



Original Article



Qualitative and Quantitative Analysis of Medical Wastes of Shariati Hospital in Tehran

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Abstract

Background: Given the increasing need for health care and the expansion of various medical facilities in health care centers, it is necessary to determine the adverse effects of subsequent medical wastes. In this study, we aimed to perform a qualitative and quantitative analysis of medical wastes of Shariati public hospital in Tehran.

Methods: We weighted the medical wastes to determine the share of each hospital section in total hazardous medical wastes generation. Then, the components of common and infectious medical wastes were analyzed. The raw data were analyzed using Excel and R software.

Results: The total amount of generated medical wastes of common, infectious, sharp, and chemical/pharmaceutical wastes in the hospital were 982.78 ± 27.08 , 885.76 ± 26.11 , 37.062 ± 1.55 , and 45.33 ± 3.2 kg/day, respectively, and the average amount of wastes generation in each ward of the hospital per day was between 1.47-6.86 kg/bed. Also, we considered the production of medical wastes in detail and found that it was 0.61-3.11, 0.77-4.78, 0.03-0.23 and 0.01-0.91 Kg/patient/day for common, infectious, sharp and chemical/pharmaceutical wastes, respectively.

Conclusion: The average amount of wastes produced in the hospital was consistent with the World Health Organization's (WHO's) report based on the amount of daily wastes generation in academic hospitals (4.1-8.7 kg/bed/day). However, the overall amount of infectious and sharp wastes in the hospital was 47.37% which exceeded the recommended amount by the WHO (15-25%).

Keywords: Hospital, Medical waste, Waste generation, Waste management

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Introduction

The medical wastes include the generated wastes from health care centers, research institutes and laboratories, along with other small sources of home care wastes, such as dialysis, insulin and self-care. According to World Health Organization's (WHO's) reports, 80-85% of the wastes produced in health care centers are safe or common, and the remaining (15-20%) are considered as hazardous wastes which may have adverse effects on human health (i.e., 10% are infectious and 5% are chemical/radioactive wastes).¹ Given the potential hazardous nature of medical wastes, the disposal and safety management of these wastes is a public and occupational concern.² Therefore, the safe handling of medical wastes is a managerial issue which entirely needs the participation of health center staffs.³

Hence, waste management has two crucial components. The first one is the management of various types of common and hazardous wastes generated from different sources, which must be carefully separated, collected, transmitted and disposed. The second is the effective training and supervision of the various responsible groups in the waste management system.⁴ According to WHO's statistics, more than two million health workers suffer from skin-related injuries due to sharp wastes in the health care centers each year. Therefore, improvement of medical wastes management could be carried out through national regulation, internal management system, safety training programs, ensuring personnel safety, creating programs for estimating the amount of produced wastes and evaluating the disposal methods.⁵ Many researches



on waste management have been conducted which can help decision makers improving the disposal facilities and special cares in order to handle the medical wastes in a safe way. In this regard, Muluken et al found that only 31.5% of employees were aware of medical wastes management practices in Ethiopia.⁶ Another study showed that the implementation of waste management laws and knowledge of wastes handlers about medical wastes were poor. Also, it has been shown that there was no specific dedicated budget for waste management in Baku.⁷ So, there may be many challenges faced with medical wastes management such as the ineffective execution, lack of information and awareness, remarkable differences and somewhat contradictions between the methods of separation and disposal, considering an efficient budget for medical wastes management.⁸ Accordingly, several case or cohort studies need to be conducted in order to address the medical wastes management issue.⁹ In Iran, there are a few studies assessing the medical wastes management status. Malekhamdi et al conducted a study and evaluated the current status of medical wastes management in Tehran's hospitals. Their results indicated that medical wastes management in 5.6% of cases was excellent. In addition, 50.7%, 26.4%, 13.9% and 3.5% of cases were at good, moderate, poor and very poor condition, respectively.¹⁰ Also, Mohammadian Fazli et al assessed the status of medical wastes management in Zanjan city, and the results showed that the generation of medical wastes in the studied hospitals was higher than the recommended amount by WHO.¹¹ Medical wastes have some properties such as toxicity, pathogenicity, explosiveness or flammability and corrosion. Due to the high volume of productions of medical wastes and their risks, we need to know about the field of various health facilities and the amount of medical wastes generated in the health care centers. In the present study we aimed to investigate the quantitative as well as qualitative of medical wastes generated at Shariati Hospital which is the second largest hospital in Tehran, Iran in terms of number of active beds.

Materials and Methods

Study Design

This study was conducted in 2018 in Shariati hospital with an area of 57 762 m² which has 834 approved beds, 524 fixed beds and 478 active beds. This hospital includes a central building with 7 floors, an emergency room on 4 floors, nuclear medicine on 1 floor and a laboratory on 3 floors. In this descriptive-analytical study, we first investigated the share of each ward and unit of the hospital in generation of medical wastes. To do so, the weighed wastes collected in bags from all units of Shariati hospital were daily measured during a month. Based on WHO's report, one month is at least a period to investigate the daily generation of wastes.¹ During this period, the modality of labeling and filling of bags to $\frac{3}{4}$ of capacity, transferring the wastes from each unit to the final chamber and using personal protective equipment were also examined. Then, the infectious and

common components of subjected wastes were analyzed in order to investigate status of the wastes disposal of Shariati hospital.

In order to minimize the effect of weekend shutdown on the amount of common wastes, weighing was done at the end of each working day for 4 consecutive days (Sunday, Monday, Tuesday, and Wednesday). The samples were weighed and separated to further analysis before transferring them for disposal. The method of this study was first to analyze the weighing of wastes samples to obtain an estimation of overall wastes generation. In order to obtain the wastes samples for analysis, the amount of wastes produced per day was divided by four according to previous studies. The number obtained by this method, was the amount of wastes to be analyzed at every day.¹²

It has to be mentioned that before analyzing and separation of the wastes, the researchers who involved in this study were first examined for hepatitis B virus antibody titres, and they were vaccinated three times in the absence of immunity to prevent unintended infection. Also, for more precise safety measures in all stages of separation, the workers were equipped with personal protective equipment including work gloves, protective glasses, and activated carbon masks (FFP2 class).

Statistical Analysis

The obtained raw data from weighted wastes, along with components and the effect of educational intervention were analyzed using Excel and R software.

Results and Discussion

One of the most important challenges for waste management, especially in developing countries, is the disposal of medical wastes because the medical system is more based on therapeutic approach rather than addressing public health and preventive measures in the countries. It seems that studying the details of wastes generation in medical and health care centers could help improving the medical wastes management. In this regard, some studies have been carried out at various hospitals in Iran. However, for fulfillment of an efficient medical wastes management, further studies are needed to address this issue in detail.

In the present study, the amount of generated medical wastes in the Shariati hospital in Tehran was evaluated in detail, and share of each unit of hospital in total amount of generated wastes was analyzed.

Figures 1-4 show the mean generation (kg/day) of common, infectious, sharp/winning and chemical/pharmaceutical wastes in different wards of the Shariati hospital, respectively.

According to the results, the maximum daily generation of common, infectious, sharp/winning and chemical/pharmaceutical wastes was observed in the kitchen, operating room, emergency department and blood clinic, respectively. Also, nearly 18 percent of the bags and safety boxes (sharp containers) were transferred to the wastes

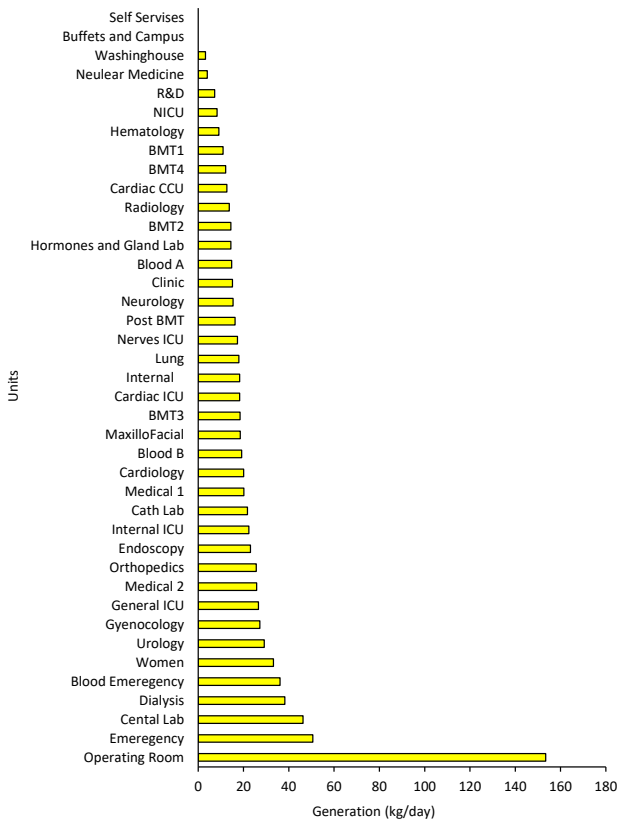


Figure 1. The Mean Generation (kg/day) of Infectious Wastes in Different Wards of the Shariati Hospital.

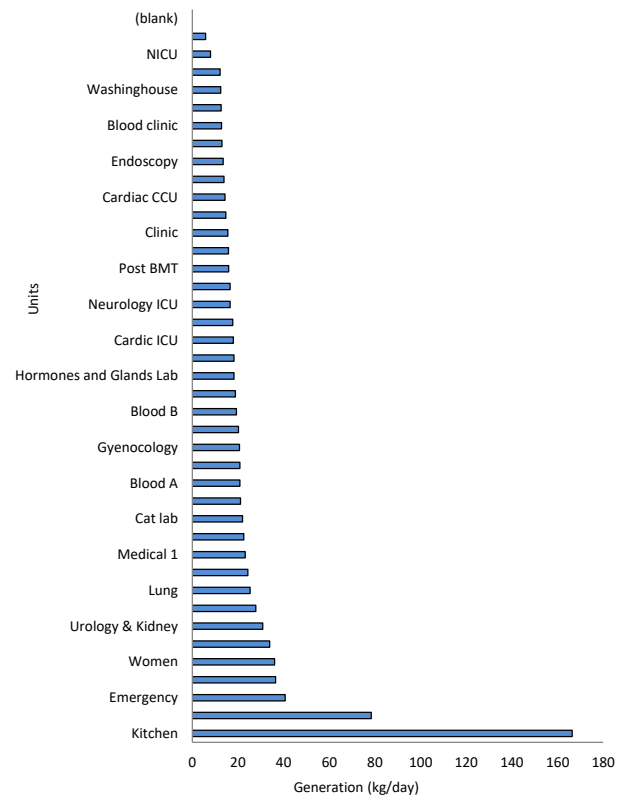


Figure 2. The Mean Generation (kg/day) of Common Wastes in Different Wards of the Shariati Hospital.

chamber in excess of the capacity of 0.75, and only 34 units of the hospital (72 percent) regularly separated the bags and labeled them.

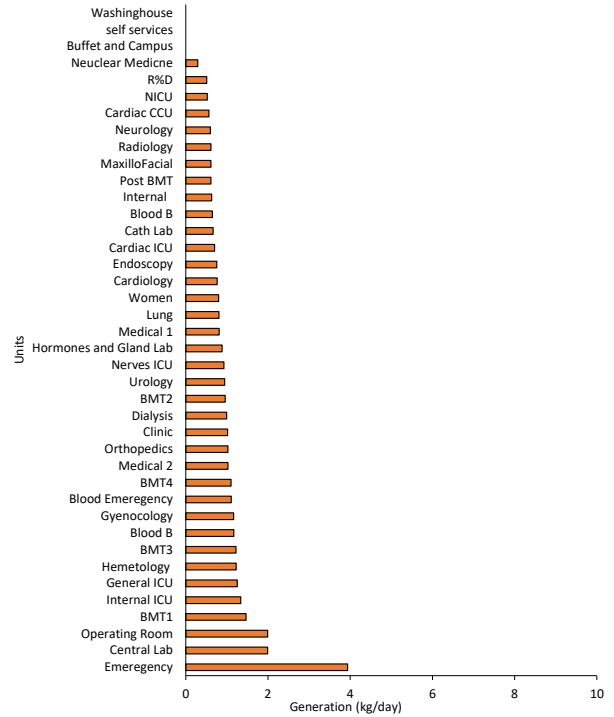


Figure 3. The Mean Generation (kg/day) of Sharp/Wining Wastes in Different Wards of the Shariati Hospital.

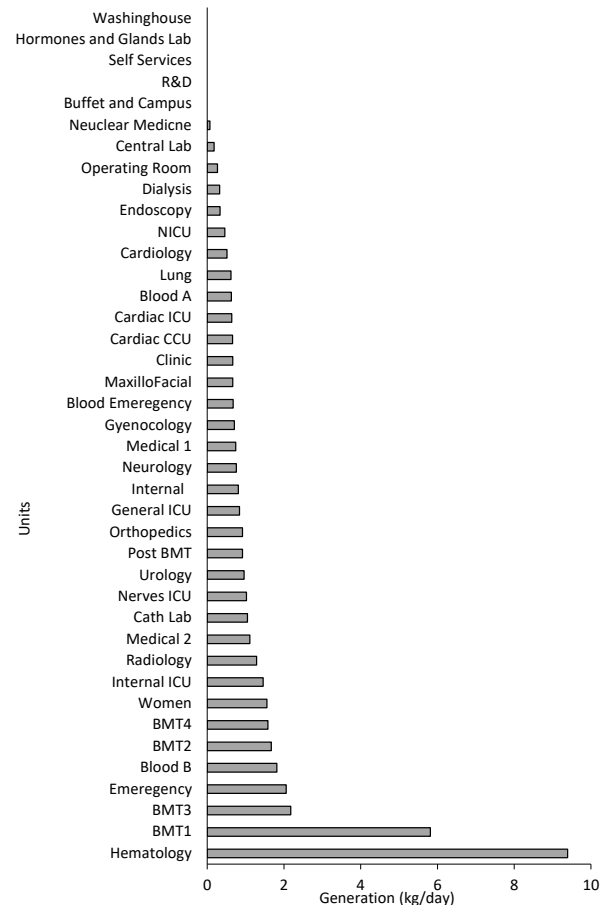


Figure 4. The Mean Generation (kg/day) of Chemical/ Pharmaceutical Wastes in Different Wards of the Shariati Hospital.

In the present study, the sum of total wastes, common, infectious, sharp/winning, and chemical/pharmaceutical in the studied hospital was 1950.521, 982.7 ± 27.08,

885.75 ± 26.11, 37.062 ± 1.55 and 45.03 ± 2.3 kg/day, respectively.

The generated wastes (per daily capita) by different wards have been presented in [Figures 5-8](#).

The average generated wastes in the different units was between 1.46-4.86 kg/bed/day.

In this research, generated per capita wastes including common, infectious, sharp/winning, and chemical/pharmaceutical were 0.61-3.11, 0.7-4.78, 0.03-0.23, and 0.01-0.91 kg/bed/day, respectively.

Compared with other studies conducted in hospitals, it became clear that the total amount of generated medical wastes in the subjected hospital was entirely differ which may be due to having more active units and beds, which makes it more important to take the necessary measurements related to waste management in this hospital. So, the amount of generated hospital wastes is different between hospitals which may complicate the waste management in future.

There are many factors which should be considered in order to have an efficient medical wastes management in small or referral hospitals. The factors can be type of hospital activity, size of the hospital, specialized units of hospitals, number of beds, quality of health services, use of disposables, number of patients, correct collection and separation of different wastes, method of recycling, number of hospitalization days, level of staff awareness and related laws dealing with managing the transportation and disposal of wastes, etc.¹³

The most important principle in the planning and management of medical wastes is to estimate the amount of generated wastes by the subjected institute.¹

The average generated wastes in this study indicates that the amount of generated hazardous and sharp wastes substantially differs in the studied hospital compared with the study of the Torbat Heydariyeh hospital¹⁴ and Wahab.¹⁵

The average amount of produced wastes (per unit bed and day) was between 1.46-6.86 kg. In line with present study, some studies were also conducted in the 11 provinces of Iran in 2012. The studies showed that total wastes generation was 3.5, 4.6, 2.7, 2.3, 4.5 and 4 kg/bed/day in 14 hospitals in Tehran, 3 main hospitals in Sistan and Baluchestan, 7 hospitals in Kerman, 3 hospitals in Khorasan Razavi, 2 hospitals in Kermanshah and 2 central hospitals, respectively¹⁶. Our results are somewhat consistent with findings of the mentioned studies.

Also, our results are in accord with the WHO's report in which the daily wastes generation rate in academic, general and regional hospitals are 4.1-8.7, 1.2-4.2 and 0.5-1.8 kg/bed/day, respectively.⁵

In addition, according to [Figure 9](#), the percentage of household-like, infectious, sharp/winning, and chemical/pharmaceutical wastes in the hospital was 50.38%, 45.41%, 1.91%, and 2.31%, respectively.

Farzadkia et al conducted a study in Tehran academic hospitals, and they reported 10-15% (12.51%) more infectious wastes.¹⁷ Davoodi et al did a study which was

conducted in 10 hospitals in Mashhad city and they found 61.85% of common wastes, 34.9% of infectious wastes and 3.25% of sharps wastes.¹⁸ Also, Debere et al. in their study reported 58.69% household-like wastes and 41% dangerous medical wastes which is somewhat consistent with our results.¹⁹ The study conducted by Taghipour and Mosaferi found 29.4% infectious and 0.45% sharp wastes.²⁰

The percentage of infectious wastes components before and after training is shown in [Figures 10 and 11](#). Considering the importance of waste management laws as well as the existence of numerous hazards due to wastes disposal, the training course was done in different units of the studied hospital to reduce these wastes.

Also, percentage of the physical components of infectious wastes before training were 1.93% foodstuffs, 7.37% paper and cardboard, 58.26% plastic, 0.47% metals, 1.19% glass, .31% sharp wastes, 1.68% pharmaceuticals, 28.58% textiles, 0.01% mercury and 0.21% others. However, after training the including components of infectious wastes were 1.50% foodstuffs, 8.35% paper and cardboard, 56.50% plastics, 0.26% metals, 0.19% glass, 0.14% sharp wastes, 2% pharmaceuticals, 30.91% textiles, 0% mercury and 0.16% others. [Figures 12 and 13](#) show the percentage of common wastes components before and after training.

In this study, percentage of the physical components of the common wastes before training were 43.48% food, 20.46% paper and carton, 22.52% plastic, 2.54% metals, 1.32% glass, 0.05% sharp, 0.53% pharmaceuticals, 8.06% textiles, 0.19% wood, 0.01% mercury and 0.85% others. After training, there were 39.1% foodstuffs, 21.51% paper and carton, 25.94% plastics, 1.79% metals, 1.89% glass, 0% winner, 0.01% pharmaceuticals, 9.70% textiles, 0.05% wood, 0% mercury and 0% others.

In the present study, in terms of the components of ordinary wastes, educational intervention caused a significant decrease (P value < 0.05) in the rate of incorrect disposal of sharp wastes.

Also, in terms of infectious wastes, educational intervention caused a significant decrease (P value < 0.05) in the rate of incorrect disposal of sharp wastes, metals and glass.

Based on the Wilcoxon signed-rank test, the effect of training on reduction of common wastes only caused a significant difference between the median components of the sharp/winning and chemical/pharmaceutical wastes (P value < 0.05). In terms of infectious wastes, it caused a significant difference between the median components of the sharp/ winning, metals, and glass (P value < 0.05).

A study was conducted in 14 hospitals in Zahedan, Iran, in which the component of hazardous wastes was analyzed in detail, it included 43.82% plastic, 4.72% glass, 19.08% food residues, 4.28% metals, 18.18% textiles, 6.12% paper and carton and 3.84% others. In terms of hazardous wastes, the highest percentage was for plastic, food wastes, textiles, paper and carton, glass, metals and others, respectively. However, in the case of common wastes, there were 40.98% plastic, 4.32 glasses, 3.88% etc, 20.74% food

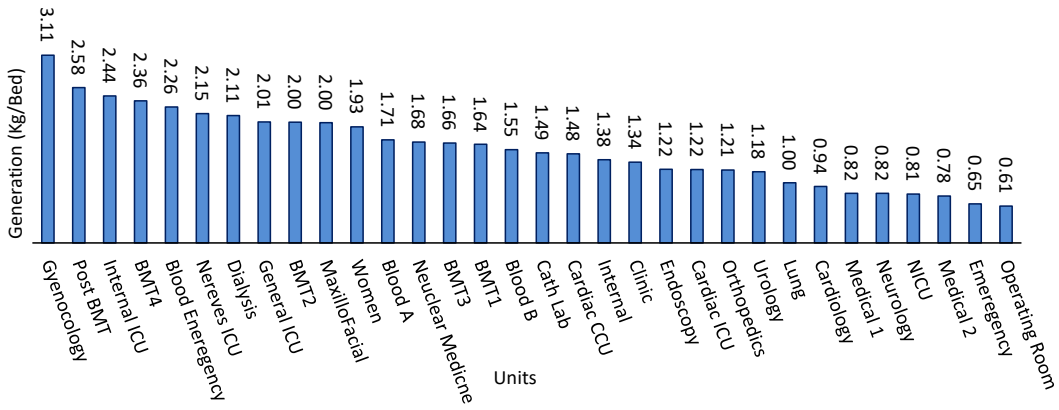


Figure 5. Generated Common Wastes in Different Wards of Shariati Hospital (kg/bed).

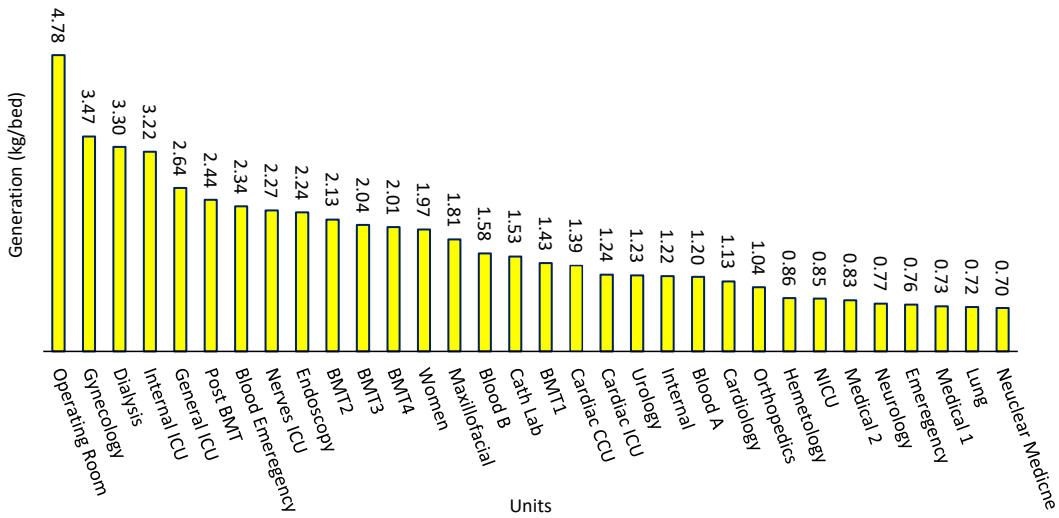


Figure 6. Generated Infectious Wastes in Different Wards of Shariati Hospital (kg/bed).

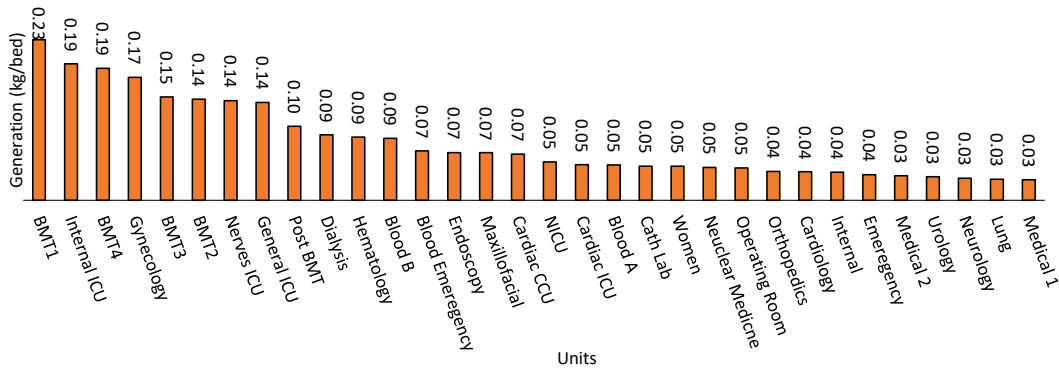


Figure 7. Generated Sharp/Wining Wastes in Different Wards of Shariati Hospital (kg/bed).

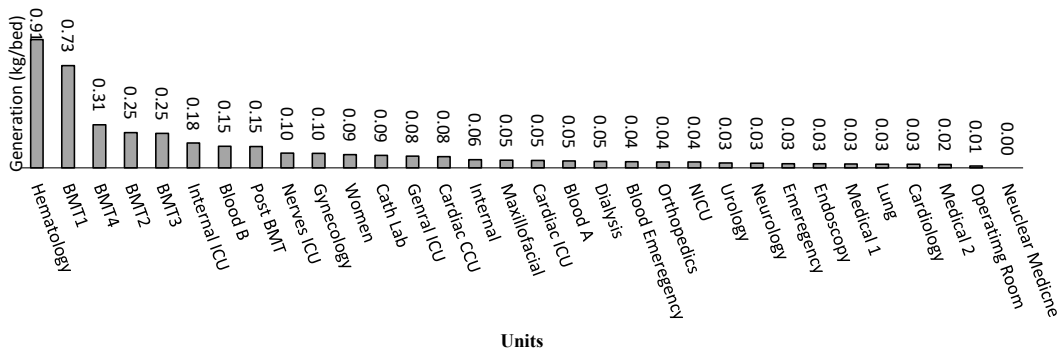


Figure 8. Generated Chemical/Pharmaceutical Wastes in Different Wards of Shariati Hospital (kg/bed).

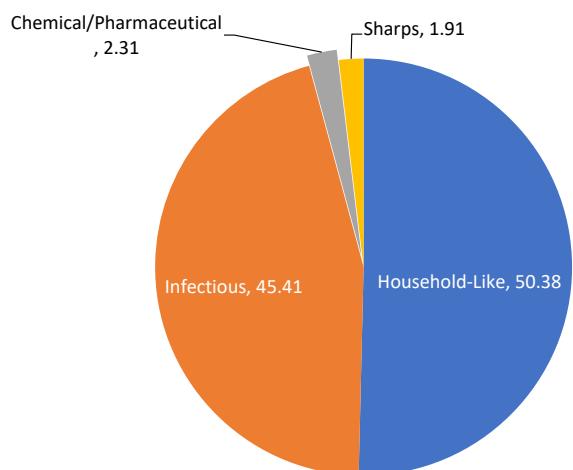


Figure 9. Percentage of All Types of Generated Wastes in the Shariati Hospital.

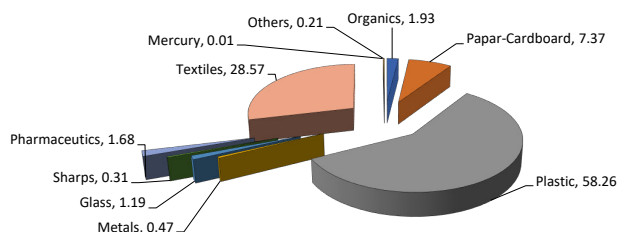


Figure 10. Frequency of Infectious Wastes Components Before Training in the Studied Hospital.

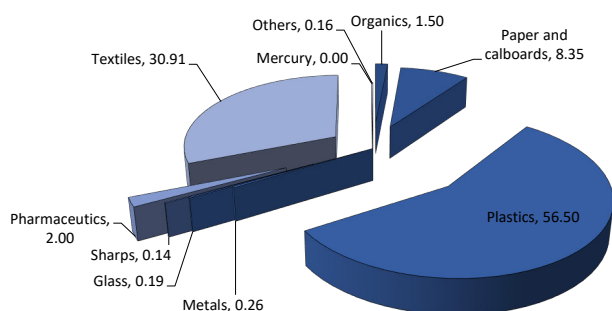


Figure 11. Frequency of Infectious Wastes Components After Training in the Studied Hospital.

residues, 17.2% textiles, 4.92% metals, and 7.96% paper and carton,¹³ which was somewhat consistent with the hazardous wastes components in our study.

In another study which assessed the medical wastes management in 10 hospitals of Tabriz, Iran, it was shown that the physical components of hazardous wastes included 35.72% plastic, 20.84% textiles, 16.70% liquids, 11.36% paper and carton, 7.17% glass, 1.35% sharp, and 6.86% others. Also, in the study, it was shown that the household-like wastes were composed of 46.87% food residues, 16.4% plastic, 13.33% paper and carton, 7.65% liquids, 6.05% textiles, 2.60% glass, .92% metals, and 6.18% other materials,²⁰ which is consistent with our results. The results of a study conducted in the United States showed that household-like wastes mainly composed of 53% paper wastes, 17.5% food residues, 14.6% plastic, 3.5% textiles, 2.6% metals, 1.8% glass, 1.6% of the detergent residues and 4.5% of the other materials.²¹

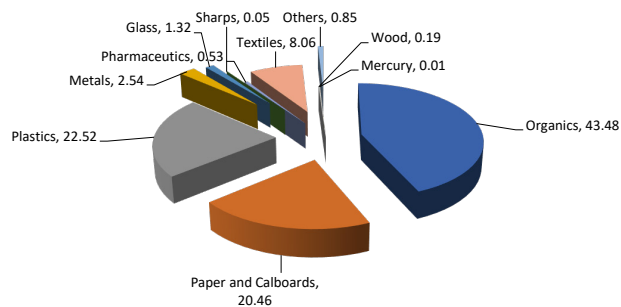


Figure 12. Frequency of Common Wastes Components Before Training in the Studied Hospital.

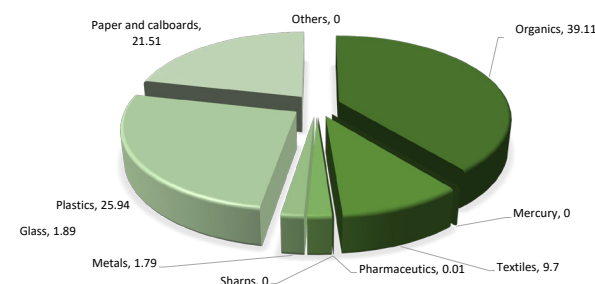


Figure 13. Frequency of Common Wastes Components After Training in the Studied Hospital.

According to WHO, 85% of generated wastes in hospital and health care centers are safe or general, and only 15-25% of them are hazardous (10% infectious and 5% chemical / radioactive). However, our findings clearly showed that 47.37% of the generated wastes are infectious and sharp wastes in the hospital, which is higher than the recommended amounts by WHO. It may be due to various factors such as number of hospitalized patients, disposable items, visited patient, beds, hospitalization days, etc.¹

Conclusions

The generated medical wastes in the hospital were between 1.47-6.86 kg/bed/day, which are in accord with daily waste generation rate in academic hospitals (i.e., 4.1-8.7) reported by the WHO. However, the results showed that the percentage of the infectious/dangerous wastes were higher than the values reported by WHO (i.e., 15-25%). Analysis of the medical wastes components showed that training has significantly reduced the rate of improper disposal of sharp and winning wastes. In this regard, one of the basic measures in the waste management is the proper separation of general and infectious/dangerous wastes. Ultimately, the results of this study showed that a dramatic change could be achieved in medical waste management by proper training of staffs involved in medical wastes collection and separation. It is recommended that a research should be conducted in order to compare private and public hospitals in solving problems related to medical wastes management.

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Authors' Contribution**Conceptualization:** Mahmood Alimohammadi, Najmeh Bayat.**Data curation:** Najmeh Bayat, Mahmood Alimohammadi.**Formal analysis:** Ramin Nabizadeh, Kamyar Yaghmaeian, Mohammad Hadi Dehghani.**Funding acquisition:** Mahmood Alimohammadi.**Investigation:** Najmeh Bayat.**Methodology:** Mahmood Alimohammadi, Najmeh Bayat.**Project administration:** Najmeh Bayat.**Resources:** Najmeh Bayat, Mahmood Alimohammadi.**Supervision:** Mahmood Alimohammadi.**Validation:** Ramin Nabizadeh, Kamyar Yaghmaeian, Mohammad Hadi Dehghani.**Visualization:** Najmeh Bayat, Masoomeh Askari, Kamyar Yaghmaeian.**Writing – original draft:** Masoomeh Askari, Najmeh Bayat, Hamed Soleimani.**Writing – review & editing:** Masoomeh Askari, Najmeh Bayat, Hamed Soleimani.**Competing Interests**

There is no conflict of interest between the authors and others.

Ethical Approval

Not Applicable.

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References

- Chartier Y. Safe Management of Wastes from Health-Care Activities. World Health Organization; 2014.
- Yilmaz O, Kara BY, Yetis U. Hazardous waste management system design under population and environmental impact considerations. *J Environ Manage.* 2017;203(Pt 2):720-31. doi: [10.1016/j.jenvman.2016.06.015](https://doi.org/10.1016/j.jenvman.2016.06.015).
- Mathur V, Dwivedi S, Hassan M, Misra R. Knowledge, attitude, and practices about biomedical waste management among healthcare personnel: a cross-sectional study. *Indian J Community Med.* 2011;36(2):143-5. doi: [10.4103/0970-0218.84135](https://doi.org/10.4103/0970-0218.84135).
- Al-Khatib IA, Al-Qaroot YS, Ali-Shtayeh MS. Management of healthcare waste in circumstances of limited resources: a case study in the hospitals of Nablus city, Palestine. *Waste Manag Res.* 2009;27(4):305-12. doi: [10.1177/0734242x08094124](https://doi.org/10.1177/0734242x08094124).
- Teimori G, Fattahzadeh M, Avakh A, Vahabi M, Nourian R, Karimi MA, et al. Review of hospital waste management in Iran. *Int Res J Appl Basic Sci.* 2014;8(6):649-55.
- Muluken A, Haimanot G, Mesafint M. Healthcare waste management practices among healthcare workers in healthcare facilities of Gondar town, Northwest Ethiopia. *Health Sci J.* 2013;7(3):315-26.
- Alba Mesa F, Sanchez Hurtado MA, Sanchez Margallo FM, Gomez Cabeza de Vaca V, Komorowski AL. Application of failure mode and effect analysis in laparoscopic colon surgery training. *World J Surg.* 2015;39(2):536-42. doi: [10.1007/s00268-014-2827-1](https://doi.org/10.1007/s00268-014-2827-1).
- Mohamed LF, Ebrahim SA, Al-Thukair AA. Hazardous healthcare waste management in the Kingdom of Bahrain. *Waste Manag.* 2009;29(8):2404-9. doi: [10.1016/j.wasman.2009.02.015](https://doi.org/10.1016/j.wasman.2009.02.015).
- Nie L, Qiao Z, Wu H. Medical waste management in China: a case study of Xinxiang. *J Environ Prot.* 2014;5(10):803-10. doi: [10.4236/jep.2014.510082](https://doi.org/10.4236/jep.2014.510082).
- Malekahmadi F, Yunesian M, Yaghmaeian K, Nadafi K. Analysis of the healthcare waste management status in Tehran hospitals. *J Environ Health Sci Eng.* 2014;12(1):116. doi: [10.1186/s40201-014-0116-4](https://doi.org/10.1186/s40201-014-0116-4).
- Mohammadian Fazli M, Baziar M, Nassiri J, Mehrasebi MR. Assessment of hospital waste management in Iran: a case study of Zanjan. *Switzerland Res Park J.* 2013;102(11):1268-76.
- Bayat N, Alimohammadi M, Nabizadeh Nodehi R, Dehghani MH, Yaghmaeian K, Binesh Berahmand M, et al. A survey on the status of hospital waste management using rapid assessment tool unique (I-RAT). *J Res Environ Health.* 2015;1(3):217-27.
- Yuan F, Yao R, Sadrizadeh S, Li B, Cao G, Zhang S, et al. Thermal comfort in hospital buildings—a literature review. *J Build. Eng.* 2022;45:103463. doi: [10.1016/j.jobe.2021.103463](https://doi.org/10.1016/j.jobe.2021.103463).
- Alavi N, Mohammadi MJ, Vosoughi Niri M, Salimi J, Ahmadi Angaly K, Ghaffari Zadeh F, et al. Survey of quantity and quality of medical waste during 2009-2011 in Razi hospital of Torbat-e-Hydareih, Iran. *J Torbat Heydariyeh Univ Med Sci.* 2014;1(4):32-40. [Persian].
- Wahab AB, Adesanya DA. Medical waste generation in hospitals and associated factors in Ibadan metropolis, Nigeria. *Res J Appl Sci Eng Technol.* 2011;3(8):746-51.
- Damani N, Koolivand A, Sadat M, Mahvi AH, Mazloomi S. Hospital waste generation and management in some provinces of Iran. *Toxicol Environ Chem.* 2013;95(6):962-9. doi: [10.1080/02772248.2013.840374](https://doi.org/10.1080/02772248.2013.840374).
- Farzadkia M, Akbari H, Gholami H, Darabi A. Management of hospital waste: a case study in Tehran, Iran. *Health Scope.* 2018;7(2):e61412. doi: [10.5812/jhealthscope.61412](https://doi.org/10.5812/jhealthscope.61412).
- Davoodi R, Eslami Hasan Abadi S, Sabouri G, Salehi M, Ghooshkhaneh H, Rahmani S, et al. Medical waste management in the second largest city of Iran (Mashhad) with three-million inhabitants. *Patient Saf Qual Improv.* 2014;2(4):160-4. doi: [10.22038/psj.2014.3401](https://doi.org/10.22038/psj.2014.3401).
- Debere MK, Gelaye KA, Alamdo AG, Trifa ZM. Assessment of the health care waste generation rates and its management system in hospitals of Addis Ababa, Ethiopia, 2011. *BMC Public Health.* 2013;13:28. doi: [10.1186/1471-2458-13-28](https://doi.org/10.1186/1471-2458-13-28).
- Taghipour H, Mosaferi M. Characterization of medical waste from hospitals in Tabriz, Iran. *Sci Total Environ.* 2009;407(5):1527-35. doi: [10.1016/j.scitotenv.2008.11.032](https://doi.org/10.1016/j.scitotenv.2008.11.032).
- Marinković N, Vitale K, Janev Holcer N, Dzakula A, Pavić T. Management of hazardous medical waste in Croatia. *Waste Manag.* 2008;28(6):1049-56. doi: [10.1016/j.wasman.2007.01.021](https://doi.org/10.1016/j.wasman.2007.01.021).