

Research Paper: Comparing and Prioritizing Different Methods of Collection and Decontamination of Waste in Decen- tralized Healthcare Centers



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Citation Ostad F, Mortezaadeh F, Gholami-Borujeni F. Comparing and Prioritizing Different Methods of Collection and Decontamination of Waste in Decentralized Healthcare Centers. Journal of Advances in Environmental Health Research. 2021; 9(4):277-284. <http://dx.doi.org/10.32598/JAEHR.9.4.1217>

 <http://dx.doi.org/10.32598/JAEHR.9.4.1217>



Article info:

Received: 13 Apr 2021

Accepted: 10 Aug 2021

Publish: 01 Oct 2021

Keywords:

Waste decontamination,
Health care waste,
Decentralized health
centers

ABSTRACT

Background: One of the most critical problems in the safe management of healthcare wastes is using different methods in decentralized centers in Iran. This study aimed to compare and prioritize different methods of collection and decontamination of healthcare waste in decentralized health centers in Iran.

Methods: In this descriptive-analytical research, we studied various methods of collecting and decontaminating the healthcare waste of decentralized healthcare centers in Iran in terms of administrative, health, economic and environmental. Also, the opinions and the preferences of experts for selecting each method were collected and analyzed.

Results: According to environmental health experts, health issues had the highest priority for decontamination of waste from decentralized health centers. Waste collection by special vehicles with the help of the private sector and transfer to centralized disinfection centers is the best method of collecting waste (33%). Also, decontamination by autoclave was the most desirable method (56%) of decontamination. According to the experts' opinions, landfilling is the most harmful, and autoclave/hydroclave is the least harmful method to the climate and soil. Based on the environmental health experts, the health aspect was the most important priority in waste management of decentralized healthcare centers (54%).

Conclusion: The most appropriate way to decontaminate this type of waste is autoclaving after collection at a centralized location. It is suggested that further studies be conducted on modern collection and disinfection systems along with localization and determination of workplace health policies.

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1. Introduction

Healthcare waste is the total waste stream that, regardless of its volume, characteristics, and composition, is produced from health centers, health research centers, and laboratories, hospitals, clinics, medical research centers, drug factories, pharmacies, etc. [1]. These wastes account for around 1%–2% of urban wastes. Still, they are significant in terms of health issues. Because of the increase in population and healthcare facilities, the per capita health waste production has been increased and become a serious threat to the environment and people [2]. Waste management in hospitals is done according to the law on waste disposal [3]. Patwary et al. reported that a significant risk factor for disease transmission could be mismanagement of medical waste in developing countries [4]. In these countries, insufficient attention is paid to the management and disposal of medical and health waste. So that hospital waste may be mixed with household waste, which in addition to increasing the volume of hazardous waste, endangers people's health [5]. Hospital waste is very toxic compared to other wastes. Although 75% to 90% of the healthcare waste generated is non-toxic, the remaining 10%–25% is considered “hazardous” [6, 7]. The results of a cross-sectional study in selected Addis Ababa hospitals showed that the average waste production rate varies between 0.361 and 0.669 kg/patient/d and consists of 58.69% and 41.31% of non-hazardous and hazardous waste, respectively [1].

The World Health Organization (WHO) has stated that the goal of biomedical waste management is to eliminate and treat it with confidence in health, environment, and economy through safe methods at all stages [8]. Since handling biomedical waste is a hazardous activity that requires high training and skills, the waste generated in healthcare centers must be properly managed before disposal. This process includes all activities related to waste generation, segregation, transportation, storage, treatment, and final disposal [1]. The production of healthcare waste depends on local laws, structure, location, the capacity of health facilities, medical waste segregation system, the number of patients being treated, and so on [2]. Garbage must be collected and transported in a harmless way to human and the environment. At the hospital, waste transportation routes must be determined. Wheeled containers or carts must be used to transport waste to the storage site [9]. If hospital wastes are not properly disposed of, infectious diseases such as fungi, viruses, and bacteria can spread and affect human health and the environment [10]. Also, the environment might be polluted

by releasing toxic pollutants into the air by medical waste incinerators and scattering toxic ash residues to landfills for disposal that may infiltrate groundwater [11].

Principled management of health care waste emphasizes continuous control over the production, storage, collection, transportation, decontamination, and disposal of this waste. Reducing waste generation is also one of the management measures and a key factor in minimizing hazardous waste. In Iran, several studies have been conducted on hospital waste management [12]. Al-Khatib et al. reported that hospital waste management plays an important role in reducing the volume of waste generated and the pollution of this waste [13]. In a case study of Farzadkia et al. in five selected hospitals in Tehran in 2018, the average production waste was 4.72 kg/bed.d, of which 2.3 kg/bed.d was related to infectious waste [14]. According to the study of Khosravipour and Nejati in public hospitals in Urmia City, Iran, the average total production of waste was 7430.11 kg/d and 2712 ton/y, which consisted of 65% general waste and 35% hazardous waste [15]. Also, Zazouli et al., in the study of hospital waste in Gorgan City, Iran, reported that the average total rates of production waste and hazardous waste were 2.63 kg/bed.d and 1.03 kg/bed.d, respectively [16].

The medical waste generated by healthcare activities is more likely to transmit infectious diseases. Regulations of infectious waste management recommend using technologies, such as incineration, microwave, and hydroclave, which are expensive treatment options for less economically developed countries [17]. Incineration is the most widely-used technology and expensive treatment for medical waste management in developing countries. Still, because of the different types of pollutants released from the incineration of medical waste, such as dioxins, eruptions, etc., it poses a great risk to health and the environment [6]. Tiwari and Kadu studied the classification, legislation, and management practices related to biomedical waste in India. They concluded that incineration of biomedical waste is one of the most common treatment methods in India, which has adverse effects on the environment [18]. Saeb et al. reported that 46% and 36% of infectious wastes have been destroyed by incineration and safe methods, respectively. Biological monitoring showed that the function of most safety devices was at an acceptable level in hospitals. They eliminate the waste with an average of 80% of microorganisms [5]. Also, Gupta showed that autoclave and hydroclave as biomedical waste treatment technologies were economically, technologically appropriate, and environmentally friendly, and therefore are cost-effective technologies [11].

On the other hand, medical waste is considered a source of soil and water contamination if not rendered harmless before landfilling [19]. Chung and Meltzer estimated the total US carbon footprint. Their study showed that healthcare contributes to about 8% of greenhouse gas emissions in the nation [20]. Also, Karthikeyan et al. reported that greenhouse gases and particulate emissions are an important issue for municipal solid waste disposal sites. Incineration of hospital waste at these sites releases harmful pollutants such as dust, carbon black, ammonia, sulfate, and nitrate into the air, which cause various types of respiratory problems in nearby residents [21]. The choice of medical waste disposal should be made in accordance with today's climate change environment and the spread of infections. Because of the spread of various diseases, proper disposal of biomedical waste is a necessary process [10]. At present, in Iran, according to the Law on Medical Waste Management, in hospitals and other production centers of such wastes, collection and decontamination are done by producers, and municipalities bury decontaminated wastes. One of the most critical problems in the safe management of such wastes is related to decentralized centers such as offices, clinics, and small healthcare centers. Various methods in different countries are used to treat waste generated in decentralized centers. Based on the research background, many studies have been conducted on waste management and decontamination in centralized centers (hospitals, health care centers). Still, no study has been conducted on waste management in decentralized centers. This issue has many health, economic and technical aspects, which created disagreement among different experts to introduce a suitable method for decontaminating the affected infectious waste. Comparison of different aspects of infectious waste decontamination methods and experts' opinions are useful in decision-making processes and educational issues. This study aimed to compare and prioritize different methods of collection and decontamination of healthcare waste in decentralized healthcare centers in Iran.

2. Materials and Methods

Study tools

In this descriptive-statistical study, a questionnaire was used to obtain the views of environmental health experts on various methods of collecting and decontaminating waste in decentralized treatment centers.

Study population

The study population was environmental health experts. A total of 49 experts with a PhD, MSc, or BSc in Environmental Health were invited to complete the questionnaire voluntarily.

Questionnaire questions

The questionnaire included questions to examine the various aspects of each waste disposal method, including economic, health, social acceptability, political, legal acceptance, impact on water, soil, and living resources. The questionnaire's disposal methods included incinerator, landfill, on-site decontamination, concentrated decontamination, autoclave decontamination, chemical disinfection decontamination, and microwave decontamination. For this study, a 28-question questionnaire was prepared, and experts' opinions on five decontamination methods and the final disposal of decentralized health care centers were collected and analyzed. The validity and reliability of the questionnaire used were assessed using the Cronbach α test.

Data analysis

Descriptive statistics (mean, mode) were used to analyze the data. The data obtained from the questionnaires were analyzed in Excel software.

3. Results and Discussion

Demographic characteristics of the respondents

According to Table 1, among environmental health experts in terms of age, 53% were between 20 and 30 years old, 25% between 30 and 40 years, 18% between 40 and 50 years, and 4% between 50 and 60 years. Of these 49 experts, 63% had a bachelor's degree, 27% had a master's degree, and 10% had a doctorate. Also, in terms of the type of employment, 45% were students, 6% were environmental health experts, 39% were environmental health engineers, 4% were university professors, and 6% were others.

Experts' views on waste collection and decontamination

According to Figure 1, 33% of the environmental health experts said that collecting waste from offices and clinics and their decontamination in the hospital in a centralized method is the most practical method for collecting and disposing of decentralized health waste. In comparison, 18% of them considered the centralized collection of waste from offices and clinics and their decontamination in the same office as the most impractical method. Also,

Table 1. Sociodemographic characteristics of respondents (n = 49)

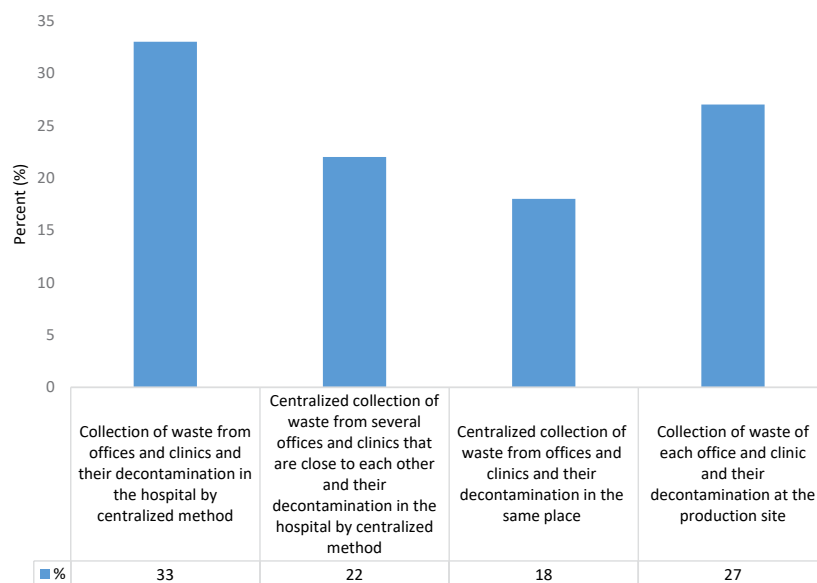
Variable	Variable Components	No. (%)
Age, y	21-30	26 (53)
	31-40	12 (25)
	41-50	9 (18)
	51-60	2 (4)
Educational level	BS	31 (63)
	MS	13 (27)
	PhD	5 (10)
Occupation	Student	22 (45)
	Environmental health expert	3 (6)
	Environmental health engineer	19 (39)
	University professor	2 (4)
	Others	3 (6)

according to 41% of experts, collecting waste from offices and clinics and decontaminating them in a centralized method is the most economically-acceptable method.

According to experts' comments, the method of centralized collection of waste from several offices and clinics that are close to each other and their decontamination in a centralized manner has the least environmental risk. In contrast, collecting waste and its decontamination in a centralized manner produces the highest risk in the environment. They also chose the same method of decontamination as the best method for disposing of the waste of several centers in separate places.

According to [Figure 2](#), decontamination by autoclave (56%) and then the use of incinerators (20%) had the highest degree of desirability from the perspective of environmental health professionals. However, the desirability of safe landfill and disinfection with chemicals was the least, with 6%.

According to the findings, environmental health experts described the autoclave/hydroclave method as the most desirable method and landfilling as the most undesirable method from a health and economic point of view. On the other hand, they believed that among the final decontamination methods, first the autoclave/hy-

**Figure 1.** Prioritization of the method of collection and disposal of decentralized health care waste in terms of application

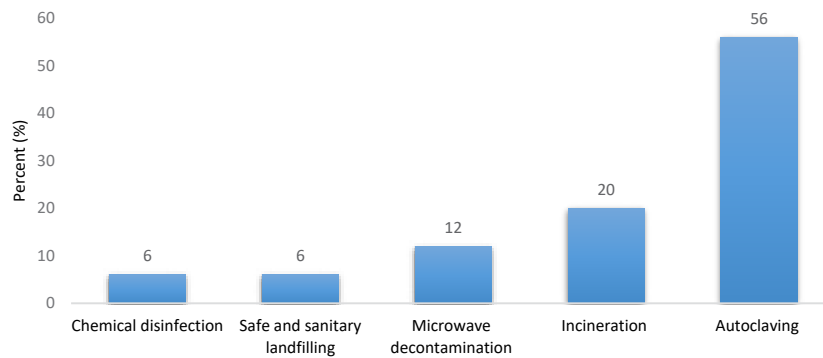


Figure 2. The desirability of the waste decontamination method of decentralized health centers

droclave method (33%) and then the landfilling method (27%) requires more hygienic measures, including regular monitoring. Also, they are among the appropriate methods of waste decontamination, according to the current situation in our country.

Figure 3 shows that most people believed that all decontamination methods required specialized personnel to monitor the process directly. According to Figure 4, health issues with 54% and impact on water and soil with 0% had the highest and lowest priority for health professionals to decontaminate the waste of decentralized health centers. The experts believed that the landfill method had the most and the autoclave/hydroclave method had the least harm to the climate and soil.

The use of different decontamination methods for healthcare waste has been reported in various parts of the world and Iran. Jonidi et al. on the performance of sterilization equipment in hospitals of Iran University of Medical Sciences reported that all but four psychiatry hospitals were equipped with safe waste equipment (autoclave, hydroclave, chemiclave, and dry heat). Autoclave is also used in 42.42% of private hospitals, 60%

of public hospitals, and 80% of other hospitals. As a result, among the four types of devices mentioned, it has the most commonly used in the studied hospitals [22]. Also, Daštpak et al. reported that disinfection methods of infectious waste in Iran were autoclaving and hydroclaving in more than 70% of cases [23]. In South Korea, the final disposal method is incineration (52.7% of hospital waste), steam sterilization (46.4% of hospital waste), and other methods such as microwave and chemical disinfection (less than 0.2% of hospital waste) [24]. Kalhor et al. reported that health waste in Qazvin City, Iran, was disinfected with autoclave, hydroclave, and chemicals [25]. Also, Nangbe’s study at Private Clinics in Cotonou Town shows that private clinics use three methods to treat their waste: incineration, Secure landfill, dumping and burning in the open air [8]. Tiwari and Kadu studied biomedical waste in India. They reported that incineration of biomedical waste was one of the most common treatment methods in India because, despite the adverse effects on the environment, it is cheap. In addition to incineration, methods such as autoclave and microwave treatment are used [18]. In Japan, 82% of the infectious waste generated per year is eventually incinerated [26]. In different countries of the world such as Algeria, Ban-

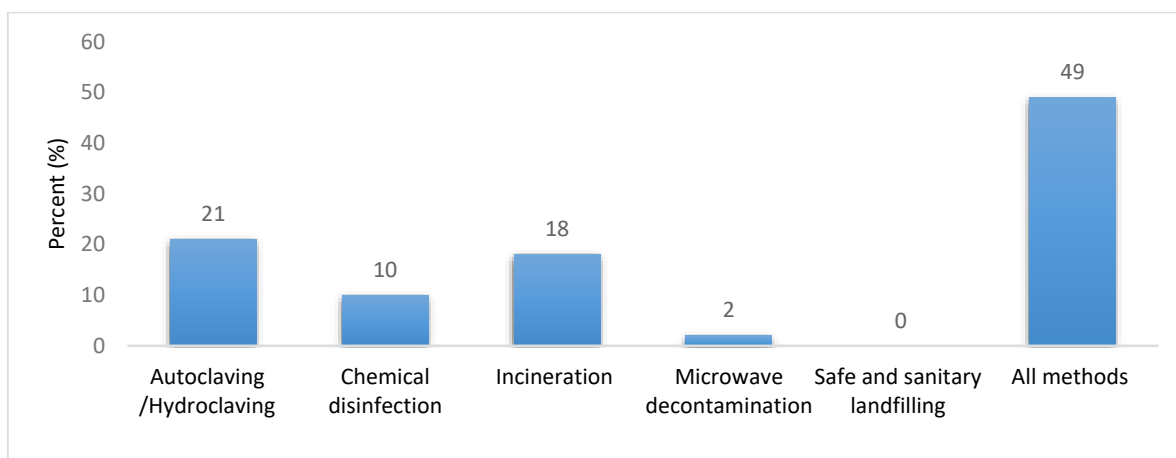


Figure 3. Prioritization of methods that require specialized personnel for monitoring

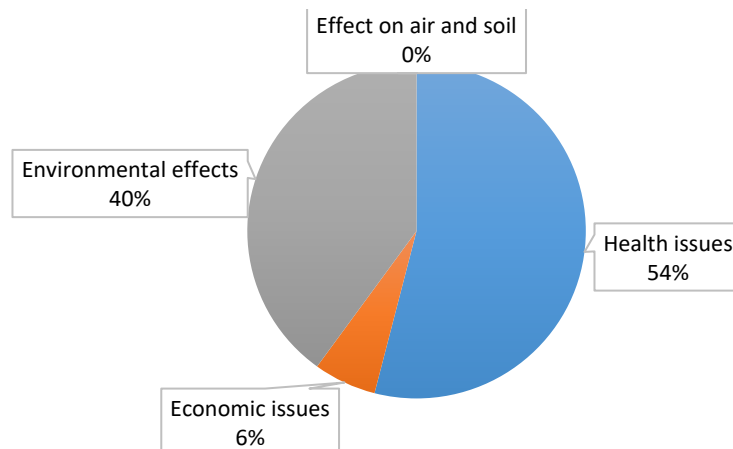


Figure 4. Prioritization in selecting the appropriate method of decontamination of decentralized health waste

gladesh, Nigeria, Libya, and Egypt, incineration method and in countries such as Mongolia, Bahrain, Korea, Palestine, and South Africa, in addition to the above methods, sanitary landfill, autoclave, and thermal disinfection are used [22]. Comparison of these reports with the results of this study shows that incineration is one of the most widely-used methods for decontaminating medical waste in the world. Experts chose the autoclave method because health and environmental issues are their most important priority.

According to previous studies, about 49%-60% of medical waste is treated by incineration, 20%-37% by autoclave sterilization, and 4%-5% by other methods [27]. Burning is known as the best disposal method, and internationally, it is the most common treatment method used worldwide, including Argentina, Brazil, Peru, Pakistan, India, and Bangladesh [19]. However, this method emits toxic air pollutants and ash residues and is the primary source of dioxins in the environment. Dioxins have been linked to cancer, immune system disorders,

diabetes, birth defects, and sexual dysfunction. Incineration of hospital waste also not only releases toxic acid gases (CO, CO₂, NO₂, SO₂, etc.) into the environment but also leaves ash solids as residues, which increase the level of heavy metals, inorganic and organic compounds in the environment [28-30]. Studies show that non-incineration technologies are better for the environment and more cost-effective [31-32]. Ferdowsi et al. reported that incineration has more depreciation than autoclave and is less energy efficient than in autoclaves [30]. Concerns about flue gases and water and soil contamination in the landfill method have led environmental health experts to recommend the use of autoclave as the best option for decontaminating healthcare waste. Sanitary landfilling is one of the final methods of disposing of medical waste due to concerns about groundwater and soil contamination [33]. The use of sanitary landfilling is less acceptable. According to the results of Figure 4, the greatest concern of environmental health experts in choosing a method for decontamination and final disposal of waste

- General waste
- Pathological waste
- Radioactive waste
- Chemical waste
- Infectious waste
- Pharmaceutical waste
- Used pressure vessels

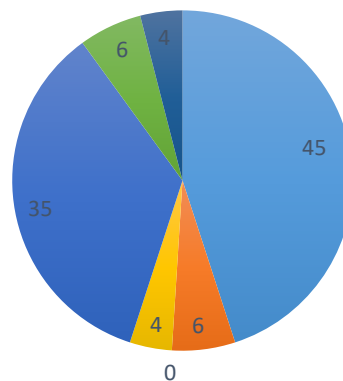


Figure 5. Percentage of waste in health centers, clinics, and offices from the perspective of health

was the health aspect (54%), and attention to issues such as economics (6%) was of lower importance. It seems that this issue has made waste decontamination by autoclave the most important for decontamination of health care centers, which is consistent with the results of Torkashvand et al. [34]. Also, according to Figure 5 and environmental health experts, ordinary waste (45%) and then infectious waste (35%) constitute the highest amount. In contrast, radioactive waste (0%) includes the lowest waste from health centers, clinics, and offices.

4. Conclusion

This study was conducted to obtain the opinions of environmental health experts on various methods of collection and decontamination of waste from decentralized healthcare centers. In recent years, due to population growth and the expansion of hospitals to improve the quality and quantity of community health, the amount of hospital waste, especially infectious waste, has increased. Because of the health and environmental hazards of hospital waste, environmentally friendly, economical, and high-efficiency methods should be used to eliminate these wastes. According to the environmental health specialist, the health aspect was the most important priority in waste management of decentralized healthcare centers. Therefore, autoclaving is the most appropriate way to decontaminate this type of waste. Collection by special vehicles with the help of the private sector and transfer to centralized disinfection centers is the best collection method.

Also, according to the results and the current situation of healthcare waste management in our country, it is recommended to reduce the amount of waste produced using appropriate methods. This reduction will eventually lower the cost of waste collection and decontamination. Further studies should also be conducted on modern collection and decontamination systems and their localization and determination of workplace health policies.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Mazandaran University of Medical Sciences, Mazandaran (Code: IR.MAZUMS.REC.1399.950).

Funding

This study was supported by the Deputy of Research at Mazandaran University of Medical Sciences, Sari.

Authors' contributions

The manuscript was designed, prepared, and revised by all authors as well as the final manuscript was read and accepted

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors express their appreciation to the Deputy of Research of Mazandaran University of Medical Sciences for the financial support.

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