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Assessment of Solid Waste Management in Hospitals and Healthcare Centers: A Case Study in Sari, Iran

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Abstract: Infectious waste is categorized as hazardous waste that can cause the transmission of infectious diseases, so the objective of this study was to survey the hospitals and healthcare centers waste management in Sari, Iran in 2015. This study was analytical cross-sectional study. The study population consisted of all hospital (private and public) and all healthcare centers, medical diagnostic laboratories, offices included (public, specialized and dental offices) which was selected through random sampling. In the present study, the questionnaire consisted of open and closed questions was used. The result showed that per capita of hospital waste generation was 2.41 kg/day per active bed in hospital, 0.13 kg/day per person in laboratories and 1.73 kg/day per generated unit in healthcare center. Infectious wastes constituted 35.87% of total generated waste, 65.42% of total generated waste in laboratories, 7.11% of total generated waste in healthcare centers and 33.19% of total generated waste in offices as well. The amount of waste that separated in hospital, healthcare center, offices. The maximum amount of infectious waste generation were related to hospitals, healthcare center, medical laboratories and offices included (public, specialized and dental offices), respectively. In regard to improper separation of waste in offices and laboratories, it is recommended to encourage employees to reduce the hazardous waste, burning the infectious waste and collecting the noninfectious waste through the special machines.

Key words: Solid waste management, hospital, healthcare centers, Sari, Iran

INTRODUCTION

In recent years, the special consideration to the environment aspects such as solid waste in the communities has been interest of worldwide. Now a days, growth of rapid population, industry development, technology progress and increased consumption of people led to more solid waste generation which can create the huge social and economic crisis in the community (Mousavi *et al*., 2015). Hospital and healthcare center waste are considered as one of the most important source of solid waste generation in every city and actually generated a wide range of solid waste (Verma *et al*., 2008). Despite the few number of hospitals but generated the most of hospital and medical waste rate in every country among the various source of medical waste generation (Oweis *et al*., 2005). According to the definition of World Health Organization (WHO), hospital waste is refered to generated waste in the process of diagnosis, treatment, immunization of human being and animal and research and biological test, etc. Hospital waste are classified into different category included, household and hazardous wastes.

The generated infectious waste by hospitals categorized as the hazardous waste in respect to the type of activity and hygiene standard that constitute 3-90% of total medical waste. Disregard the infectious waste collection is regarded as one of the hazardous waste classification. The generated infectious waste by research healthcare activities includes pathogens can transmitted the infectious diseases potentially (Dehghani *et al*., 2008). Hospital waste management emphasized the control and constant monitoring of the production, storage, collection, transport, treatment and disposal of waste (Sawalem *et al*., 2009). Therefore the quantity and characteristics of solid waste should be identified, this

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solid waste include the generated waste in medical facilities and medical waste that should be managed. Unfortunately, there in not sufficient information regarding the quantities and characteristics of various waste that generated in medical facilities. Therefore, the proper medical waste management particularly in developed countries is almost difficult (Diaz *et al*., 2008). Now a days, the numerous researches have been carried out about the hospitals and healthcare center waste management (Bazrafshan and Mostafapoor, 2011). Mohee (2005) surveyed the medical wastes characterization in healthcare institutions in Mauritius and found that 10% of generated solid waste in this center was categorized in dangerous type (infectious, pathological and chemical) (Mohee, 2005). Bdour *et al*. (2007) assessed the medical wastes management practice in the Northern part of Jordan and showed that there was not a defined practice regarding the handling and disposal of healthcare center waste and specific rules and regulation for classification and separation of hospital waste as well. Owing to growing rate of infectious waste and different publication regarding the quantity of infectious waste inside and outside the country and also dearth of information about current situation of infectious waste in hospital and healthcare system in Sari, Iran so present study surveyed the quantity and quality analysis of infectious waste and also assessed the existing situation of hospital waste management system in 2015. By consideration the result of this research, the risks associated with medical waste management and defects in the system will be determined. And also by identification the quantities of generated waste and the other parameter it will allows the hospital designers, officials that involved in healthcare center management and municipal services to planning the general policies, required instruments, staffing services and related cost base on obtained statistic and information.

MATERIALS AND METHODS

This analytical cross-sectional study was done in Sari, Iran in 2015. The study population consisted of all hospital in Sari which included five private hospital and four pubic and academic hospital, 21 healthcare center, 15 medical diagnostic laboratory, 35 laboratory in the city and 235 offices included (general, specialized and dental offices). The questionnaire that was used in the present study were consisted of open and closed questions. In order to identified the weight of bag waste (little, medium and large) in some of the offices, hospitals and healthcare centers, a lab balance (PM Mettler model with precision weighing of 0.01 gram) was used. The average weight of little, medium and large bags were 1.5, 3.5 and 7 kg, respectively and the average volumes of waste bags were identified. The 50 small bag, 20 medium bags and 10 large bags occupy a volume equivalent to 1 m^3 individually. The data collection from addressed centers were arranged in tables and then analyzed through Excel Software.

It should be noted that also the average weight and volume of generated waste in addressed centers were calculated and then the final information were depicted by chart. In this study, the healthcare center waste were divided into two categorize (ordinary or domestic and infectious waste) in respect to environmental importance and potential risk. Per capita of waste generation in offices, healthcare center and laboratories (according to kg/patient/day) and in hospital (according to kg/bed/day) were determined through following relationship (Eq. 1 and 2):

$$\text{Per capita of waste generation (kg) per active bed} = \frac{\text{The amont of waste generation (kg)}}{\text{Active bed}} \quad (1)$$

$$\text{Per capita of waste generation (kg) per active bed} = \frac{\text{The amont of wastegeneration (kg)}}{\text{The average of referred patient}} \quad (2)$$

RESULTS AND DISCUSSION

It was found that hospital waste generation in Sari was 3130 and 1120 kg of this hospital waste related to infectious waste (Table 1). The total of generated hospital waste were related to private (45.68%) and public hospitals (54.31%). The infectious and noninfectious waste constituted 35.78 and 64.21% of total generated waste, respectively in surveyed hospital in Sari. As it can be seen in Table 2, 44.64 and 55.35% of total infectious waste in hospitals were related to private and public hospital, respectively. The amount of generated waste in surveyed hospital was equal to 2.41 kg/day per active bed in hospital which compare to total amount of generated waste in the city (430 ton/day), constitute 0.72 of total

Table 1: The weight of generated waste in surveyed hospitals in sari base on ownership

The weight of infectious waste in hospitals (Kg/day)		The weight of noninfectious waste in hospitals (Kg/day)		The total of generated waste in hospitals (Kg/day)	
Public	Public	Public	Private	Public	Private
620	620	1080	930	1700	1430

Table 2: The weight of total generated waste in surveyed hospitals in Sari base on name of hospital

The name of hospital	The weight of infectious waste (Kg/day)	The weight of noninfectious (Kg/day)	The total of waste (Kg/day)
Imam	200	300	500
Booali	180	280	460
Zare	130	300	430
Fatemeh Zahra	110	200	310
Mehr	70	120	190
Hekmat	80	140	220
Shafa	140	260	400
Nime Shaban	140	280	420
Amir	70	130	200

The total weight (kg/day): 3130

Table 3: Per capita of total waste generation in surveyed hospitals (kg/day) base on ownership

	Per capita of total waste generation per active bed		
The type of hospital	Infectious	Noninfectious	Total
Public	0.73	1.27	2.01
private	1.10	2.05	3.15

Table 4: Per capita of waste generation in surveyed hospital in sari base on name of hospital

	Per capita of total waste generation per active bed		
The type of hospital	Infectious	Noninfectious	Total
Imam	0.710	1.079	1.798
Booali	0.720	1.120	1.840
Zare	0.650	1.500	2.150
Fatemeh Zahra	0.940	1.700	2.649
Mehr	1.550	2.660	4.220
Hekmat	1.379	2.410	3.790
Shafa	0.930	1.730	2.660
Nime Shaban	0.930	1.860	2.800
Amir	1.400	2.600	4.000

Table 5: The volume of generated waste in surveyed hospitals in Sari

	The volume of generated waste (m^3/day)		
The name of hospital	Infectious	Noninfectious	Total
Imam	3.0	4.3	7.3
Booali	3.0	4.0	7.0
Zare	2.0	4.3	6.3
Fatemeh Zahra	1.0	3.0	4.0
Mehr	1.0	2.0	3.0
Hekmat	1.2	2.0	3.2
Shafa	2.0	3.7	5.7
Nime Shaban	2.0	4.0	6.0
Amir	1.0	2.0	3.0

waste in Sari. The amount of generated waste was 2.01 kg/day per active bed in public hospital and 3.15 kg/day per active bed in private hospital (Table 4).

Also, the total volume of waste in surveyed hospitals was 45.5 m^3/day and 16 m^3 of this amount was related to infectious waste (Table 5). The result of study showed that waste generation in laboratories were 94 kg/day that consisted of infectious waste (65.42%) and noninfectious waste (34.57%) (Table 6). Per capita of generated waste in laboratories was 0.13 kg/day per person. And the investigation showed that per capita of generated waste in laboratories was 1.35 m^3 /day and 0.89 m^3/day of waste related to infectious waste (Table 6). Per capita of generated waste in healthcare centers was 81.63 kg/day which consisted of infectious waste (7.11%) and noninfectious waste (92.88%) (Table 7).

Per capita of generated waste in healthcare centers was 1.73 kg/day per each generated center of infectious waste (Table 8). And also, the amount of generated waste in healthcare center was 1.162 m^3/day and 0.072 m^3 of this amount related to infectious waste (Table 7). The result found that the surveyed offices consisted of general physician (19.14%), specialist (54.89%) and dentist (40%) and 86.46% of these center generated infectious waste and other only generated noninfectious waste.

Based on obtained result, the amount of generated waste in total offices was 804.5 kg/day and 32.19% and 67.81% of this amount were related to infectious and noninfectious waste, respectively.

And also 13.42, 32.13 and 54.4% of total generated waste in offices were related to general physician, specialist and dentists, respectively. Per capita

Table 6: Per capita of total waste generation in surveyed laboratories in sari (kg/day)

	The weight of waste generated (kg/day)			The volume of waste generated (m^3/day)		
The name of laboratories	Infectious	Noninfectious	Total	Infectious	Noninfectious	Total
Mazandaran	7.0	7.0	14.0	0.10	0.10	0.20
Dey	3.5	2.0	5.5	0.05	0.03	0.08
Bozorgmehr	1.5	1.5	3.0	0.02	0.02	0.04
Bahar	1.0	2.0	3.0	0.02	0.03	0.05
Markazi	3.0	5.0	8.0	0.04	0.07	0.11
pars	8.0	2.0	10.0	0.12	0.03	0.15
Roshan zamir	7.0	1.5	8.5	0.10	0.20	0.12
Danesh	14.0	3.0	17.0	0.20	0.04	0.24
Borzoie	4.0	1.5	5.5	0.06	0.02	0.08
Nirroye entezami	1.0	0.5	1.5	0.02	0.01	0.03
Shahriyar	5.0	2.0	7.0	0.07	0.03	0.10
Andisheh	5.0	1.0	6.0	0.07	0.01	0.08
Razi	1.5	3.5	5.0	0.02	0.05	0.07

Table 7: The weight and volume of generated waste (day) in surveyed healthcare center in Sari

	The weight of generated waste (kg/day)			The volume of generated waste (m^3/day)		
No. of health center	Infectious	Noninfectious	Total	Infectious	Noninfectious	Total
1	0.2.0	2.80	3.0	0.002	0.04	0.042
2	0.23	4.77	5.0	0.003	0.07	0.073
3	0.60	5.40	6.0	0.008	0.08	0.088
4	0.20	3.80	4.0	0.002	0.05	0.052
5	0.23	4.27	4.5	0.003	0.06	0.063
6	0.24	5.76	6.0	0.003	0.08	0.083
7	0.21	3.29	3.5	0.003	0.05	0.053
8	0.50	4.50	5.0	0.007	0.06	0.067
9	0.19	3.31	3.5	0.002	0.05	0.052
10	0.20	2.80	3.0	0.002	0.04	0.042
11	0.27	2.93	3.2	0.003	0.04	0.043
12	0.27	3.23	3.5	0.003	0.05	0.053
13	0.50	4.50	5.0	0.007	0.06	0.067
14	0.27	2.73	3.0	0.003	0.04	0.043
15	0.25	2.75	3.0	0.003	0.04	0.043
16	0.26	2.74	3.0	0.003	0.04	0.043
17	0.26	4.74	5.0	0.003	0.07	0.073
18	0.24	2.76	3.0	0.003	0.04	0.043
19	0.24	3.26	3.5	0.003	0.05	0.053
20	0.22	2.78	3.0	0.003	0.04	0.043
21	0.23	2.77	3.0	0.003	0.04	0.043

Table 8: Per capita of total generated waste in surveyed healthcare center in Sari

Per capita of infectious waste per each generated unit (kg/day)		
Infectious	Noninfectious	Total
1.73	1.61	0.12

of waste generated in offices was 0.39 kg/day per person and 10.823 m^3 of waste generated in offices and 3.618 m^3 of this amount was infectious waste. Base on obtained result from hospital staff, generally (2981 person which reflected the 14.59%) of the total hospitals staff are solid waste services workers and also in laboratories (153 person equal to 12.41%) and in healthcare center (166 person equal to 40.96%) of the total hospitals staff and maximum 1 person in each office was solid services worker. The investigations showed that the surveyed hospital used the wheelbarrows for waste collection. The time of waste collection was at the end of the shift. In addition, all of the surveyed hospitals in Sari has a waste temporary storage place for infectious and noninfectious waste that 44.44% of storage place did not have any problems but 55.55% of storage place have the problem such as lack of washing and lack of disinfection frequency and ventilation as well. And 44.44% and 55.55% of temporary storage place had less and more distance than (50 m) to nearest wards, respectively. All of the hospitals are equipped with incinerator and incinerator model were phoenix (44.44%) and column (55.55%) incinerator. All of incinerators were active and has a specific responsible. The function of 66.66% incinerator reported good and rest of incinerator (33.33%) have problem. Among all of the hospitals, 55.55 and 44.44% of hospital were located at more and less distance of (50 m) to the nearest residential areas, respectively. The result revealed that 15.38 and 84.61% of laboratories worked one and two work shift, respectively. And also the waste separation has been performed in 76.92% of laboratories and from this number, 80% of laboratories used different container with specified colors, 10% used the bag waste with specified colors and 10% of laboratories used the separate container with specified labels. The result showed that the martial of waste container in laboratories

Table 9: The criteria for total number of facilities staff according to number of bed

The number of bed	<100	100-200	200-300	300-400	400-500
The number of facility staff	12	21	33	45	58

were ordinary (53.48%) and specified plastic (46.15%). Base on finding, laboratories transformed the infectious waste in specified bags and tightly closed (96.3%) and used the other practices (3076%). The investigation showed that healthcare center in Sari worked one work shift (15.38) and two work shift (84.61%) and 47.47% of generated waste in healthcare center was infectious waste. The waste separation was performed in entire healthcare center in Sari. The result revealed that the sharp infectious waste collected in safety box and the other waste are collected in separate containers bags with specific colors. The material of waste container at all of healthcare center for infections and noninfectious waste were ordinary and specified plastic, respectively. Also all the healthcare center did not have the waste temporary storage place and infectious waste collected base on daily schedule. All the healthcare centers did not have incinerator and infectious waste were transferred to hospitals.

It was seen that offices performed the separation of infections waste (54.78%) and among these offices, separation in separate container with specified colors were (30.15%), separation in container with specified labels were (6.34%) and separation the infectious waste in bags with specified colors were (39.68%) and also 26.98% of offices use the other practices. Offices worked in one work shift (40.6%) and two work shift (59.39%) and it was also found that 13.53 and 86.46% of offices have the specefic and nonspecific time for collecting and disposal of waste, respectively. Also, transport and disposal of solid waste in offices were done in specefic plastic (2.25%) and ordinary plastic (97.74%). The material of waste container in offices was plastic (93.23%) and Stainless Steel (6.76%). The obtained result found that offices that generated infectious waste used incinerator for waste disposal was (3.47%) and offices disposed the waste with support of municipalities' services was (96.25%).

The investigation showed that all of the surveyed hospitals and healthcare centers in Sari generated more than 3130 kg/day of infectious and non-infectious waste. Per capita of solid waste in developed and industrialized countries are approximately 4.54 kg/bed/day (Mohee, 2005). Comparing this figure with annual per capita of waste (2.41 kg/bed/day) in this city represent the notable topic regarding the different per capita of waste per bed in different countries and maybe in different cities of a country.

It may be attributed to the better quality of services and also more use of disposable containers in private hospitals. Difference the waste generation rate per bed in different cities of a country can be associated with the items such as use of disposable container, the type of healthcare services and the function of hospital according to hygiene rules, cultural and economic aspect and the number of visitors, students and staff as well (Birpinar *et al*., 2009). And also difference the per capita of infectious waste generation in different center such as hospital, medical laboratories and healthcare center may be attributed to differences in the number of these centers, the number of centers that represent health services and associated with referred patient, waste services workers and the type of services (Yong *et al*., 2009; Da silva *et al*., 2005).

The investigation regarding the waste container showed that all of healthcare center did not have any problems in terms of material the waste container and hygiene condition as well. Wheelbarrow is used in all of the hospitals to transfer the waste from point source to the collection center but for this purpose in laboratories and healthcare centers the manual method (trash bag) are used. In respect to lack of temporary storage waste place in the offices, laboratories and health center and the role of manual method in environment pollution such as leakage of leachate from bags, so waste collecting would be better perform by specified wheelbarrow like the hospitals. The best practice in hospital waste management is transfer of waste as soon as possible to determined place without repeatedly movement. And it is better that the waste collection be performed when the number of employed staff and referred patient are low. Waste collection is done at the end of work shift at all of the hospitals.

Infectious wastes in healthcare center are collected base on daily schedule and the noninfectious waste are stored for 7 h. The time average of stored waste in the offices is 17 h. This time doesn't create the problems in hospital due to proper condition of hospitals but in the healthcare center and offices, too long hour may be creating the environmental pollution and unfavorable odor (Parandeh and Khanjani, 2012). According to addressed criteria in Table 9 and comparing them with the number of waste collection workers in the hospitals, it can be concluded that the number of facilities staff are more in compare to addressed criteria. The leading reason of this

subject may be result of different task of solid waste service worker and moreover related activity. And the other reason may be due to numerous staff. Actually a certain task has not been devoted to staff and as a result it led to low quality of waste collecting in the hospitals. All of the hospital have the waste temporary storage place. Although, offices, laboratories and healthcare center did not have waste temporary storage place, because the waste stored <24 h and also less volume of waste generation in addressed centers. And another issue related to improper space and inadequate site which lead to waste located outside the temporary stage. Generally, the weather in Sari is rainy and it led to increase the weight of waste and also create the leachate in courtyard of the hospital and cause the contamination of hospital environment. Based on obtained result the waste separation do not performed completely in all of the offices and laboratories, it may be due to dearth of appropriate practice for disposal of infectious waste. It was also found that all the hospital has performed the waste separation, but sometimes the infectious waste was seen in the noninfectious container. One of the reasons may be related to lack of responsibility among the doctors and nurses in the words or associated with educational problem and generally the education regarding the hospital waste management. In regard to high level of groundwater in some area, mixing of infectious and noninfectious waste and disposal with municipal solid waste can create difficulties such as leakage of leachate and creates the hygiene concern for people involved in solid waste services and on the other hand the use of plastic in the infectious waste by profiteering which can create the numerous problems. Some of the risk assessment methods must be used in hospital for assessing health risk factor (Yarmohammadi *et al*., 2016; Pirsaheb *et al*., 2016). Technical committee of nosocomial infections is useful in management of solid waste and etc (Vatankhah *et al*., 2014). knowledge, attitude and performance of staff of hospital in relation to job's environmental health must be useful in waste management (Almasi *et al*., 2016).

CONCLUSION

In regard to the low disposal of infectious waste in offices, it should be necessary to corporation of municipalities and Environmental Protection Agency aimed at treatment of infectious waste in order to prevent the problems of mixing the infectious and noninfectious waste.

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