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Analysis of quality and quantity of health-care wastes in clinical laboratories: a case study of Ilam city

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Abstract Generation of health-care wastes is one of the major concerns in health-care institutions worldwide due to direct and indirect impact on human health and environment. The purpose of the present work was to estimate the quantity and quality of clinical laboratory wastes in the city of Ilam, Iran. In this cross-sectional study, randomly eight clinical laboratories including five in private sector and three governmental clinical laboratories were selected for sampling according to the purpose of the study. The results showed that the total amount of waste generation was 27,700.90 kg/year. The average amount of health-care wastes generation in Ilam city was 0.2 kg/person/year. The portions of general, pathologic, sharp, infectious, and pharmaceutical and chemical wastes were 37, 5, 2, and 56% (by weight), respectively. As a considerable amount of waste is generated in clinical laboratories of Ilam city, therefore, it is necessary to implement integrated plans for the proper management of these wastes. Thus, sufficient training and education programs must be developed for all clinical staffs and that the existing training and education procedures should also be promoted.

Keywords Health-care wastes · Clinical laboratories · Ilam city

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Introduction

In recent decades, concern over the health-care or medical wastes from health-care settings has sharply increased throughout the world (Oweis et al. 2005). The management of health-care wastes has become a critical issue in most of the developing countries including Iran due to less attention to proper waste management procedures (Qasemi et al. 2018; Patwary et al. 2011; Taghipour and Mosaferi 2009; Shams et al. 2013; Gavrancic et al. 2012). Having the enough information about the quantity and quality of solid waste can affect health, economy, and environmental aspects (Qasemi et al. 2018; Mazloomi 2015; Najafpoor et al. 2014). The WHO reported that 64% of hospitals in 22 countries do not perform proper waste management procedures (Oroei et al. 2014). Based on WHO report, health-care wastes pose a great impact on health-care workers and other exposed individuals, patients, public and their surrounding environment if improperly handled in storage, treatment, transportation and ultimate disposal

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stages (WHO 2005). Generally, 15 to 25% (by weight) of health-care wastes are infectious which must be handled carefully (Yong et al. 2009). The term health-care waste is considered for all types of wastes in solid or liquid forms generated during diagnosis, treatment, or immunization of patients in hospitals, clinics, clinical laboratories, pharmacies, and other related health-care services (Hossain et al. 2011; Damani et al. 2013). The health problems of health-care waste may vary from respiratory, gastroenteric, and skin infections to more serious problems such as acquired immune deficiency syndrome (AIDS), hepatitis B, and hepatitis C (Hanumantha Rao 2008). It has been reported that use of contaminated syringes in 2000, caused 21 million hepatitis B, 2 million hepatitis C, and 260,000 AIDS infections (Hauri et al. 2003). In the past, health-care wastes were mixed with municipal wastes and disposed of improperly in municipal waste landfills or improper treatment facilities where poor people in some communities may scavenge them for their livelihood. Scavengers separate discarded objects including needles and syringes, soiled cotton, bottles, tubes, and urine bags and sell them to earn money (Sharma and Gupta 2017). Therefore, it is necessary to develop and implement integrated management plans for health-care wastes in the communities in order to prevent accidents, avoid any environmental impact and protect public health. Although a considerable progress has been seen in the management of health-care wastes worldwide, literature reviews show the need to enhance the existing health-care waste management methods.

The quantity of health-care waste generation varies from nation to nation based on their income or the level of development. Developed nations have a larger generation of health-care waste than two others (Marinković et al. 2008). Recently, the quantity of health-care wastes has increased rapidly. The reason for sharp increase in health-care wastes can be generally attributed to the rapid population expansion, increase in the number and size of health-care institutions and extensive use of disposable health-care products (Bharti et al. 2016). Health-care waste can be classified in infectious, pathological, pharmaceutical, chemical, and general categories as well as sharp objects contaminated with blood, infectious items, tissues, organs, etc. (Jang et al. 2006; He et al. 2016). Although health-care waste represents a small portion of the total solid waste stream in Iran, such waste must be managed properly because of the potentially infectious and hazardous materials contained in it (Taghipour and Mosaferi 2009). The purpose of the present work was to evaluate the quantity and quality of clinical laboratory wastes in the city of Ilam, Iran.

Materials and methods

Study area description, sampling, and analysis

This cross-sectional study was conducted in order to analyze the quality and quantity of clinical laboratory wastes in Ilam city, western Iran. Ilam city is the center of Ilam province with a total population of 213,575 individuals (Fig. 1). This population increases during the typical work day. In this study, clinical laboratories were selected because they generate a variety of health-care wastes and also due to the lack of available information in this regard in Ilam city. Generally, a clinical laboratory is a laboratory where tests are performed on clinical specimens (also known as a patient sample), in order to get information regarding the health of a patient as pertaining to the diagnosis, treatment, and prevention of disease. Laboratory medicine is generally categorized into two sections anatomic pathology and clinical pathology. In anatomic pathology, it includes histopathology, cytopathology, and electron microscopy. Clinical pathology, typically includes the following areas (clinical microbiology, clinical chemistry, hematology, blood bank, molecular diagnostics, reproductive biology). Based on the ownership of the clinical laboratories, eight clinical laboratories including five in private sector and three governmental clinical laboratories were selected for sampling according to the purpose of the study. Among these, only four cases were generating pathological wastes. The laboratories were coded as A, B, C, D, E, F, G, and H. For each laboratory, three visits were performed in different days with a total twenty four visits in this study. The visits were based on the number of referrals to each laboratory. Each sample was taken at the end of working period in a day. The collected samples were analyzed accurately at the end of each day. Then, before any decontamination process, each sample was weighed and separated into its components. Initially, each waste sample was separated manually into its components and then weighed using an exact laboratory scale. For safety, the samples were handled using appropriate uniforms and protective equipment. The average value of total amount of waste generation was calculated by multiplying the number of the working days during a

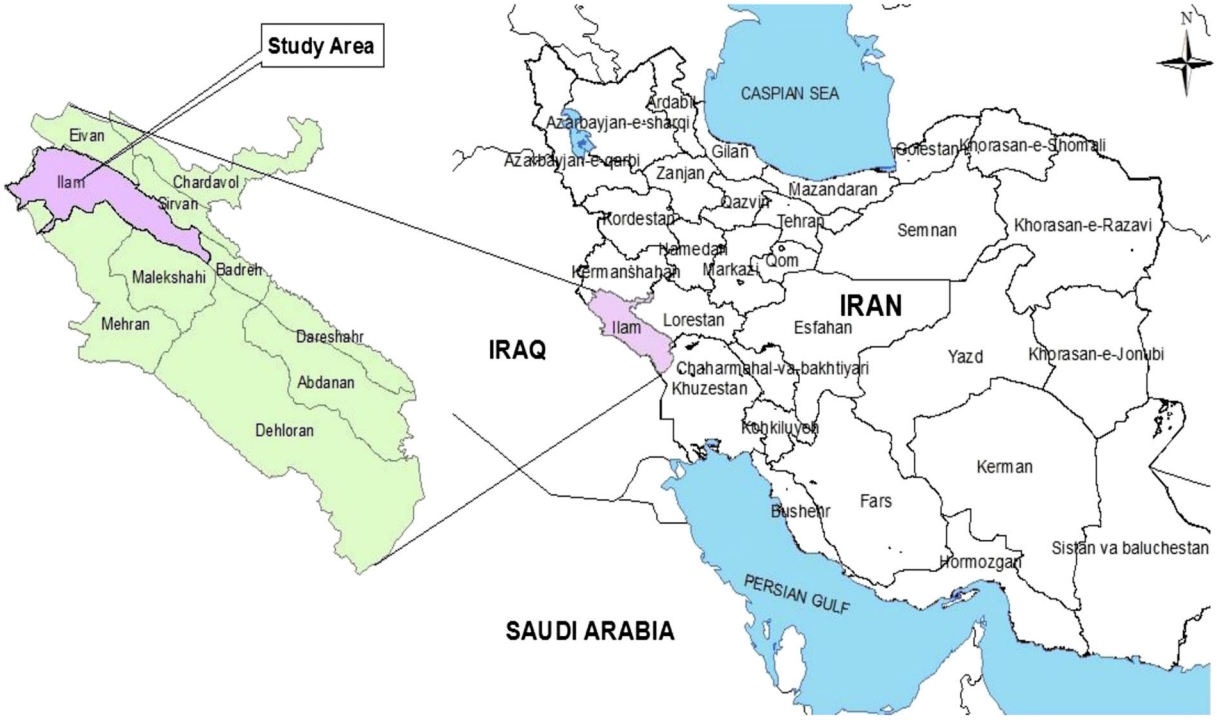

Fig. 1 Location of the study area in Ilam province

year with the daily amount of waste generation. The collected data were finally analyzed using Excel software.

Results

Tables 1 and 2 summarize the average annual and daily quantities of health-care wastes in Ilam city which were obtained in three visits. As can be seen, in most of the cases, the pathological waste category was not generated. This table also shows that the annual average quantities of wastes in governmental laboratories H, G, and F were 7549.29, 5426.94, 4017.61 Kg, respectively. The annual average quanities of waste generation in private laboratories A, B, C, D, and E were 4172.33, 1910.84, 2093.48, 426.80, and 779.86 kg, respectively. Table 2 represents the quantities and composition of wastes in clinical laboratories in Ilam city in this study during 1-year analysis. The relative proportion of the components of wastes generated from clinical laboratories of Ilam city is presented in Fig. 2. As can be seen in Table 2 and Fig. 2, from a total waste generation of 27,700.90 kg, the highest amount was related to infectious and pharmaceutical wastes and was 15,441.80 kg (56% by total weight). Among studied clinics the highest amount of infectious and pharmaceutical wastes was observed in clinic H. Furthermore, the lowest amount (597.12 kg) was attributed to sharp objects that accounts for 2% of total waste generated annually. The average amounts of health-care wastes generation in each studied clinic can be calculated anuually for each referee, by consuidering the total referees come to each laboratory (Number of referees during a year in clinic A=26781, B=26121, C=12891, D=33720, E=10080, F=7050, G=6030, H=5373) and anuual average waste generation in each clinic which is given in Table 1. The highest amount was observed in clinic H (1.40 kg/person/year). The average amount of health-care waste generation in Ilam city was 0.2 kg/person/year.

Discussion

Health-care waste and its proper management has recently become a serious topic in Iran. The use of improper and insufficient waste disposal techniques induce not only environmental and health issues, but also political problems. Proper management may take a long time to achieve, require high investment with integrated political will and almost certainly need international

Table 1 The quantities of health care wastes (kg) in clinical laboratories in Ilam city

Clinic (coded)	First visit				Second visit				Third visit
	Infectious and pharmaceutical	General waste	Sharp objects	Pathologic	Infectious and pharmaceutical	General waste	Sharp objects	Pathologic	Infectious and pharmaceutical
A	10.05	4.05	0.28	None	11.14	4.44	0.3	None	9.26
B	2.68	2.71	0.08	None	3.45	3.76	0.06	None	2.86
C	5.92	2.54	0.05	None	1.71	2.38	0.03	1.33	3.82
D	1.15	0.54	0.27	0.90	1.38	3.19	0.29	None	0.93
E	2.55	1.37	0.03	None	1.14	1.90	0.02	None	4.29
F	12.70	3.83	0.24	None	13.37	3.03	0.26	None	16.96
J	7.12	4.97	0.24	None	7.70	7.35	0.84	None	7.55
H	31.22	9.47	0.15	None	14.42	4.95	0.07	None	7.13
Sum	73.39	29.48	1.34	0.91	54.31	31	1.87	1.33	52.82

Clinic (coded)	Third visit			Daily average				
	General waste	Sharp objects	Pathologic	Infectious and pharmaceutical	General waste	Sharp objects	Pathologic	Annual average
A	2.39	0.18	0.61	10.15	3.63	0.26	0.20	4172.32
B	3.90	0.05	None	3	3.46	0.07	None	1910.84
C	3.22	0.42	None	3.82	2.72	0.17	0.44	2093.48
D	1.35	0.25	None	1.16	1.55	0.27	0.30	426.80
E	4.10	0.02	None	2.66	2.52	0.02	None	779.86
F	3.77	0.29	None	9.90	3.55	0.27	None	4017.61
J	5.50	1.02	10	4.89	5.94	0.70	3.33	5426.94
H	9.01	0.04	None	12.78	7.81	0.09	None	7549.29
Sum	33.24	2.27	10.61	48.36	31.18	1.85	4.27	26,377.14

Table 2 Quantities and composition of wastes in clinical laboratories in Ilam city

Waste category	Amounts (kg)
Infectious and pharmaceutical wastes	154,441.80
General waste	10,167.40
Sharp objects	597.12
Pathological waste	1494.53
Sum	27,700.90

cooperation. As can be seen in Table 1, the highest amounts of infectious waste among studied clinics was attributed to infectious category in H and the lowest amount was due to sharp objects in E laboratory. Due to the possibility of general wastes contamination by infectious wastes, it is necessary to separate these waste appropriately at source of generation (Higgs 2006). Voudrias et al. (2012) reported that toxic medical wastes (pharmaceutical and chemical) constitute around 6% (*w*/*w*) of the total hazardous medical waste (HMW) in a typical public hospital in Greece (Voudrias et al. 2012). Graikos et al. (2010) found that the HMW fraction from a small public facility (without permanent beds) in Greece ranged from 13% to up to 92% of the total medical waste, depending on the department/laboratory of that facility (Graikos et al. 2010). Komilis et al. (2017) results indicated that on average 35% of the total MW was hazardous (infectious) medical waste (IFMW) (Komilis et al. 2017). In this study, the quantity of wastes generated by governmental clinical laboratories was considerably more than those generated by private clinical laboratories (Table 2). There was a significant association ($P < 0.05$) among different laboratories related to the annual quantity of waste generated. Based on Table 1, the lowest amount of waste generation among clinical laboratories was attributed to sharp objects. The highest amounts varied considerably among different laboratories. In the other word, the highest waste amounts in A, C, E, F, and H was recorded for infectious and pharmaceutical wastes. For B and D clinics, the general waste category was the highest. Moreover, in the clinical laboratory of J, the pathological waste was maximum. In another study regarding the quantity and quality analysis and management of health-care waste in Bandar Abbas city in south of Iran in 2012, the highest amounts of wastes were due to infectious and general wastes. Also, in their study, the lowest rank came from sharp objects (Koolivand et al. 2012). Another study about the status of infectious wastes management in governmental hospitals of Gorgan city in north east of Iran showed that general wastes and sharp objects accounted for highest and lowest amount of wastes generation, respectively (Alavi et al. 2014). Abbasloo et al. studied the management status of medical wastes in hospitals of Khoy city in Iran and reported that no one of the hospitals were equipped with incinerator for their wastes due to the lack of sufficient installation area in those hospitals. In these settings, the sharp objects were autoclaved and were disposed in sanitary landfill with municipal solid wastes (Abasloo 2005). In another study by Tahsini et al. about the status of medical waste management in hospitals and health-care settings in Birjand city, Iran, 14.28% of health-care institutions were equipped with incinerators. But no one was operated due to the lack of air pollution control systems (Abasloo 2005). Based on the results obtained in the preset study, in no one of the laboratories the separation of chemical waste was done appropriately and it was mixed with

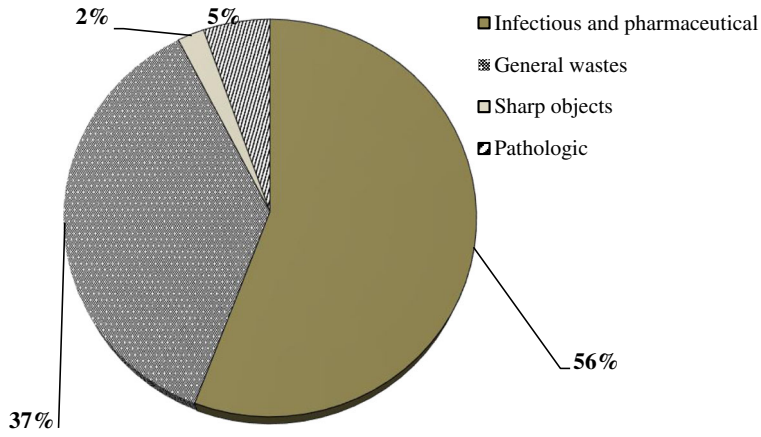

Fig. 2 The relative proportion of the components of wastes generated in clinical laboratories of Ilam city

infectious wastes. The healthcare solid wastes in Ilam are daily collected by special vehicles. The wastes were firstly shredded by a grinder to obtain the average particle size of 2 to 3 cm, at the treatment site. Then, the materials were mixed with concentrated hydrogen peroxide spray (35%) for 2 min at room temperature (25 °C). Finally, the disinfected compounds were transported to municipal solid waste landfill. The sharp objects were stored in plastic safety boxes in all the studied laboratories. It is interesting to note that among laboratories with infectious wastes, in all laboratories the used formalin was stored and managed accurately except two cases where it was discharged into sinks whereas, formalin is a hazardous material and should be managed based on the Resource Conservation and Recovery Act (RCRA) regulations.

In a study, the management status of infectious and biological wastes was investigated in Tabriz University of Medical Sciences. In the studied laboratories, infectious, sharp, biological and radioactive as well as chemical wastes were generated which were all mixed with other wastes. In 71.42% of laboratories (totally 7 laboratories), the wastes were autoclaved (Mohammad Mosaferi 2013).

In another study medical waste management in clinical and educational laboratories of Rafsanjan University of Medical Sciences in Iran was studied. In 57.1% of studied laboratories, there was no a special list of chemicals which must not be mixed with other wastes. The wastes were disinfected using an autoclave only in 14.3% of cases (Mohseni Moghadam et al. 2016).

Conclusions

The number of private and governmental health-care institutions in Iran is continuously increasing which leads to the increase in the amounts of health-care waste generation from these institutions. The work brings an overview about the quantities and nature of the waste generated in clinical laboratories in Ilam, Iran throughout a whole year. Such gathered data are important for proper planning of waste management procedures. However, several suggestions can be considered to promote the existing health-care waste management procedures. High percentage of infectious wastes in health-care wastes represents that despite of implementation of plans in the management of health-care wastes aimed to ensure appropriate handling and processing of health-care waste, there is still problems which must be addressed exactly. Therefore, separation of hazardous and infectious wastes at the point of generation is a critical step to avoid contamination of other health-care wastes. From the other side, training of the staffs in health-care institutions regarding the proper source separation of infectious wastes is an influential factor in health-care waste management. Also, use of autoclave and efficient sterilization instruments for infectious waste decontamination must be a priority. The sharp objects also must be stored carefully in the safety box in all health-care settings.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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