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Research Article

Assessment of Waste Management in the Healthcare Facilities of Dubai Health Authority, Dubai, the United Arab Emirates

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Abstract

Dubai has witnessed a rapid development in the healthcare sector. Dubai plans to be a world hub of health tourism which caused considerable increase in the number of healthcare facilities. Despite the resulting increase in the generated wastes, there are very limited studies assessing the healthcare waste management in Dubai. This study conducted to assess the waste management practices of the healthcare facilities of Dubai Health Authority (DHA) and to propose measures for improving their waste management systems. The results showed that DHA facilities are very similar in their waste management practices as they are managed by the same entities. The facilities have proper waste segregation and onsite transport systems, but the wastes are not weighed until taken for off-site transport. The studied facilities have appropriate on-site waste storage rooms except for three facilities with no storage rooms. The waste management staff have proper training, but they

have limited knowledge on legislation related to healthcare wastes, and the method of their final treatment and disposal. The hazardous wastes of the surveyed facilities are treated in Jebel Ali by incineration with the produced ashes buried in a landfill at the same location. The waste management in DHA's facilities can be improved by: establishing waste minimization systems; weighing the wastes after segregation; and establishing better coordination between the waste management systems in the studied facilities and the waste treatment facility in Jebel Ali. Similar studies are also recommended to include other facilities especially those belonging to the private sector.

Keywords: Healthcare waste management; Medical waste; Healthcare waste; Dubai; United Arab Emirates (UAE)

1. Introduction

Healthcare waste typically includes "hazardous" wastes (e.g. pathological, infectious, chemical, pharmaceutical, radioactive) and "non-hazardous" or "general" wastes [1, 2]. Inadequate and inappropriate healthcare waste management is still causing many health and environmental concerns especially in the developing countries [3-6] because of many challenging technological, economic and social difficulties [7, 8]. The processes of decision making, planning and carving effective polices pertinent to healthcare waste management systems rely heavily on properly collected data [9].

Due to the rapid economic growth, and the announcement of health tourism strategy in the Emirates of Dubai, the number of healthcare facilities has witnessed a significant increase [10-12]. The increase in number of healthcare facilities and the subsequent increase of healthcare wastes has created a unprecedented need to enforce the existing environmental regulations related to handling healthcare wastes [13-14].

Despite the vast growth of the healthcare sector in Dubai, very limited information and publications are available about the waste management practices of its healthcare facilities. This is evident in the absence of any record for Dubai or the UAE in reviews of healthcare waste management publications (e.g. [6, 15]. This problem is additionally aggravated by the inadequacy of the available governmental records of the healthcare waste management systems in Dubai. This could compromise any efforts of the current policies, regulations and practices of healthcare waste management in Dubai.

The main objective of this study is to assess the waste management practices of the healthcare facilities that are operated and managed by Dubai Health Authority (DHA) as this will help the policy and decision makers to overcome any possible challenges in the future planning of the rapidly growing healthcare sector in Dubai.

2. Methodology

A preliminary survey was conducted to identify different healthcare facilities within the jurisdictions of DHA. The survey also identified the inpatients and outpatients services. Based on the preliminary survey, the study selected three hospitals and 14 primary

healthcare centres for further assessments of their waste management practices. The detailed characteristics of the included the selected healthcare facilities included in this study are presented in Table 1. The facilities were coded. The hospitals took the code of H1-H3. The medical centres were labelled MC1-MC9 while the clinics were tagged C1-C5. According to DHA, the hospitals provide both inpatients and outpatients services while the medical centres and clinics provide only outpatient services.

Facility Code	Facility type*	Outpatients/day*	Inpatients beds	Other services beds	Non-functional beds	Total beds
H1	Hospital	920	658	50	71	779
H2	Hospital	800	403	59	216	678
H3	Hospital	700	330	138	0	468
MC1	medical centre	302	-	-	-	-
MC2	medical centre	211	-	-	-	-
MC3	medical centre	262	-	-	-	-
MC4	medical centre	284	-	-	-	-
MC5	medical centre	322	-	-	-	-
MC6	medical centre	344	-	-	-	-
MC7	medical centre	350	-	-	-	-
MC8	medical centre	75	40	0	44	84
MC9	medical centre	428	-	-	-	-
C1	Clinic	85	-	-	-	-
C2	Clinic	194	-	-	-	-
C3	Clinic	264	-	-	-	-
C4	Clinic	62	-	-	-	-
C5	Clinic	85	-	-	-	-

* Data from the study survey. Other columns are updated from DHA, 2017

Table 1: Characteristics of the studied healthcare facilities of DHA.

The primary data was collected using a structured questionnaire through face-to-face interviews with the head of the support services in each of the surveyed facilities. The questionnaire was formulated based on the guidelines of WHO [16] and the International Committee of the Red Cross (ICRC) [17] for waste

management in healthcare facilities. The questionnaire was also constructed to fit the local conditions. A pre-test of the questionnaire was conducted to ensure that it could capture all the key information required to achieve the study objectives. After pre-testing, the questionnaire was modified to make the process of data collection more efficient.

The term "healthcare wastes" was used in in the questionnaire and the whole study to indicate both hazardous (such as sharps, anatomical wastes, infectious wastes and pharmaceutical wastes) and general or non-hazardous wastes (such as office wastes, household refuse and kitchen wastes). The term "medical wastes" was used to refer to hazardous healthcare wastes which include all types of healthcare wastes other than the general wastes. This was done to be in accordance with the terms used by the national and local laws and regulations for handling healthcare waste. This use of terminology was also similar to what was found in other studies (e.g. [18, 3,,4]).

The questionnaire contained questions about the waste generated by each sampled facility as well as the core aspects of segregation, collection, internal and external storage, transport, treatment, and final disposal. There were also questions about the responsible waste management staff, their training, safety practices in addition to their knowledge and awareness of the local, national and international regulations and guidelines of healthcare waste management. All interviews were carri ed out by the researchers to ensure that no misunderstanding would occur during answering any question. Site walkovers were also conducted to various units within each facility such as its departments, wards, and storage areas. The walkovers were very helpful in verifying some of the answers obtained by the questionnaire.

The study included also key person interviews to collect the data that could not be obtained from the surveyed facilities. The first interview was with the head of the transportation sector of DHA to collect data about the transport process, such as the total quantity of medical waste generated by each facility, the processes of cleaning and disinfecting the transport vehicles, specifications of transport vehicles, precautions, and emergency plans. The second interview was with the head of the medical waste treatment and disposal unit at Jebel Ali hazardous waste treatment facility (HWTF) to collect data about the processes of treatment and final disposal of healthcare wastes.

The results obtained from the questionnaire were entered, coded and checked using Statistical Package for the Social Sciences (SPSS) version 17. One-way ANOVA was used to compare between the three groups after ensuring normality of the variables using Kolmogorov-Smirnov test. Post-hoc tests were used to determine which groups differ if the one-way ANOVA was significant.

3. Results

3.1 Current and future demand on healthcare facilities in Dubai

There is significant increase in the demand on healthcare due to accelerated development of the Emirate of Dubai. It is manifested in the expansion of

the emirate urban agglomerations and population size. DHA estimated that the population growth rate can increase from 3.1% in 2018 to a range of 4 to 5.5% in 2030 [19]. There is also an additional demand on the healthcare services due to organization of Expo 2020 and adoption of health tourism initiatives to position Dubai as an emerging global health tourism destination. Dubai healthcare facilities receives significant numbers of patients from other emirates as it is known with its developed healthcare sector with varied specialities.

The included hospitals (H1, H2 and H3) in this study received a total of 2420 outpatient/day comprising 42.5% of all outpatients received by the sampled facilities (Table 1). The outpatient serviced by the medical centres is 2578 outpatient/day representing about 45.3% of total outpatients received daily by DHA facilities. The clinics are visited by a total of 690 outpatient/day which make their share the smallest (12.2%) of the three groups (Table 2). The inpatient services are provided only by the hospitals of the DHA healthcare facilities, except for MC8 which provides this service only for elderly (Table 1). DHA hospitals provide 28.5% of the total inpatient service in Dubai [12]. The three hospitals have beds for inpatient service in addition to short stays. Delivery suites, neonatal incubators or bassinets are available only at H2 and H3. H1 has the largest value of functional beds. DHA hospitals have 76.9% bed occupancy rate with a turnover rate of 56.3 and average length of stay of 5 days. The bed occupancy rate is slightly higher than the 75% target optimal value set by DHA [12].

Type of healthcare facility	**Hospitals** **n = 3**	**Medical centres** **n = 9**	**Clinics** **n = 5**
Average out-patients/day‡	806.7[a] (110.1)	286.4[b] (99.9)	138[c] (87.2)
Average in-patient beds	437.3 (141.7)	45* -	- -
Average number of all bed types	639.3 (128.0)	45* -	- -

Figures in parentheses are standard deviations

‡ P-value for one-way ANOVA < 0.001

[a,b,c] Groups with similar letters have no significant difference and groups with different letters have significant difference at p < 0.05 according to Benferroni and Gabriel *Post Hoc* tests

*Only one facility has in-patient service

Table 2: Main services provided by the three groups of healthcare facilities of DHA.

3.2 Waste management staff

All the surveyed facilities have a specialized waste management team (Table 3). Each facility has only one waste management team leader whose tasks are assigned to the head of the support services. Other team members are the housekeeping supervisors and

the cleaners. The number of housekeeping supervisor differs according to the type of the facility type. Medical centre and clinic have only one housekeeping supervisor for each facility. Rashid hospital has the largest number (26) of housekeeping supervisors followed by Dubai hospital (16) while Latifa hospital has only 9 supervisors. There is a significant difference in the number of cleaners between the hospitals and the other two groups (Table 3). The medical centres and clinics have similar number of cleaners with no statistical difference. The housekeeping supervisors and cleaners are provided by a private company which is contractually obliged to apply DHA healthcare waste management policies and guidelines.

Type of healthcare facility	**Hospitals** **n = 3**	**Medical centres** **n = 9**	**Clinics** **n = 5**
- Number of team leaders	1*	1*	1*
- Average number of housekeeping supervisors	14	1*	1*
Range	(8.5)		
- Average number of cleaners‡	9 - 26	12.1[b]	6.6[b]
Range	211[a]	(3.2)	(0.90)
	(96.6)	8 - 18	6 - 8
	124 - 315		

Figures in parentheses are standard deviations

‡ P-value for one-way ANOVA < 0.001

[a,b,c] Groups with similar letters have no significant difference and groups with different letters have significant difference at $p < 0.05$ according to Benferroni and Gabriel *Post Hoc* tests

*Numbers are constant for the whole group

Table 3: Waste management team.

3.3 Waste segregation

Waste segregation is practiced similarly by all the facilities of this study. The generated wastes are separated at the generation points into general (household and kitchen), sharps, infectious, anatomical, pharmaceutical, laboratories and radioactive. The general wastes are collected in black plastic bags labelled only with waste category. Sharps including vacuette needles and butterfly needles are collected in rigid puncture-proof yellow plastic containers fitted with covers. The containers have a special opening where the needles are distorted before disposal. Sharp containers are disposed with the needles. It was found that sharp containers are labelled with the place and date of collection, waste category, and the international biohazard symbol.

The same labelling details were also present on the yellow plastic bags used for the collection of infectious wastes. The anatomical wastes are disposed

as infectious wastes. The body parts are disposed according to local customs, where they are collected and buried in the cemetery with the proper arrangements with the patient and/or the patient's family. The blood and urine samples from laboratories of all the survey facilities are filled into special vials that are disposed in yellow bags to be disposed with other hazardous wastes. The liquid and chemical wastes from the laboratory or other departments are diluted to very low concentrations or neutralized to be disposed into the municipal sanitary sewage network. Pharmaceutical wastes are collected in yellow bags and disposed separately from other medical wastes in arrangement with Dubai Municipality for final treatment and disposal at Jebel Ali HWTF. The radioactive wastes are stored safely in shielded and isolated areas for not less than 4 half-life time of its isotopes and then disposed with general waste. The survey respondents did not identify the procedure used for the disposal of pressurized containers such as gas cylinders, gas cartridges and aerosol cans.

3.4 Waste collection and In-house transport system

All bags and containers are collected and replaced with new ones once a day or when they reach two thirds of their capacity. All the facilities use metal trolleys with a lid for in-house transport of wastes. The trolleys in all facilities are cleaned and disinfected once daily. Only the three hospitals use separate trolley for hazardous wastes than those used for general wastes. Specific route for in-house transport were also available only at the hospitals. A separate elevator for transporting all wastes is found in all hospitals, although hospital H1 uses a garbage chute for the general wastes.

3.5 Waste storage

In all the surveyed facilities, general wastes are stored in covered large containers outside the buildings of the surveyed facilities. The medical wastes are also temporarily stored on-site till collection for off-site transport. Each hospital has two specialized storage rooms for medical wastes. One room is used for temporary storage and located inside the hospital building. This room is usually used to reduce the number of trips needed by the collection personnel to the main storage room (Table 4). The main storage room in each of the three hospitals is located within the hospital premises but as a separate building. All clinics and six medical centres (67%) have one storage room located in each facility as a separate building within their premises. the remaining 33% of medical centres, the waste storage is done unsystematically. The results of this study showed that all the on-site storage rooms have covered roofs with concrete walls and floors. They have doors labelled with the biohazard international symbol and warning signs indicating limited access to the responsible personnel. The storage rooms are cleaned and disinfected daily. All hospitals and only two medical centres (22%) have storage rooms provided with drainage system that is connected to the municipal sanitary sewage network (Table 4). The storage rooms are air-conditioned in all hospitals, six medical centres (67%) and three clinics (60%). The different types of medical wastes are not stored separately in on-site storage rooms, although they were segregated at generation sources and during onsite collection.

Health care facility	**Hospitals n = 3**		**Medical centres n = 9**		**Clinics n = 5**	
	No.	%	No.	%	No.	%
Do you have a waste storage place in your facility?						
Yes (1)	3	100	6	67	5	100
No (2)	0	0	3	33	0	0
Temporary waste storage place inside the facility premises (a room in the building).						
Yes (1)	3	100	0	0	0	0
No (2)	0	0	9	100	5	100
Temporary waste storage place within the facility boundaries.						
Yes (1)	3	100	6	67	5	100
No (2)	0	0	3	33	0	0
Is the storage area separated from the facility building?						
Yes (1)	3	100	6	67	5	100
No (2)	0	0	3	33	0	0
Type of the walls of the storage area.						
Concrete (1)	3	100	6	67	5	100
Others (2)	0	0	3	33	0	0
Is the storage area covered and sheltered from the sun.						
Yes (1)	3	100	6	67	5	100
No (2)	0	0	3	33	0	0
Type of the floor of the storage area						
Concrete (1)	3	100	6	67	4	80
Others (2)	0	0	3	33	1	20
Is there a drainage system in the storage area?						
Yes (1)	3	100	2	22	0	0
No (2)	0	0	7	78	5	100
Is the storage area air conditioned?						
Yes (1)	3	100	6	67	3	60
No (2)	0	0	3	33	2	40
Do you monitor the temperature in the storage area?						
Yes (1)	4	100	6	67	4	80
No (2)	0	0	3	33	1	20
How often do you clean the storage area?						
Once daily (1)	4	100	6	67	5	100
Others (2)	0	0	3	33	0	0

Table 4: Characteristics of the storage chambers.

3.6 On-site treatment and disposal

None of the surveyed facilities had any pre-treatment activities for their medical wastes. The on-site treatment activities are limited to autoclaving the microbiological cultures at the laboratories of the three hospitals. The products of autoclaving are disposed in yellow plastic bags as infectious wastes. No operational incinerators or landfills are found at the facilities of this study.

3.7 Off-site transport

The general wastes are collected and disposed with the domestic solid waste by Dubai Municipality. DHA transportation sector is the responsible authority for transporting the medical wastes from the studied facilities to Jebel Ali HWTF. They are transported in vehicles which are closed, secured, labelled and temperature-controlled. These results conform to the details obtained from an interview with the head of the transportation sector of DHA as well as the on-site visits. A waste tracking system is designed to prevent illegal transport of wastes. It involves the use two consignment forms which are held by the vehicle driver. The first form is filled during loading hazardous waste from the medical facility. The second is filled after unloading and weighing at Jebel Ali HWTF. The two forms are compared to ensure that the drivers collected wastes only from the authorized facilities. No information could be obtained about the presence of specific transportation routes from the facilities to Jebel Ali HWTF.

Healthcare facility	**H1**	**H2**	**H3**	**Medical centres and clinics**
Average monthly weight of medical waste‡	4480.1[a] (340.8)	4241.3[a] (447.1)	3418.4[b] (373.1)	2256.6[c] (330.2)
Average daily weights of medical wastes‡	147.7[a] (11.4)	139.8[a] (16.3)	112.6[b] (11.9)	74.5[c] (11.8)
Average daily weights of medical wastes per bed‡	0.28[a] (0.022)	0.32[b] (0.037)	0.33[b] (0.035)	- -

Figures in parentheses are standard deviations

‡ P-value for one-way ANOVA < 0.001

[a,b,c] Groups with similar letters have no significant difference and groups with different letters have significant difference at $p < 0.05$ according to Benferroni and Gabriel *post-hoc* tests

Table 5: Quantity of medical wastes in kilograms.

3.8 Waste quantities

The general and medical wastes are not weighed by any the facilities of this study at any stage. The medical wastes are weighed only when they were taken to Jebel Ali HWTF by DHA transport vehicles to determine the disposal costs to be paid by DHA.

The medical wastes of all medical centres and clinics are collected and weighed together, whereas they are collected and weighed for each hospital separately. The weights of the medical wastes were available only at the transportation sector of DHA (Table 5). There were no available records for the weights of the general wastes generated by all studied facilities because they are not weighed at all.

The average monthly and daily weights of medical wastes were similar for H1 and H2 which were significantly higher than those collected from H3 (Table 5). The primary healthcare centres generate medical waste in much lower quantities compared to the three hospitals. The rate of generated medical waste of the hospitals is calculated as described by Windfeld and Brooks (2015) [20]. H2 and H3 exhibited similar average daily weights of medical waste per functional bed, but both have significantly higher values than H1. The medical waste generation rate of the primary healthcare centres was calculated using the method applied by Al-Zahrani et al. (2000) [21]. The average daily generation rate for these facilities was 0.023 kg/visitor/day.

3.9 Off-site treatment and disposal

The waste management teams of the surveyed facilities have no information about how the medical wastes of their facilities are treated or disposed. They also don't know how their activities affect these processes. The head of the medical waste treatment and disposal unit of Jebel Ali HWTF explained that infectious wastes, sharps and pharmaceutical wastes are treated by incineration which produces wet ash to limit the emitted particulate matter. The ashes are collected and buried in the landfills at the same facility. Jebel Ali HWTF is managed by Dubai Municipality which is used to handle the medical waste of all healthcare facilities in Dubai, DHA facilities and those of the private sector.

3.10 Medical waste management regulations and policies

All respondents from the sampled facilities stated that they don't know if there are any medical waste management legislations at the local or national levels. Nevertheless, it was found that all facilities have medical waste management policy and guidelines in addition to infection control policies. The respondents indicated that they do not know the amount of budget allocated for medical waste management in their facilities, but they experienced no budget constraints. None of the sampled facilities has any waste minimization policy. All the surveyed healthcare facilities obtained ISO 9001 and the Joint Commission International (JCI) certification.

4. Discussion

4.1 Characterization of healthcare facilities

The numbers of outpatients received per day are higher in the hospitals than the medical centres and the clinics because hospitals have notably more specialties and medical staff (consultants and specialists) [12]. This is also the reason of increasing the numbers of outpatients of the medical centres than the clinics. The presence of a trauma centre is one of the main reasons that made H1 serves the highest value of inpatients in all healthcare facilities of DHA. It receives all types of accidents in Dubai as well as those referred from other Emirates. The high number

of specialties and medical staff play also a significant role in increasing the number of inpatients in H1 compared to H2 and H3. The three hospitals have similar number of beds as some hospitals serving population in countries with similar socio-economic settings as those found in Saudi Arabia [21], Kuwait [22] and Bahrain [23].

4.2 Waste management staff

The general structure of the waste management staff is the same for all the facilities of this study. This is because the waste management activities in all facilities are operated by the same administration of DHA in cooperation with a private company. The size and number of services provided by the hospitals are the main reasons for increasing the numbers of their waste management staff. Training employees is a critical step for a successful healthcare waste management programme [24]. All surveyed facilities train all their waste management staff on the required medical waste management practices. This differs from other places in the UAE. Bani-Hashim (2007) [10] concluded that most of the healthcare facilities in Abu Dhabi don't have skilled or well-trained waste management workers.

4.3 Waste segregation

The use yellow plastic bags for infectious wastes conform with the guidelines of the international organizations such as ICRC [17] and WHO [2]. This differs from the requirements the Cabinet Order No.37 of 2001 for Executive Order of Federal Law No. 24 of 1999 for Regulation of Handling Hazardous Materials, Hazardous Waste and Medical Waste which requires the use of red plastic bags for infectious wastes. This is similar to the results obtained by Al-Dahiri et al. (2008) [13] for the hospitals in Dubai. The facilities of this study collect pharmaceutical wastes in yellow plastic bags as required by Law No. (24) of 1999.

It was noticed that in a few of the surveyed facilities, the general wastes have been disposed in yellow bags which would increase the burden and the costs of hazardous waste handling and disposal. Such practices are not uncommon in healthcare waste management practices especially in developing countries [4]. Proper segregation using colour-coded plastic bags and containers was found to be practiced only by 18.7% of the healthcare facilities in the West Bank of the Palestinian Territory [25]. Manga et al. (2011 [9]) found that poor segregation caused mixing infectious wastes with the general waste of the healthcare facilities in Southwestern region of Cameroon which would increase volume and costs of waste handling and treatment.

Based on the International Atomic Energy Agency standards, the WHO guidelines recommended that the radioactive wastes should be stored for at least 10 half-life times for radioactive isotopes with a half-life of less than 90 days [2]. This differs from the practices of the sampled facilities which store radioactive wastes for just 4 half-life times of contained isotopes. The DHA facilities do not also use specific methods for handling pressurized containers, although DHA guidelines describes that the pressurized containers should be collected in white plastic bags to be treated by incineration. Similar results were reported by Al-Dahiri et al. (2008) [13]

regarding the limited attentions giving to the disposal of pressurized containers in major hospitals in the UAE including those in Dubai.

The surveyed facilities label their hazardous waste packages with the waste category, date and place of collection, and the international hazard symbol. This makes them not fully complying with the regulations of Law (24) of 1999 as it requires adding also the place of destination. The general wastes and pharmaceutical wastes are not properly labelled which could pose serious risks if they were not well segregated all through the waste stream. Labelling of healthcare wastes is not practiced as required in the UAE [13].

4.4 Waste collection and in-house transport system

Special routes and lifts for in-house waste transport are additional safety measures found only in the three hospitals. These measures are recommended by WHO [2] to reduce patient exposure risks to medical wastes during their in-house transport. These measures are not available in the medical centres and clinics because of their size and structure. Similar practices are found in private and governmental hospitals in Kuwait, where specialized carts are used for in-house waste transport [22], 26]. However, it was not found in other countries in the region such as Bahrain [23], Jordan [27], Libya [28] and Yemen [29].

4.5 Waste storage

It was found that the drainage system is installed only at the storage rooms of the three hospitals and two medical centres. lack of drainage system may create a major problem for the collection of water and other fluids used during the daily cleaning and disinfecting of the storage rooms. it is important to secure and regularly sanitize the storage rooms and this necessitate the installation of proper drainage systems in all storage rooms [22].

4.6 Waste quantities

The medical waste generation rate varied from 0.28 to 0.33 kg/bed/day for the three hospitals with an average of 0.3 kg/bed/day. Al-Dahiri et al. (2008) [13] reported much higher values for medical wastes of two hospitals in Dubai which was 1.1 kg/bed/day, although the same method of calculation was used as this study. This could be attributed to the differences in the data sources. This study used the actual weights recorded by DHA for medical wastes, while Al-Dahiri et al. (2008) [13] relied on the answers obtained through a questionnaire with the waste management staff. The general wastes and pharmaceutical wastes could not be calculated because there were no available records in all concerned agencies. The executive order of Law (24) of 1999 requires that facilities handling or dealing with medical wastes to maintain records reflecting ample description of the quantities of medical wastes and their sources, rates and collection. This will make the surveyed facilities not fully complying with the national regulations. The medical waste generation rates of the three hospitals of this study are similar to some hospitals in Saudi Arabia [21]. Higher values were found in the hospitals of Kuwait [27], and Bahrain [23].

4.7 On-site treatment

Autoclaving of microbiological culture is the only treatment methods found in all the facilities of this

study which is practiced only by the three hospitals. Autoclaving is considered as a costly process as it is a double treatment method that cannot handle all types of medical wastes especially in large quantities [25]. It is usually used as a pre-treatment method which requires another treatment method such as incineration before final disposal [30, 4]. Similar practices were found in Bahrain [23] and Kuwait [26] where autoclaving was used to treat some infectious waste prior to incineration and final disposal.

4.8 Off-site transport system

The surveyed facilities use specialized vehicles of DHA for transporting their medical waste to Jebel Ali HWTF. The specifications, labelling, maintenance and operation system of these vehicles comply with the regulations indicated by the executive order of Law (24) of 1999, also the transportation of the medical waste is controlled with tracking system. These are important factors in controlling unauthorized transport and illegal dumping of medical waste during transporting [20].

4.9 Off-site treatment and disposal

Incineration is the most widely used treatment method of medical wastes all over the world [6]. It is recommended to centralize the incineration of the medical waste from as many healthcare facilities as possible [2]. Dubai Municipality phased out all the on-site incineration activities at all healthcare facilities. The medical treatment is now centralized at Jebel Ali HWTF to handle all the medical wastes produced by all healthcare facilities in Dubai. One of the major concerns related to the operation of the incinerators is the air emissions. It was found that all emissions are below the local and national air emission standards. The incinerator minimizes manual handling of wastes and produced ashes through the use of automatic systems for loading and de-ashing. The ashes are disposed at the landfill found at the same facility which reduced the risks of their transport. Elsewhere in the UAE, the centralized incineration is applied for medical waste of all the hospitals and clinics in Al-Ain city – Abu Dhabi [31]. Medical waste incineration was also the main waste treatment method in other neighbouring countries with similar conditions such as Kuwait, Qatar and Oman [32].

4.10 Healthcare waste management regulations and policies

In this study, it was found that the national and local laws and regulations indicate a well-established legislative structure for medical waste management in Dubai. The implementation of these regulations is not hurdled by any budget restrictions at any of the surveyed facilities. However, the limited knowledge of the waste management staff of the DHA healthcare facilities could reduce the effectiveness of the implementation of these laws and regulations. They don’t have sufficient knowledge of the impacts of their activities on the whole medical waste management process. This is further proven by their limited knowledge of the treatment and disposal practices. previous studies asserted the importance of the awareness of medical waste workers in all medical waste management processes [6, 20, 33]. The improper implementation waste management regulations and programmes were also considered major problems in the healthcare waste management

of the neighbouring countries, such as Bahrain [23], Kuwait [26] and Iran [34].

5. Conclusions and Recommendations

This study showed that the surveyed facilities have similar waste management systems in components and implementation. These similarities are consequently present in the structure and functions of their waste management teams. It can also be concluded that the waste management practices of the DHA facilities included in this study are systematic and complying with most of the local and national laws and regulations. Nevertheless, there are certain areas that require more attention which could help in improving the waste management practices of the facilities of this study.

The surveyed facilities lacked waste minimization practices such as centralized purchase of materials and choosing less wasteful materials. These practices could contribute to significant reduction of the amounts of generated wastes and hence reducing the financial and environmental burdens of waste treatment and disposal. The use of hazardous chemicals must be reviewed by DHA for all its facilities and replace them with less hazardous or non-hazardous alternatives whenever possible which could be an important practice for implementing a waste minimization programme.

None of the surveyed facilities weigh any type of their generated wastes. Each facility should have a proper waste quantification mechanism in terms of weigh and volumes as this will help the waste managers in each facility to monitor the trends in their waste generation rates. Also, collected data can be used centrally in reviewing the waste management programme of each facility to identify the practices and/or departments that must be targeted to reduce their waste generation.

The study provided evidence that the waste collection practices are done with limited problems, although some mixings between the general and hazardous waste were observed in some facilities. This issue requires more control on the waste collection activities through more stringent inspection by the housekeeping supervisors and team leaders. Some healthcare centre and clinics need to establish a proper waste storage place which lacked in several facilities. Additionally, the different types of medical wastes are subjected to mixing in the on-site storage rooms which undermines the waste collection and segregation practices done. The storage rooms would better be subdivided to establish specific part to each type of the medical wastes. This segregation must also be maintained until the medical wastes are delivered at Jebel Ali HWTF.

The training programmes are needed on continuous bases. These programmes should aim at improving the knowledge of waste management teams about the local and national laws and regulations for handling medical wastes. The training programmes should also aim at creating the minimum level of awareness among medical waste mangers regarding the methods of medical waste treatment and disposal as well as the impacts of their practices on the waste management processes. This will significantly help in achieving any future waste minimization targets.

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Conflict of Interests

The authors declare no conflict of interest.

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