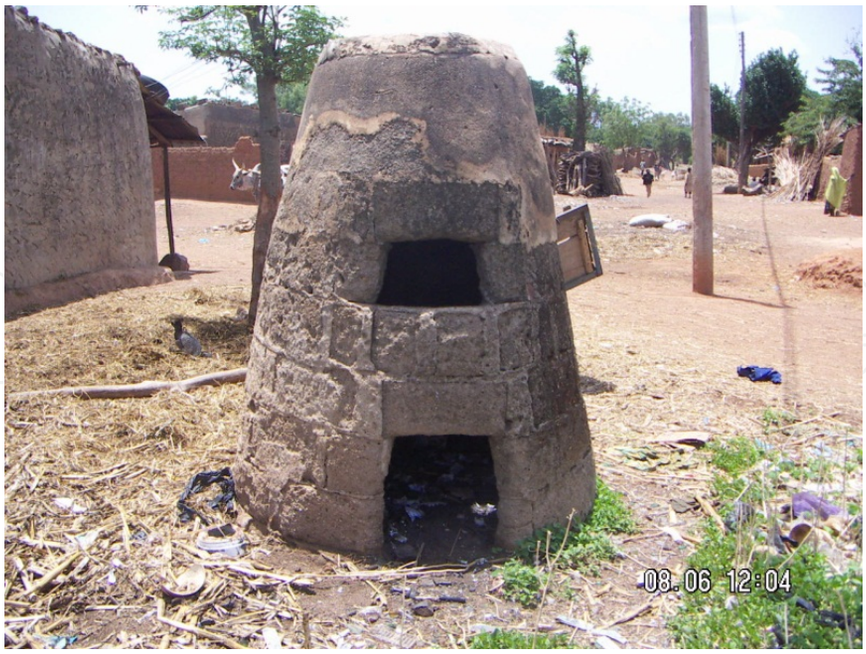

Figure 2. Locally developed incinerator using sandcrete

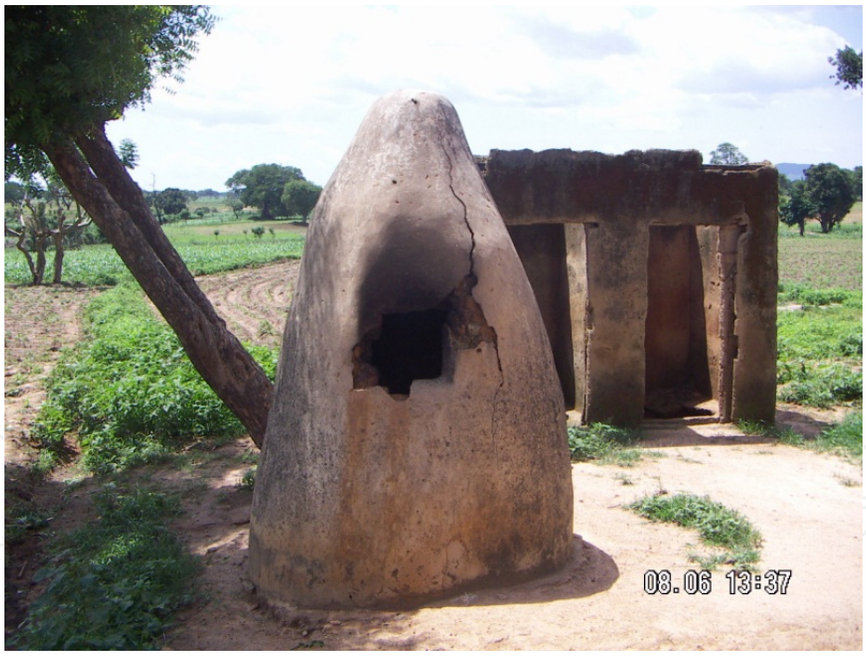

Figure 3. Locally developed incinerator using mud blocks

The expected volume is 3.14 m^3 (20254 x 5 x 31 cm^3). The expected volume for non-infectious waste is 3.3 m^3 (10657.50 x 10 x 31 cm^3). The non-infectious waste should be disposed twice in a month (10 working days). From these calculations, the provision of 3.5 m^3 or above of locally developed incinerators will help in dental waste treatment technique.

2.2. Medical waste elsewhere in nigeria

Waste generation and characterization in Ibadan: Coker et al [13] reported that the nature and amount of healthcare waste (HCW) generated in the various Health Care Facilities (HCFs) is presented in Table 4.

MW Component	Generated waste in each HCFs category (kg/d)					
	Tertiary (n= 1)	Secondary (n= 19)	Primary (n= 1)	Diagnostic (n= 9)	Total wastes for all surveyed HCFs	Percentage of total waste (%)
Human anatomical part	766.5	6279.3	1693.6	-	8739.4	4.0
Plastic, PVC, syringes	1412.6	40233.4	1109.5	1461.2	44216.7	20.1
Swabs, absorbents	36.5	8509.4	9820.7	613.6	18980.2	8.6
Alcohol, disinfectant	-	2094.0	57.9	-	2151.9	0.9
Animal infected anatomical	-	1232.9	-	-	1232.9	0.6
Glass	203.7	54202.5	3082.6	10.5	57599.3	26.1
Bedding, shavings, paper, faecal matter	10.9	9224.5	973.6	0.32	10209.3	4.6
Gauze pads, garments, cellulose	98.6	39109.3	2892.3	-	42100.2	19.1
Sharps, needles	30.3	24551.0	269.9	0.41	14851.6	11.3
Fluids, residues	-	1002.5	1232.1	0.41	2235.0	1.0
Infectious wastes	20.1	8085.6	52	2.0	8112.9	3.7
Daily total generation (kg/d)	2579	194524	21137	2088	220329	100
Generation / facility (kg/d)	2579	10238	919	232		

Source: Coker et al., 2009

Table 4. Nature and mean generation rate of medical waste (MW) in various HCFs surveyed in Ibadan, Nigeria (on a weight/ facility basis.

The bulk (39%) of total solid medical waste materials comprise of plastics, PVC, syringes, gauze pads, garments, and cellulose. Other main solid medical wastes were sharps and needles (11.3%), swabs and absorbents (8.6%), and beddings, shavings, paper and faecal matter (4.6%). Overall, infectious wastes constituted only 3.7% of total waste. A similar study by [24] in Bangladesh reported 10.5% infectious waste. With the exception of the tertiary HCFs, there was no proper segregation in most HCFs. In fact, the study team had to implement waste sorting and segregation at source by providing coded separate receptacles for each identified components of waste. Previously, waste which otherwise could have been handled and disposed as household waste, would end up being mixed together with HCW, thus increasing the amount of waste regarded as medical waste. This supports the argument that waste segregation does reduce waste volumes. It was opined that only waste capable of initiating infectious diseases should be considered infectious, such that the presence and virulence of

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pathogens, entry portal and host susceptibility should be overriding considerations when estimating risk [25]. Their study (at the University Hospital Freiburg, Germany) revealed that up to 70% of the content of infectious waste consisted of household waste (such as journals, newspapers; packaging, paper, and glass) without risk for infection.

In Ibadan, the non-sorting approach at many HCFs causes contamination of materials with blood, which promotes unnecessary waste items in the waste stream. In this case, many benefits would accrue (both environmental and financial) if some materials were reprocessed and reused without risking patient health. The peak average rate of waste generation/facility was from the secondary HCFs whose value of 10,238 kg/d was almost quadruple of the tertiary HCF, ≈11 times the primary HCFs and≈ 25 times the 232 kg/d rate of diagnostic centres (Table 4). Similarly, in Karachi, Pakistan, another developing nation, secondary HCFs generate more solid medical waste than other HCFs [26]. Indeed, secondary HCFs have greater patronage of patients than any other kind in Ibadan. In such HCFs, the management allows home-cooked food and other essentials to be brought-in for patients. Thus, general household waste all too easily becomes mixed with medical waste destined for the waste stream. Waste sorting and segregation, practiced at the tertiary HCF, has aided substantial reductions in what would otherwise eventually end up in the waste stream. This is because pro-active recycling of some materials is employed. Unlike elsewhere in Ibadan, the hospital (UCH) is known to uniquely follow standard international practices of patient care and hygiene. However, treatment costs at UCH, which are beyond the reach of many patients, have forced many people to patronize secondary HCFs. The declining patronage of UCH seems intrinsically linked with government expenditure reductions on health-related programmes. For instance, percentage of government expenditure spent on healthcare dropped from 33.5% in 2000 to 25.6% in 2002, with private sector expenditure accounting for the other 66.5% and 74.4%, respectively [27]. However, as with other nations, the private sector is profit-driven. Meanwhile, the primary HCFs chiefly attend to outpatients and, as such, have a much-reduced generation/facility rate. However, that said, diagnostic laboratories have the least amount of waste generation because patients mostly come to drop-off specimens.

In Lagos metropolis (Nigeria) medical waste generation in selected hospital are as presented in Tables 5 and 6. From the tables, medical waste generation in surveyed hospitals (kg/ bed. day) and the total waste generation (kg/day) can be obtained.

Designation	Hospital Type	Number of beds	Total waste generated (kg/day)	Waste generated rate (kg/bed/day)
A	Private	40	22.5	0.563
B	Private	50	28.1	0.562
C	Public	600	399.6	0.666
D	Public	378	161.3	0.427
Total		1068	611.5	0.573
Average rate = 0.573 kg/bed/day (Source: Longe and Williams, 2006)				

Table 5. Medical waste generation in selected hospital in Lagos, Nigeria

Waste category	Hospital A (Private 1)	Hospital B (Private 2)	Hospital C (Public 1)	Hospital D (Public 2)	Average
Regulated waste	51	66	50	50	54
Infectious	34	19	37	37	32
Sharps/Pathological	11	10	10	10	10
Chemical	2	4	3	3	3
Others	2	1	-	-	1
Total	100	100	100	100	100

Source: Longe and Williams, 2006

Table 6. Composition of medical waste generation in selected hospital in Lagos, Nigeria

It was discovered that most hospitals had no record of the volume of waste being generated by them. The amount of wastes generated is easily expressed in volume as most storage facilities are in litres aside those at depot centres [28]. Medical waste generation rates ranged between 0.427 and 0.666 kg / bed. day was obtained. The total volume of medical waste generated in all the hospital was 611.5 kg/day. This translates to 17.19 kg/bed month and calculated total waste volume of 18345.00 kg/ month by all hospitals. Out of this infectious waste was 5, 870.4kg/month, sharps, 1845 kg/month and chemical waste 550.35 kg/ month. Regulated domestic waste constitutes 54% of the total medical waste stream. Another noticeable inference is that the proportion of medical waste from the two public hospitals was more than 91% of the total volume of waste stream. The percentages by weight of infectious waste generated by these hospitals are also of higher magnitudes compared with others. The only explanation for this has to do with the number of available medical services and facilities in the two public hospitals [28]. Based on the data from [29] presented in Table 7(a) and 7(b), it was discovered that 65% of hospitals/clinics do not segregate waste generated in their clinics.

Serial Number	Name of hospital and clinics in Akure	Number of beds	General	Infectious	Hazardous
1	State Specialist Hospital	110	13.055	3.48	0.87
2	Optimum clinic	8	4.2	1.12	0.28
3	City Hosiptal	8	3.6	0.96	0.24
4	Royal Medical Centre	6	2.55	0.68	0.17
5	Don Bosco Health Centre	4	2.775	0.74	0.185
6	St John and Mary Hospital	10	7.65	2.04	0.51
7	Sijuwade Specialist Hospital	12	3.975	1.06	0.265
8	St Michael Hospital Pol. HQ	10	3.975	1.06	0.265
9	Banjo Memorial Hospital	30	2.45	0.66	0.165
10	Adetade Hospital Ondo Rd	10	1.875	0.5	0.125
11	First Mercy Hospital Gbogi	42	14.071	3.92	0.98

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12	FUTA Gate Clinic	4	4.05	1.08	0.27
13	Oludare Hospital Fanibi	12	11.755	3.14	0.785
14	Abitoye Hospital Ijapo	22	2.926	0.78	0.195
15	University Health Centre	6	4.5	1.2	0.30
16	Faith Clinic Oke Aro	6	1.95	0.52	0.13
17	Abitoye Hospital, Ijoka	15	0.75	2.6	0.65
18	Crown Hospital	17	10.725	2.86	0.715
19	Hope Hospital Ijoka	6	3.225	0.86	0.25
20	Momaak Specialist Hospital	10	4.65	1.24	0.31

(a)

Serial Number	Name of hospital and clinics in Akure	Total waste/day (kg)	Daily waste generation (kg/day)		
			General (75%)	Infectious (20%)	Hazardous (5%)
1	State Specialist Hospital	17.4	13.05	3.44	0.87
2	Optimum clinic	5.6	4.2	1.12	0.28
3	City Hosiptal	4.8	3.6	0.96	0.24
4	Royal Medical Centre	3.7	2.78	0.74	0.18
5	Don Bosco Health Centre	3.4	2.55	0.68	0.17
6	St John and Mary Hospital	10.2	7.65	2.04	0.51
7	Sijuwade Specialist Hospital	6.6	4.95	1.32	0.33
8	St Michael Hospital Pol. HQ	5.3	3.975	1.05	0.265
9	Banjo Memorial Hospital	3.3	2.475	0.66	0.165
10	Adetade Hospital Ondo Rd	2.5	1.875	0.5	0.125
11	First Mercy Hospital Gbogi	19.61	14.708	3.922	0.981
12	FUTA Gate Clinic	5.4	4.05	1.08	0.27
13	Oludare Hospital Fanibi	15.7	11.775	3.14	0.785
14	Abitoye Hospital Ijapo	3.9	2.925	0.78	0.198
15	University Health Centre	6.0	4.5	1.2	0.3
16	Faith Clinic Oke Aro	2.6	1.95	0.52	0.13
17	Abitoye Hospital, Ijoka	13.0	9.75	2.6	0.65
18	Crown Hospital	14.3	10.725	2.86	0.715
19	Hope Hospital Ijoka	4.3	3.225	0.86	0.215
20	Momaak Specialist Hospital	6.2	4.65	1.24	0.31

(b)

Source: Babatola (2008)

Table 7. (a): Daily Waste Generation (kg/day) and the Numbers of Beds in Each Hospitals/Clinics (b): Waste Generation by Waste type

However, 30% do segregate infectious waste as recorded. Waste segregation is the only key step to hospital waste management. Unlike in other developing countries, waste segregation is virtually not being carried out in Nigeria. The present study also confirms this. The composition study is based on field sorting events around hospitals/clinics in Akure main town. The waste samples were analysed and survey.

It is apparent that average waste generation rate per bed per day was 2.782 kg/bed/day. Generation rate (Total weight) per health institution is as follows: National Hospital, 3.59kg; Garki General Hospital, 2.86kg; Wuse General Hospital, 2.50kg; International Diagnostic Centre, 1.98kg and National Institute for Pharmaceutical Research and Development, 2.18kg. Non– hazardous waste ranged from 1.48kg/bed/day at International Diagnostic Centre (IDC) to 3.14kg/bed/day at National Hospital, while hazardous waste ranged from 0.15kg at National institute for pharmaceutical research and development to 0.50kg/bed/day at IDC. The average of hazardous and non-hazardous waste generated from the five health care institutions amounted to 0.346kg and 2.276kg respectively. There was a significant variation in the volume of hazardous and non-hazardous wastes generated at P=0.05. General waste had a mean percentage of 73.5%; infectious waste (spent cultures/swabs/cotton wool), 19.5% and paper/cellulose 2.5%, Sharps (needles, blades, syringes, scalpel, broken glass, and nails), 4.5%. Figures showing variation in the volume of waste generated from each health care institution and solid wastes generation rate per kg/bed/day from the five selected institutions in the Federal Capital Territory, Abuja are presented on Table 8 [30]. Results obtained from investigation on generation rate per/bed/day are presented on Table 9 [30].

Institutions	Generation rate kg/ bed/ day (%)		
	Non-Hazardous	Hazardous	Total
National Hospital (NHA)	3.14 (87)	0.45 (13)	3.59
Garki Gen. Hospital (GGH)	2.45 (85)	0.41 (15)	2.86
Wuse Gen. Hospital (WGH)	2.28 (91)	0.22 (09)	2.50
International Diagnostic Centre (IDC)	1.48 (75)	0.50 (25)	1.98
Nat. Inst. Pharm. Res. & Dev. (NIPRD)	2.03 (93)	0.15 (07)	2.18
Total	11.28	1.73	13.91
Average	2.276	0.346	2.782

Source: Bassey et al., (2006)

Table 8. Solid waste generated from selected health care institutions in the Federal Capital Territory, Abuja

http://dx.doi.org/10.5772/53194

Ward/ Unit	Garki Gen. Hospital (GGH)	National Hospital (NHA)	Wuse Gen. Hospital (WGH)	Nat. Inst. Pharm. Res. & Dev. (NIPRD)	International Diagnostic Centre (IDC)
Out patient	0.68	0.88	0.23	-	0.13
Female medical	1.84	1.37	1.24	-	0.80
Male medical	1.00	0.88	0.90	-	0.14
Dressing Room	0.83	0.64	0.34	-	0.33
Male Surgical	0.97	0.82	2.90	-	0.42
Female Surgical	1.02	0.79	1.33	-	0.81
Theater	1.89	0.94	2.07	-	1.32
Post natal	3.11	3.35	2.81	-	2.03
Neo natal	2.33	2.71	2.00	-	1.88
Eye clinic	0.21	0.11	-	-	-
ENT	0.08	0.18	-	-	-
Physiotherapy	-	0.22	-	-	-
Psychiatric	-	-	-	-	-
Orthopaedic	-	1.28	-	-	-
Laboratory	2.51	1.89	3.01	-	1.93
Pharmacy	0.69	0.43	0.85	-	0.83
Casualty / Emergency	0.33	0.41	0.66	-	0.14
Labour Room	2.59	4.08	5.67	-	3.03
Ante-natal	0.18	0.10	-	-	0.14
Pharmacology	-	-	-	5.03	-
Microbiology	-	-	-	1.14	-
Diagnostic	-	-	-	1.32	-
Biochemistry	-	-	-	1.67	-
Average	1.261	1.151	1.862	2.290	1.053

[1]A plot is equal to 25m x 50 m

Source: Bassey et al., (2006)

Table 9. Ward/Unit wise distribution of wastes generated in kg/bed/day

In Garki General Hospital generation rate ranges from 0.08kg/bed/day in Ear Nose and throat (ENT) unit to 3.11kg/bed/day in post natal unit. In the National Institute for Pharmaceutical Research and Development, Idu, waste generation rate ranges from 1.14kg in microbiology

unit to 5.03kg in the Pharmacology unit. Generation rate in National Hospital ranges from 0.10kg/ bed/day in antenatal unit to 4.08kg/bed/day in the labour ward. In Wuse General Hospital generation rate ranges from 0.23kg/bed/day in the outpatient unit to 5.67kg/ bed/day in the labour unit. At the International diagnostic centre generation rate ranges from 0.13kg/bed/day in outpatient unit to 3.03kg/bed/day in the labour ward.

Tables 10 to 13 present composition of the waste into: generated per department (Table 11), infectious and non-infectious (Table 12) and combustible and non- combustible (Table 13). Table 11 shows generation of waste from the selected hospitals. From the table the waste generated by these hospitals ranged from 1.16 to 1.95 kg/bed.day with overall mean of 1.49 kg/bed. day with standard deviation of 0.235.

Hospitals	Locations as per Residential area	Size (plot[1] of land)	Outpatient section	Wards, inpatient, Nursing section	Medical records	Laboratory/ pathology section	Waste Transport section	Pharmacy/ administration section	Radiography (X-ray, ultra sound etc)	Environmental section	Consulting rooms	Emergency ward	Nature of the premises
A	Low dense	8	Present	Present	Present	Absent	Absent	Present	Present	Absent	Present	Present	Fenced
B	Residential area	>10	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Fenced
C	Medium dense	2	Present	Present	Present	Present	Absent	Present	Absent	Absent	Present	Absent	Fenced
D	Residential area	2	Present	Present	Present	Absent	Absent	Present	Absent	Absent	Present	Absent	Fenced
E	Residential area	8	Present	Present	Present	Absent	Absent	Present	Absent	Absent	Present	Absent	Fenced
F	Residential area	2	Present	Present	Present	Absent	Absent	Present	Present	Absent	Present	Absent	Fenced
G	Residential area	3	Present	Present	Present	Absent	Absent	Present	Absent	Absent	Present	Absent	Fenced
H	Low dense	2	Present	Present	Present	Absent	Absent	Present	Absent	Absent	Present	Absent	Fenced
I	Residential area	2	Present	Present	Present	Present	Absent	Present	Absent	Absent	Present	Absent	Fenced
J	Dense	3	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Not Fenced

[2]Some of the patients transport their waste directly to the final disposal unit

[3]Specialist hospitals with clinics on Mondays and Thursdays

(source: Oke et al., 2011)

Table 10. Classification and characteristics of the selected hospitals

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These results were similar to results obtained in literature but have different magnitude. Tables 14 showed on average basis, infectious waste was 79.4 kg and 0.053 m^3 by weight and volume, respectively, while non-infectious waste was 34.1 kg and 0.073 m^3 by weight and volume, respectively. This indicates that 0.077 x 44 (3.388) m^3 and 0.053 x 44 (2.332) m^3 of non-infectious and infectious, respectively, were generated during each of the EPI campaigns in Kano state [3].

Hospitals	Outpatient Department (kg/day)	Wards, inpatient, Nursing Department (kg/day)	Medical records (kg/day)	Laboratory/ pathology Department (kg/day)	Waste Transport Department (kg/day)	Pharmacy/ administration Department (kg/day)	Radiography (X-ray, ultra sound etc) Department (kg/day)	Environmental Department (kg/day)	Consulting rooms (kg/day)	Emergency Department (kg/day)	Total weight (kg/day)	Total waste generated (kg/bed. day)
A	2.2	8.5	2.5	-	-	4.7	3.0	-	2.7	2.5	26.0	1.73
B[1]	4.4	16.9	4.9	4.4	4.4	9.4	5.9	4.4	5.4	5.1	65.1	1.45
C	1.7	6.8	2.0	1.7	-	3.7	-	-	2.2	-	18.2	1.30
D[2]	2.2	8.5	2.5	-	-	4.7	-	-	2.7	-	20.5	1.33
E[3]	2.6	10.2	3.0	-	-	5.6	-	-	3.3	-	24.6	1.76
F[3]	1.6	6.1	1.8	-	-	3.4	2.1	-	2.0	-	16.9	1.41
G	2.1	8.1	2.4	-	-	4.5	-	-	2.6	-	19.7	1.52
H	1.8	7.1	2.1	-	-	3.9	-	-	2.3	-	17.2	1.32
I	1.7	6.8	2.0	1.7	-	1.9	-	-	2.2	-	16.3	1.16
J	3.9	15.2	4.4	3.9	3.9	8.4	5.3	3.9	4.9	4.6	58.6	1.95

(source: Oke et al., 2011)

Table 11. Generation of solid waste from selected hospitals

Hospitals	Characteristics of the wastes	Outpatient Department (kg/day)	Wards, inpatient, Nursing Department (kg/day)	Medical records (kg/day)	Laboratory/pathology Department (kg/day)	Waste Transport Department (kg/day)	Pharmacy/administration Department (kg/day)	Radiography (X-ray, ultra sound etc) Department (kg/day)	Environmental Department (kg/day)	Consulting rooms (kg/day)	Emergency Department (kg/day)	Total weight (kg/day) (%)
A	IFW	0.1	0.4	-	-	-	3.0	2.5	-	-	2.5	8.5 (32.7)
	NIFW	2.1	8.1	2.5	-	-	1.7	0.4	-	2.7	0.1	17.5 (67.7)
B	IFW	0.2	0.8	-	3.8	0.2	6.0	5.0	0.2	-	4.9	21.2 (32.7)
	NIFW	4.2	16.1	4.9	0.6	4.2	3.3	0.9	4.2	5.4	0.2	43.9 (67.3)
C	IFW	0.1	0.3	-	1.5	-	2.6	-	-	-	-	4.5 (24.9)
	NIFW	1.7	6.5	2.0	0.2	-	1.2	-	-	2.2	-	13.6 (76.1)
D	IFW	0.1	0.4	-	-	-	3.2	-	-	-	-	3.7 (19.1)
	NIFW	2.1	8.1	2.5	-	-	1.5	-	-	2.7	-	16.8 (80.9)
E	IFW	0.1	0.6	-	-	-	4.3	-	-	0.1	-	5.1 (20.7)
	NIFW	2.5	9.6	3.0	-	-	1.3	-	-	3.1	-	19.5 (79.3)
F	IFW	0.1	0.3	-	-	-	2.6	1.8	-	-	-	4.9 (29.0)
	NIFW	1.5	5.8	1.8	-	-	0.7	0.3	-	1.9	-	12.0 (71.0)
G	IFW	0.1	0.3	-	-	-	3.5	-	-	-	-	4.0 (20.3)
	NIFW	2.0	7.9	2.4	-	-	1.0	-	-	2.6	-	15.7 (79.7)
J	IFW	0.1	0.2	-	-	-	3.4	-	-	0.2	-	3.9 (21.3)
	NIFW	1.7	6.9	2.1	-	-	0.5	-	-	2.1	-	13.3 (78.7)
H	IFW	0.1	0.3	-	1.5	-	1.7	-	-	0.2	-	3.8 (20.9)
	NIFW	1.6	6.5	2.0	0.2	-	0.2	-	-	2.0	-	12.5 (79.1)
I	IFW	0.3	0.8	-	3.4	0.2	7.7	4.7	0.2	0.3	4.4	22.2 (37.9)
	NIFW	3.6	14.4	4.4	0.5	3.7	0.7	0.6	3.7	4.5	0.2	36.4 (62.1)

(source: Oke et al., 2011)

Table 12. Classification of the waste into infectious and non- infectious wastes

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Hospitals	Characteristics of the wastes	Outpatient Department	Wards, inpatient, Nursing Department Medical records	Laboratory/pathology Department	Waste Transport Department	Pharmacy/administration Department	Radiography (X-ray, ultra sound etc) Department	Environmental Department	Consulting rooms	Emergency Department	Overall
A	NCBW (%)	5.5	5.8	1.0	-	-	65.5	86.0	-	1.5	97.5	33.7
	CBW (%)	94.5	94.3	99.0	-	-	34.5	14.0	-	98.6	2.6	66.3
B	NCBW (%)	5.7	6.1	1.6	88.0	5.8	66.0	86.9	5.6	2.6	97.8	34.0
	CBW (%)	94.3	93.9	98.4	12.0	94.2	34.1	13.1	94.4	97.5	2.2	66.0
C	NCBW (%)	3.5	6.1	1.6	88.0	-	70.2	86.9	-	2.6	97.9	26.1
	CBW (%)	96.5	93.9	98.4	12.0	-	29.8	13.1	-	97.5	2.1	73.9
D	NCBW (%)	4.5	6.2	1.5	-	-	69.1	-	-	2.6	-	19.3
	CBW (%)	95.6	93.8	98.5	-	-	30.9	-	-	97.5	-	80.7
E	NCBW (%)	3.6	6.8	1.6	-	-	78.3	-	-	6.6	-	22.1
	CBW (%)	96.5	93.2	98.4	-	-	21.7	-	-	93.4	-	77.9
F	NCBW (%)	5.0	7.0	1.8	-	-	80.1	86.4	-	3.6	-	30.5
	CBW (%)	95.0	93.0	98.2	-	-	19.9	13.6	-	96.5	-	69.5
G	NCBW (%)	7.5	4.7	1.7	-	-	80.1	-	-	3.6	-	21.7
	CBW (%)	92.5	95.3	98.3	-	-	19.9	-	-	96.5	-	78.3
J	NCBW (%)	7.4	4.7	1.6	-	-	88.3	-	-	9.2	-	24.3
	CBW (%)	92.6	95.3	98.4	-	-	11.7	-	-	90.8	-	75.7
H	NCBW (%)	7.7	5.7	1.4	88.0	-	91.1	-	-	9.2	-	24.8
	CBW (%)	92.3	94.3	98.6	12.0	-	8.9	-	-	90.8	-	75.2
I	NCBW (%)	9.6	6.8	1.2	88.7	6.4	93.4	90.4	6.1	9.2	97.8	39.3
	CBW (%)	90.4	93.2	98.8	11.3	93.6	6.6	9.6	93.9	90.8	2.2	60.7

(source: Oke et al., 2011)

Table 13. Classification of the waste into combustible and non- combustible wastes

Stations	Outpatient Department	Wards, inpatient, Nursing Department	Medical records	Laboratory/ pathology Department	Waste Transport Department	Pharmacy/administration Department	Radiography (X-ray, ultra sound etc) Department	Environmental Department	Consulting rooms	Emergency Department
Non-infectious waste (kg)	31.2	22.4	36.5	20.4	13.9	55.1	60.2	32.9	272.6	34.1
Infectious waste (kg)	70.4	52.3	82.5	44.6	34.8	116.7	125.3	108.5	635.1	79.4
Total (kg)	101.6	74.7	119	65	48.7	171.8	185.5	141.4	907.7	113.5

Source: Oke et al., (2011)

Table 14. Waste generation in the surveyed sites and overall average (wt%)

Tables 12 and 13 show the characterization of the wastes (infectious and non-infectious) into combustible and non-combustible, and type (glass, cloth, etc.) by weight. From the results compositions of the waste ranged from 23.3% to 32.5% (average 29.9%) for non-infectious waste and from 67.6% to 76.7% (average 70.1%) for infectious waste by weight. Compositions ranged from 53.9% to 64.0% (average 59.9%) for non-infectious waste and from 36.0% to 46.1% (average 40.1%) for infectious waste by volume [31].

3. Conclusion

The study has shown that there was no mechanism put in place towards sorting of dental wastes in the study area. This has made its characterisation cumbersome and sorting hazardous. The research also revealed that 3.3m^2 of waste were generated in a month by the eight dental clinics. Along this line, the study concludes that the dental waste generation in the third world dental hospitals especially in the study area are poorly sorted. Based on the report of the present study, the followings are recommended: Provision of a standard waste management must be put in place (segregation, storage, transportation and final disposal); locally designed Incinerators should be constructed to manage the wastes after the wastes were treated to render them non-infectious and hazardous. This pre-incinerator treatment should be in form of recycling of heavy metals such as Ag, Pb, Sn, Hg etc from the waste and the use of digital X-rays will reduce wastes generated from the X-ray rooms.

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