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ORIGINAL RESEARCH ARTICLE



Assessment of hospitals medical waste management in Chaharmahal and Bakhtiari Province in Iran

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ABSTRACT

The hospital wastes could threaten the surface waters, ground waters, soil, air environment and humans' health. This study was intended to investigate the management of medical waste generated in hospitals of Chaharmahal and Bakhtiari province, located in south west of Iran. The samples came from all 9 province's hospitals with 1156 beds. The data forms and questionnaires were completed. The questionnaire contained questions about the generation of waste and practices related to separation, collection, storage, transport, treatment and final disposal, and training and awareness. The highest generation rate on a bed basis of 3.22 ± 0.4 kg/bed/day was found in Shohada hospital, and the lowest rate was 1.37 ± 0.2 kg/bed/day for Sina hospital. There was significant variation ($P < 0.05$). The average general waste production rate was 2.12 ± 0.37 kg/bed/day at all the surveyed hospitals. The highest percentage (63%) of total medical wastes were general, 36.05% were infectious wastes. About 44.44% of the hospitals have used autoclave to disinfect their infectious medical waste prior to disposal, while incineration is used in 33.33% of the hospitals. All hospitals (100%) indicated their needs and willingness to participate in future specialized training programs in medical waste management. It has been suggested that enhancing the education, awareness and promoting programs about medical waste management for cleaning workers, doctors, nurses, and technicians.

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INTRODUCTION

The hospitals' wastes could threaten the surface waters, ground waters, soil air, environment, and humans health (Jaafari *et al.*, 2015). The solid waste from healthcare: hospitals, clinics, pathological laboratories, pharmacies and other supported healthcare services has increased throughout the world (Jaafari *et al.*, 2015). The hospital waste may contain general waste, sharp items, infectious waste, chemical/pharmaceutical waste, heavy metals, and may contain substances that are genotoxic or radioactive (Awodele *et al.*, 2016). In developed countries, technologies such as autoclaving and incineration are used for treatment

and final disposal of hospital waste. However, in developing countries, hospital waste has not received adequate attention (Hasan and Rahman, 2018), particularly when it is disposed of together with the domestic waste. In addition, in developing countries such as Iran, medical waste has not received enough attention. In many of these countries, medical waste is still handled and disposed of together with domestic waste, creating great health risks to health-care staff, municipal workers, the public, and the environment (Khandelwal *et al.*, 2019). Most of the cities in Iran dispose of domestic and medical wastes together in municipal dump sites or in poorly designed landfills, or they use on-site incinerators to treat waste that poses operational

and maintenance problems (Gunamantha, 2012). The hospital waste generation rates in many countries showed that in the Table 1 (Da Silva et al., 2005; Abdulla et al., 2008; Birpınar et al., 2009; Taghipour and Mosaferi, 2009; Yong et al., 2009; El-Salam, 2010; Ferreira and Teixeira, 2010; Abah and Ohimain, 2011; Hossain et al., 2011; Mbarki et al., 2013; Muluken et al., 2014; Farzadkia et al., 2015).

According to the World Health Organization (WHO), the hazardous waste fraction represents 10–25% of the total healthcare waste (Mohamed et al., 2009). In developed countries, technologies such as autoclaving and incineration are used for treatment and final disposal of medical waste. However, in developing countries, medical waste has not received adequate attention (Fazzo et al., 2017), particularly when it is disposed of together with the domestic waste. Improper hospital waste management practice could indeed impact both directly and/or indirectly on healthcare staffs, patients and hospitals environment (Tait et al., 2019). Diseases like hepatitis B (HBV), hepatitis C (HCV), HIV infections, cholera, dysentery, skin infection, could epidemically spread due to the mismanagement of hospital solid waste (Coker et al., 2009). Therefore, it is urgent to determine appropriate methods for the safe management of hospital waste. This study presents an overview of current management practices for hospital waste in Charharmahal and Bakhtiari province in Iran and discusses the current practices in managing hospital waste and disposal approaches, because the data available to date on hospital waste characteristics in Iran is scarce, especially in the province Charharmahal and Bakhtiari. Therefore, a determination of the amount and composition of medical waste generated in this province is a pressing necessity.

MATERIALS AND METHODS

The Charharmahal and Bakhtiari Province is a small province in southwest of Iran, with a population of 947,763 people (2018) and an area of 16,403 km². The province is mainly active in the agriculture sector. Most of the industrial sector is clustered around the center of the province. The province has the potential to become a vibrant tourist attraction because of its natural

resources. The Province has 6 cities named Shahrekord, Borujen, Farsan, Lordegan, Ardel, and Koohrang. There are 9 hospitals under the supervision of shahrekord University of Medical Sciences (the only medical university of the province) listed in the Table 2. According to the 2018 information, there are 1,156 active hospital beds. In this cross-sectional study, all 9 hospitals of Charharmahal and Bakhtiari province were assessed in a period of 6 months in 2018. In this study, general hospitals refer to hospitals that provide a large array of medical services or typically the first patient contact. “Specialized hospitals” refer to hospitals that provide medical services for a particular group of patients, such as a pediatric hospital or a limited set of services.

The wastes were weighed over a period of 3 months (one week per month). A special container with a 0.5 m³ volume was used to determine the waste volume, which allowed us to calculate the uncompacted specific weight of the waste, where this result was reported in kg/m³. In the study, the classification criteria were based on possible risks (hazardous-infectious, sharp items and general wastes) and the composition of waste (plastics, textiles, paper, glass, sharps, food waste, metals, and others). The study was conducted in the spring and summer of 2018. The data were recorded in specific data forms. In all hospitals, the waste was separated by an investigation team according to color coding the following order: Black bag contain: General waste (Non-infectious and nonhazardous waste), Yellow bag contain: Infectious, pathological, pharmaceutical, genotoxic and chemical waste, and etc. Yellow safety box contain: needles, infusion set, scalpels, blades and etc. The data forms and questionnaires were completed. The questionnaire contained questions about the generation of waste and practices related to separation, collection, storage, transport, treatment and final disposal, and training and awareness. It includes separation (9 questions), collection (2 questions), transport (4 questions), storage (6 questions), disposal (2 questions) and basic information hospital (4 questions) aspects. The mentioned questionnaire was completed by looking at the hospitals. Data was coded and analyzed using SPSS 11.5 software. Chi-squared test was used to determine the significant difference between the values at $P < 0.05$ level of significance.

Table 1. The hospital waste generation rates in many countries (kg/bed/day).

Jordon	Taiwan	Brazil	Portugal	Egypt	Korea	Nigeria	Morocco	Turkey	china	Tabriz-Iran	Karaj-Iran
3.41	2.08	2.63	1.4	0.85	0.48	0.81	0.53	0.63	0.63	3.48	4.2

Table 2. Outline of requirement of the studied hospitals in the province Charharmahal and Bakhtiari.

Name of hospital	Number of active beds	Type of ownership	Activity
Kashani	208	Medical Sciences University	Specialized and sub specialized-general
Hajar	345	Medical Sciences University	Specialized and sub specialized-general
Valiasr	150	Medical Sciences University	General
Shohada	96	Medical Sciences University	General
Seied of Shohada	90	Medical Sciences University	General
Sina	80	Medical Sciences University	Psychiatry
Imam Reza	36	Medical Sciences University	General
Imam Javad	36	Medical Sciences University	General
Imam Ali	115	Social welfare	General
Total	1156	-	-

RESULTS AND DISCUSSION

Generation rates

In this study, the generation rate of medical waste varied from 1.37 ± 0.2 to 3.22 ± 0.4 kg/bed/day with a mean of 2.12 ± 0.37 kg/bed/day. This variation attributed to the different characteristics of the studied hospitals such as number of beds as well as the number and types of services offered. Any increase in the number of beds and services might change the waste generation rates (Table 3).

In addition, the economic, social, and cultural status of the patients as well as the level of instrumentation and the general condition of the area where the hospital is situated might change its amount of generated waste (Hossain et al., 2011; Liao and Ho, 2014). Many studies have focused on the management of medical waste in countries such as the Taiwan (Patwary et al., 2011; Windfeld and Brooks, 2015). And Jordan which revealed nearly similar results where the waste generation rate ranged from 2.41 to 3.26 and 1.88 to 3.49 kg/bed/day, respectively (Bdour et al., 2007). Another report an average generation in Binzhou District, China, of about 1.22 Kg/bed-day (Ruoyan et al., 2010). A study conducted by Abdulla et al. (2008) showed that the weighted average generation rate was 0.83 Kg/bed-day in northern Jordan (Abdulla et al., 2008). In Pakistan showed an average of 1.28 kg/bed/day (Khan et al., 2019). Some European countries such as USA and Italy had higher health-care waste generation rates than those reported in the present study and ranged from 5 to 7 and from 3 to 5 kg/bed/day, respectively (Giusti, 2009; Özkan, 2013). This may be due to the high economic level in these countries with increasing trend towards the use of disposable items. Attention to different aspects of hospital waste management (especially separation, recycling,

reuse and purification of infectious waste and different levels of staff training in regards to waste management (Sawalem et al., 2009). Variety of sections of the hospital (for example surgery, general, dialysis, otolaryngology, pathological, pharmaceutical and etc.). This finding confirmed the results of the present study where the highest weight of medical wastes generated per bed daily was from hospital located in high-standard area and calculated to be 3.22 ± 0.4 kg/bed/day. The results of this study were similar to in medical waste generation in the Mediterranean region countries 1.3–3 kg/bed/day (El-Salam, 2010; Khan et al., 2019). There are multiple factors that cause rate in hospital waste generation, these are the capacity of the facility, the number of patients, policy and legislation, and the type of treatments (Al-Khatib et al., 2016; Khan et al., 2019).

Waste composition

The total amount of waste produced in the hospitals was 2403.45 kg daily (877.26t/year). The average daily generation rates of total medical waste (hazardous-infectious waste and general waste) were determined for the studied hospitals were equal to: 1.94 ± 0.5 , 1.85 ± 0.3 , 1.98 ± 0.2 , 3.22 ± 0.4 , 1.89 ± 0.3 , 1.37 ± 0.2 , 2.04 ± 0.5 , 2.12 ± 0.6 , and 2.78 ± 0.4 kg/bed/day, respectively for the Kashani, Hajar, Valiasr, Shohada, Seied of Shohada, Sina, Imam Reza, Imam Javad, and Imam Ali hospitals. The highest generation rate on a bed basis of 3.22 ± 0.4 kg/bed/day was found in Shohada hospital, and the lowest rate was 1.37 ± 0.2 kg/bed/day for Sina hospital, there was significant variation ($P<0.05$), (Table 3). The causes of these differences can be attributed to the following; condition and capacity of a hospital, variety of sections of the hospital (for example surgery, general and etc.), the number of patients and students (for training), laboratory areas.

Table 3. Composition of medical waste generated in hospitals.

Name of hospital	General waste (kg/d)	Infectious waste (kg/d)	Sharps waste (kg/d)	Pharmaceutical/chemical waste (kg/d)	Radioactive waste (kg/d)	Pathological waste (kg/d)	Total medical waste (kg/d)	Total generation rate (kg/bed-day)
Kashani	255±20.21	147.9±10.6	0.8±0.10	0.3±0.1	0.1±0.01	0.9±0.08	405±34	1.94±0.5
Hajar	390±34.5	247.4±21.6	0.9±0.11	0.4±0.09	0.1±0.02	1.2±0.07	640±21.4	1.85±0.3
Valiasr	170±24	126.95±9.8	0.3±0.12	0.25±0.02	0.1±0.02	0.4±0.05	298±22.1	1.98±0.2
Shohada	180±22.7	129.3±23.5	0.35±0.09	0.27±0.05	0.1±0.01	0	310±11	3.22±0.4
Seied of Shohada	110±19	60±9.8	0.3±0.04	0.25±0.03	0.1±0.01	0	170.65±22.9	1.89±0.3
Sina	95±23	14±8.6	0.45±0.08	0.33±0.02	0	0	109.78±12.5	1.37±0.2
Imam Reza	65±12	8±2.2	0.3±0.07	0.2±0.01	0	0	73.5±11.2	2.04±0.5
Imam Javad	70±11	6±3.4	0.3±0.06	0.25±0.02	0	0	76.55±9.8	2.12±0.6
Imam Ali	190±10	129±23.2	0.7±0.09	0.2±0.03	0.1±0.01	0	320±5.7	2.78±0.4
Average	169.44±19.5	96.5±12.52	0.49±0.09	0.27±0.04	0.066±0.01	0.27±0.06	267.05±16.73	2.12±0.37

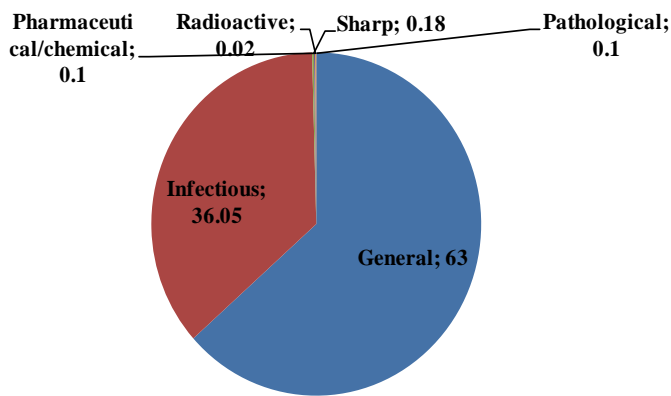


Figure 1. Percentage (wet weight) of infection general sharps pharmaceutical pathological and radioactive waste in the total medical waste in all studied hospitals.

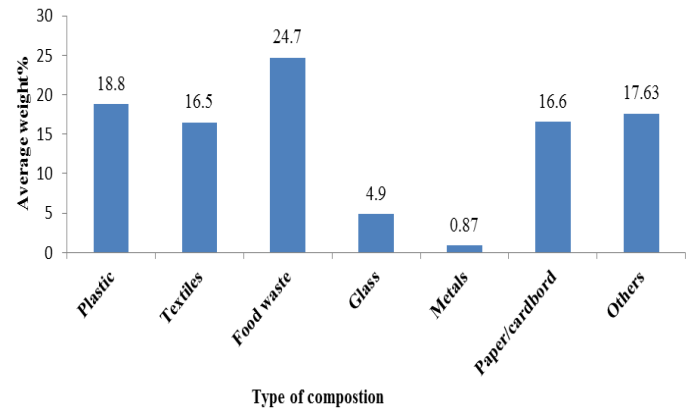


Figure 2. The average (weighted mean %) composition of total medical waste in all of studied hospitals in province Charharmahal and Bakhtiari.

The generation rates depend upon several factors such as the type of healthcare establishment, level of instrumentation, and location. We concluded that, among the various factors influencing waste generation, economical condition probably is the most significant. About 77.77% hospitals used yellow color bags for infectious waste, and 77.77% of hospitals used black bags for general waste and the remaining 22.23% of hospitals used containers with different colors. In comparison to the study performed in Fars province, Iran (80%) chose yellow and (20%) selected blue as the colour for infectious waste containers (Dehghani et al., 2008). All wastes generated by hospitals are considered medical waste. An estimated 10–15% of hospital wastes are considered infectious (Ali et al., 2016). In France, 15% - 20% of medical wastes is infectious-hazardous wastes (Mbarki et al., 2013). In the USA, about 15% of total hospital waste is considered as infectious waste. In the Nepal, about 10% -25% of medical wastes is infectious-hazardous wastes (Sapkota et al., 2014). But in India this could range from 15% to 35% and in Iran about 29.89% depending on the total amount of waste produced (Patwary et al., 2009; Yurtseven et al., 2010). This study revealed with an average of 36.05% for the whole hospital. The highest percentage (63%) of total medical wastes were general, 36.05% were infectious wastes while 0.18% were sharps, 0.1% were chemical and pharmaceuticals, 0.1% were pathological wastes, 0.02% were radioactive (Figure 1). In comparison to the study performed in Fars province, Iran, 71.44% consisted of general waste, 27.8% infectious waste, and 0.76% comprised of sharps (Dehghani et al., 2008). Nemathaga et al. (2008) showed that in South Africa (60.74%) general waste, (30.32%) medical waste and (8.94%) sharps (Nemathaga et al., 2008).

This indicates the importance for managing food preparation and serving in the hospitals in ways that reduce medical waste generation rates. According to those results, we concluded that, in order to reduce and minimize the generation rate of both hazardous-infectious and general waste, more attention should be paid to staff management and education.

The composition of the generated waste was found to be 16.6±1.44% paper, 18.8±2.35 % plastic, 4.9±0.27% glass,

16.5±1.01 % textile, 0.87±0.03% metals, 24.7±2.35% food-waste, and 17.63±1.91% other (Figure 2; Table 4). Quantitative analysis indicates that food residues had the highest contribution of 24.7±2.35%. Plastic had the second highest percentage with a range of 18.8±2.35 %. A comparison of the present study with the results of another study that was conducted in various countries does not show exact agreement. Olaniyi et al. (2019) showed that domestic wastes made up 61.1% of the total waste stream and 38.9% were hazardous. Hasan and Rahman (2018) showed that the surveyed health-care establishments in Bangladesh generated 77.4% of non-hazardous wastes and about 22.6% were hazardous. Marinković et al. (2008) showed that paper 53%, food and other organic material 17.5%, plastic 14.6%, diapers 3.5%, metal 2.6%, glass 1.8%, cleaning remains 1.6%, and other 4.5%. In Tehran, revealed that of the total waste generated, 7% was infectious, 56% domestic, and 15% sharp waste (Arab et al., 2008). In Tabriz, the average total production of the total waste, 70% was general waste, 29% hazardous, and 0.5% sharp waste (Taghipour and Mosaferi, 2009). Jaafari et al. (2015) showed that in Iran general waste 56%, medical 42%, sharp 2%. Therefore, it can be concluded that the composition of medical waste is not only different among various hospitals but also among different countries. Specific weight is typically expressed as mass per unit of volume, and it should be noted that it is commonly incorrectly referred to as density in the solid waste literature. For the purposes of medical waste management, it is important to know the specific weight of the waste for the following reasons: Determination of storage space, evaluation of capacity and size of the collection devices and vehicles, estimation of the requirements for processing equipment and etc. (Taghipour and Mosaferi, 2009). The average specific weight of total medical (hazardous-infectious and general wastes) was determined to be 161±12 kg/m³.

Assessment of the current hospital waste management system

In 77.77% hospitals, waste is transported daily and in 22.23% hospital, transportation is performed on alternate days. In 66.66% hospitals, availability of central storage facility special trucks and in 33.34% hospitals, general trucks are used for

offsite transportation of waste (Table 5). In 33.33% hospitals, availability of refrigerated storage for infectious waste Da Silva et al. (2005) reported that in southern Brazil about 85% of hospitals have external storage areas for medical waste management. Birpinar et al. (2008) reported that in Istanbul 63% of the hospitals have a temporary storage depot and transport. Farzadkia et al. (2015) reported that in Karaj-Iran 63% of the hospitals has a temporary storage. Dehghani et al. (2008) reported that in Tehran 75% of the hospitals the stay-time in storage sites was about 12-24h. 92% of medical wastes of hospitals were collected by covered-trucks.

About 44.44% of the hospitals autoclave their highly infectious medical waste prior to disposal, while incineration is used in 33.33% of the hospitals. In this study about (77.77%) were equipped only with one treatment equipment. In Iran about (82.5%) were equipped only with one treatment equipment such as: autoclave, hydroclave, chemical treatment and incinerator (Taghipour and Mosafiri, 2009; Sartaj and Arabgol, 2015). In

77.77% hospitals have training programs about medical waste management for cleaning workers; about 22.23% of the hospitals had not provided training to cleaning workers. Several studies found that Asian countries need to training programmes (Farzadkia et al., 2015; Khan et al., 2019). All hospitals (100%) indicated their needs and willingness to participate in future specialized training programs in medical waste management. Farzadkia et al. (2015) reported that in Karaj-Iran 88% of the hospitals have a waste management were ranked moderate (Farzadkia et al., 2015). Most of the hospitals (95%) used medical waste labeling to differentiate it from domestic waste. About 11.11% of the hospitals had storage period lower 24 h, 66.66% 24 to 48 h, and 22.22% higher 48 h. According to scientific standards, infectious waste in tropical areas can be kept in a temporary storage area for 24 h during the hot season and up to 48 h in cooler seasons. Several hospitals in Asian developing countries have been carried out have secure storage (Hong et al., 2018; Khan et al., 2019).

Table 4. Composition of total medical waste generated in hospitals (Wet weight %).

Name of hospital	Plastic	Textiles	Food waste	Glass	Metals	Paper/cardboard	Others
Kashani	20.6±2.7	17.2±2.2	30.1±2.6	5±0.3	1.05±0.1	15.4±1.8	10.65±1.3
Hajar	22.5±2.8	18.8±0.8	27.5±2.2	6±0.2	1±0.04	11.9±1.5	12.3±1.2
Valiasr	18.8±1.9	20.8±0.9	26.9±2.7	5±0.1	0.89±0.03	14±1.2	13.61±1.3
Shohada	11.8±2.2	13.9±0.7	30.7±3	4.5±0.3	1.01±0.03	16.9±1.6	21.19±2.1
Seied of Shohada	9.8±2.5	12.8±1.1	30±3	6.8±0.4	0.55±0.01	17.8±1.2	22.25±1.9
Sina	21.8±2.9	19.9±1.2	20.7±3.2	3.5±0.3	0.55±0.01	18.9±1.1	14.65±1.5
Imam Reza	13.8±1.2	17.9±1.12	19.2±2.2	2.8±0.4	0.78±0.02	17.9±1.3	27.62±1.8
Imam Javad	14.8±1.8	11.9±0.4	10.9±1.4	4±0.3	0.22±0.01	20.7±2.1	37.48±2.8
Imam Ali	13.9±3.2	12.9±0.7	18±0.9	5±0.2	0.76±0.02	11.9±1.2	37.54±3.3
Average	18.8±2.35	16.5±1.01	24.7±2.35	4.9±0.27	0.87±0.03	16.6±1.44	17.63±1.91

Table 5. Status of management medical waste in hospitals in the province Charharmahal and Bakhtiari.

Issues related to management medical waste	Availability of central storage facility	Availability of refrigerated storage for infectious waste	Separate chamber for domestic waste	Availability of temporary storage facility	Are storage facilities disinfected?	Daily disinfection for storage facility	Are there assigned vehicles for transporting medical waste offsite?	Distance of outside transport: Short	Storage period:	Type of treatment:	Training programs about medical waste management
Yes (%)	66.66	33.33	66.66	66.66	66.66	22.22	77.77	Short: 77.77	<24 h: 11.11	Incineration: 33.33	77.77
								Long: 22.22	24-48 h: 66.66	Autoclaving: 44.44	
									>48 h: 22.22	Others: 22.33	

Conclusion

The main findings of this study are identified below: The medical waste generation rate ranged from 1.37 ± 0.2 to 3.22 ± 0.4 kg/bed day with a weighted average of 2.12 ± 0.37 kg/bed day. About 66.66% of the hospitals had temporary storage areas. Some storage practices were not strictly conducted in accordance with the requirements of the regulations 77.77% of the hospitals surveyed has provided training for cleaning workers. This suggests that there is a lack of sufficient training and education programs for all staff and that the training and education mechanism in some hospitals is still not developed. The specific weight of total medical waste (hazardous-infectious waste, and general waste) was determined to be 161 ± 12 kg/m³. The composition analysis indicated that food waste, plastic, and paper/cardboard have the highest contributions, $24.7 \pm 2.35\%$, $18.8 \pm 2.35\%$, and $16.6 \pm 1.44\%$, respectively, in total medical waste. Management of medical waste in the province Charharmahal and Bakhtiari, and Iran has shown positive signs of improvement in recent years. This improvement has been demonstrated through national medical waste legislation, and the establishment of a centralized controlled autoclaving and incineration facility for treating hazardous and infectious medical wastes. Surveys show that an appropriate management reduces medical wastes generation by up to standard, causing less environmental and health problems in storage, transportation and disposal of hospital wastes. On this basis, training hospital staff and preparing a guideline for separation of medical wastes at the source will be a suitable measure toward a more effective waste management system.

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