Original Article

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Composition, Production Rate and Management of Dental Solid Waste in 2017 in Birjand, Iran

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Abstract

Background: The presence of toxic and pathogenic agents in the dental waste products has made it to be classified as "hazardous waste."

Objective: To assess dental waste production rate and composition and approaches used to manage these waste products in 2017 in Birjand, Iran.

Methods: 48 dental clinics were evaluated in two months of 2017. Sampling was performed from each clinic 3 times a week. Samples were manually divided into 5 categories of chemical-pharmaceutical, infectious, semi-household, sharp and cutting materials, and toxic waste products, and weighed. A checklist containing 25 questions was used to evaluate the aspects of waste management in dental clinics.

Results: The total amount of waste products generated in dental clinics was 7848.02 kg/year in which semi-household waste had the highest quantity (4263.411 kg/year) and toxic waste had the lowest quantity (9.275 kg/year). Components with the highest amounts in dentistry waste products were nylon gloves (16.7%), paper and cardboard (13.4%), latex gloves (10.8%), and pharmaceuticals (10.2%). Waste separation was restricted to sharp and cutting waste. More than half (57%) of dental units were equipped with amalgam filter. Fixing solutions were directly discharged to sewage in 48.6% of clinics. There was no program to reduce waste generation in 54% of the clinics. Autoclave was the main tool for sterilizing dental instruments.

Conclusion: This study showed a remarkable share of recyclable materials in the composition of dental waste and lack of special approach to manage waste in dental clinics. It is necessary to plan for minimizing generation of, separating, and recycling waste at source.

Keywords: Dental amalgam; Dental clinics; Dental waste; Hazardous waste; Medical waste disposal; Waste management

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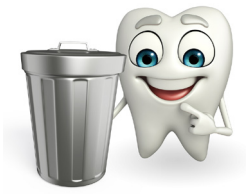

Introduction

Waste management is one of the major issues and management challenges in Iran. Each year, a significant portion of the municipals budget is allocated to this issue. Special waste products including medical waste are of particular importance. Medical waste disposal management requires the correct-

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ness of the statistics and accurate information of all parts and components of this type of the waste.[1,2] These waste products can lead to a series of hazards including health and occupational hazards, environmental and esthetic hazards such as water, air and soil pollution, and social, economic and political problems.[3,4] Among the medical waste products, dental waste has a high diversity and is very critical due to the presence of dangerous, toxic and pathogenic agents, including pathological, pharmaceutical and chemical, radioactive, infectious and sharp and cutting waste.[5] These components can be categorized based on type, potential risk, source of production, the management approach and other probably effective parameters.[1,2]

Infectious waste is among the most important part of dental waste that contain materials contaminated with blood and body fluids and sharp and cutting objects. Infectious waste due to the presence of pathogens may cause the outbreak of various diseases and compromise public health. Infectious waste may contain various types of pathogenic organisms that can enter the human body through scratching, piercing or cutting the skin, and oral mucosa, breathing or ingestion. AIDS and hepatitis B and C can be transmitted through dental waste. There are assumptions that in developing countries, infections with a wide range of pathogens are being transmitted as a result of inappropriate management of health-care waste.[1,2,6,7] Microbial content of dental solid waste was explored in a study in Brazil where 766 bacterial strains were identified; it was shown that Staphylococcus epidermidis, Stenotrophomonas maltophilia, and Enterococcus faecalis were the most frequently isolated species.[7]

Chemical and toxic waste includes components polluted with silver and mercury amalgams, lead foil, disinfectants, batteries, metals, and residues of materials used in dentistry.[1,2] Amalgam is a stable solid restorative material that has been used in dentistry since 200 years ago. Amalgam is composed of several metals including mercury, silver, tin, copper, and zinc; about half of it consists of mercury and silver. Therefore, dental clinics are one of the most important sources of mercury discharging into the environment.[8-11] Several studies have shown that about 10%–70% of mercury resulted from amalgam use in dental clinics is discharged into the sewage system, which have undesirable effects on the health and environment. The consumption of mercury from amalgam used in dentistry is estimated to be around 300 tons per year worldwide.[12] Although dental clinics produce relatively small amounts of waste, in the last decade, due to the increasing number of applicants for dental services, the use of gloves and other disposable utensils, the development of medical and pharmaceutical sciences, the high per capita consumption of medicines in Iran, and the invention, production and use of more complex drugs, the quantity and quality of waste produced have markedly been changed. It should be noted that the effects of many of these materials on the environment and public health are still unknown.[6,9]

Considering that the first step in waste management is the identification and classification of materials,[13] for lack of detailed and accurate information on dental waste quantity and quality in Iran, this study was carried out to characterize waste products created in dental clinics of Birjand, the capital of South Khorasan province, northeastern Iran.

Materials and Methods

The protocol of this cross-sectional study was approved by the Ethics Committee, Birjand University of Medical Sciences (Code: Ir.bums.REC.1396.72). The total number of dental clinics in Birjand was

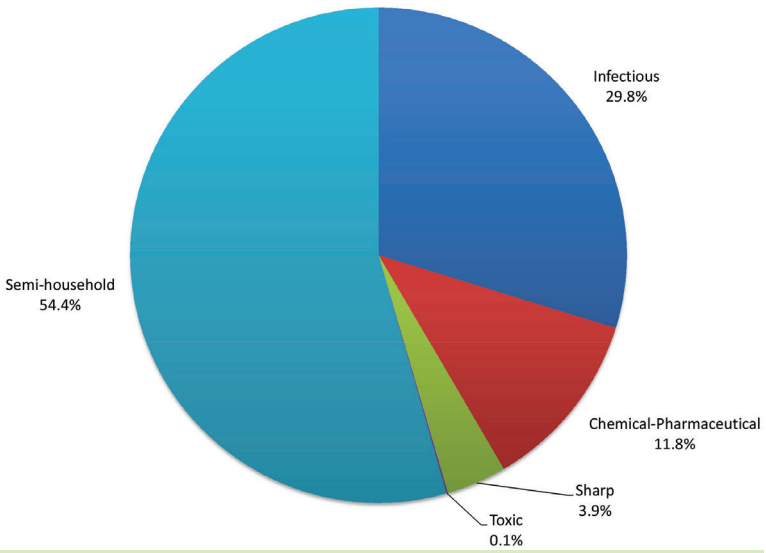

Figure 1: Percentage of types of waste produced in dental clinics in Birjand

66, out of which 48 were willing to participate in this study. There were three sampling steps within three consecutive days (Sunday, Monday, and Tuesday) in weeks without formal holidays to minimize the impact of holidays on the amount of waste generation. Sampling was done in August and September, 2017. Samples were transferred to the laboratory within a maximum of 10 hours of collection, where they were weighed and physically analyzed. At first, the samples were classified into 64 categories based on the potential hazard and environmental significance; then, they were divided into five general categories including semi-household, infectious, chemical and pharmaceutical, sharp and cutting, and toxic waste. They were then weighted using a laboratory scale with a precision of 0.01 g. Each section of the collected waste was weighted three times, and finally, the mean value of the obtained results was calculated. During the separation and weighing, gloves, masks, and protective glasses were used to ensure safety.

In the next step, by averaging the numbers obtained from three days of sampling, the average daily production of different components of waste for each dental office was derived. To determine the annual production of waste in dentistry centers, it was necessary to have annual work days of these centers. By asking dentists, it became clear that almost all of the clinics did not work on holidays. According to the Iranian calendar, there were 292 working days in the year the study was conducted. By multiplying the daily average of different components of waste in 292, the annual production of different components of waste in dental centers was calculated. Considering the total number of dental clinics in the city (n=66) and the number of clinics studied (n=48) the total amount of annual production of waste in all dental clinics in Birjand city was finally estimated by multiplying the total amount of the waste obtained in the previous step by a factor of 1.375. To determine the per capita amount of waste produced, the final value was divided by the number of people visited per working day.

A checklist containing 25 questions

TAKE-HOME MESSAGE

- About one-third of the dental waste is infected.
- A significant portion of dental waste is consisted of recyclable materials such as nylon, paper, and cardboard.
- Most of the non-used amalgam materials are finally disposed to sewage or trash bin.
- Most of the tiny and coarse particles of amalgam separated from patients' teeth are disposed to sewage and trash bin, respectively.
- Almost in half of the clinics, radiographic film packets and fixing solutions are directly disposed in trash bin and sewage, respectively.
- Dental tools are sterilized using autoclave, oven, or disinfectant solutions, or a combination of them, while autoclave was the most common one.

Table 1: The amount of various components of dental waste in studied dental clinics in Birjand

Type of waste	Amount (kg/year)	Percentage
Paper towels contaminated with saliva	235.311	5.7
Paper towels contaminated with blood	162.462	4.0
Gas (bandage) contaminated with saliva	166.600	4.1
Gas (bandage) contaminated with blood	123.148	3.0
Nylon gloves	686.850	16.7
Single-use gloves	96.740	2.4
Latex gloves	443.540	10.8
Dental impression materials	181.630	4.4
Plastic	264.310	6.4
Paper and cardboard	551.270	13.4
Syringe tip	223.260	5.4
Needles and sharp and cutting objects	122.660	3.0
Dental wood sticks	146.460	3.6
Pharmaceuticals	419.740	10.2
Dental rolls contaminated with saliva	87.490	2.1
Dental rolls contaminated with blood	88.260	2.2
Total	**4099.731**	**100**

on the production, separation, recycling, reuse, collection, and disposal of the produced waste was designed after reviewing the relevant resources and consulting experts in the field of solid waste management. The checklist was given to the dentists working in the studied clinics. The data were analyzed with SPSS® for Windows® and Microsoft® Excel®.

Results

The estimated average waste generation in dental clinics in Birjand was 62.5 g/day per capita. The total amount of waste generated was 7848.020 kg/year. The highest amount of waste produced in dental clinics was related to semi-household waste with 4263.411 kg/year. The share of infectious, chemical-pharmaceutical, and sharp and cutting waste, was 2338.463, 927.420, and 309.271 kg/year, respectively. With 9.275 kg/year, toxic waste had the lowest quantity among different categories of waste (Fig 1).

Waste components with the highest amounts included nylon gloves, paper and cardboard, latex gloves, and pharmaceuticals (Table 1). Dental rolls contaminated with saliva and blood, single-use gloves, and sharp and cutting objects had the lowest amounts of waste produced.

Only 20% of the clinics committed to implementing any recycling programs (Table 2). Waste was separated in all the studied clinics, particularly for sharp and cutting waste. More than half (57%) of dental units were equipped with amalgam filter.

Table 2: Approaches adopted to manage waste generated and sterilization methods used in dental clinics in Birjand

Items	Management method	Percentage
Additional amalgam remained in the office	Keeping in the fixing solution followed by disposal to sewage	11
	Keeping in the fixing solution followed by putting in the trash	54
	Direct disposal to the sewage system	6
	Direct disposal to the trash	17
	Recycling	6
	Keeping in the fixing solution followed by recycling	6
Amalgam particles separated from a patient's teeth	Disposal of tiny particles with the water that rinsed the patient's mouth in the dental unit, then into the sewage system; disposal of coarse particles in trash	71
	Others	29
Empty amalgam capsules	Disposal in trash	77
	Recycling the remaining of the amalgam and then disposing it in the trash	23
Radiographic film packet	Disposal in trash	29
	Separating and recycling of its lead foil and disposal of the remaining parts in the trash	11
	Disposal to the sewage system	3
	Recycling	6
	Digital photo	20
	Radiography was not performed	31
Fixing solution	Disposal to the sewage system	49
	Recycling	0
	Digital photo	20
	Radiography was not performed	31
Sharp and cutting objects	Safety box	100
	Needle cutter	0
	Temporary storage in different containers, then disposal of these containers with the contents inside them in the trash	0
Sterilize dentistry tools and equipment	Using autoclave	97
	Using oven	9
	Using disinfectant and sterilizing solutions	49
	A combination of the above methods	23

There was no program to reduce waste generation in 54% of the clinics.

Discussion

In our study, the highest share of waste generation was related to semi-household waste (54.3%); the lowest amount of waste belonged to the toxic group (0.1%) in dental clinics of Birjand. Several studies have reported similar findings, though with different amounts of waste produced. In a study by Komilis, *et al*, in dentistry clinics of Xanthi, Greece, the highest amount of waste was generated in the semi-household section (74%), while toxic waste had the lowest share in dental waste composition (0.5%).[14] In the study of Amouii, *et al*, on the waste of dental clinics in Babol, it was also found that the highest amount of waste generated was in the semi-household section (52.5%) and the lowest was in the toxic sector with 0.3%.[15] The results of this study were also consistent with the findings of Kulivand, *et al*, in Urmia, Iran.[10] These similarities in the composition of dental waste among different clinics can be related to the capacity of clinics and departments within them. In a study carried out by Kulivand, *et al*, on waste produced in dental clinics in Hamedan, Iran, it was found that the average annual amount of waste generated in dental clinics was 8677.56 kg, which was consisted of 91.1% semi-household, 6.7% chemical-pharamecutical, 2.1% infectious, and 0.02% toxic wastes.[16] This difference can be due to varieties in the provision of specialized dental services. The economic status and cultural characteristics of patients, the type of waste management system, and the extent to which reusable tools and materials are used, can be stated as other causes of fluctuations in the composition of dental waste generated. The average per capita waste generation in the dental clinics in Birjand was 62.5 g/day, which is close to the average per capita waste generation in dental clinics in Arak, Iran.[17]

In spite of the existence of semi-domestic and recyclable waste in the composition of dental waste in Birjand, all waste was finally considered infectious. According to Kizlary, *et al*, 94.7% of dental solid waste produced by private and public dental clinics studied in Xanthi was infectious and potentially infectious by weight, while 3.3% of waste by weight was domestic-type.[18]

According to the present study, the highest amount of waste was related to nylon gloves (686.85 kg/year) followed by paper and cardboard (551.27 kg/year) and latex gloves (443.54 kg/year). In the study carried out by Komilis, *et al*, paper and plastic were the largest parts of waste generated in dental clinics in Xanthi, Greece.[14] Paper and plastic were also the largest components of dental clinics waste in Brazil.[19] Ghanbarian, *et al*, reported that 60% of the total amount of waste produced in dentistry clinics in Shiraz, southern Iran, was consisted of plastic and paper.[2] About half of the waste produced in eight Turkish dental clinics was related to plastic gloves; 30% was paper waste.[20]

We found that no significant activity was undertaken to reduce, separate, or recycle the waste generated by the studied dental clinics. These centers did not have an acceptable performance in managing the waste. In only 20% of the clinics, a waste recycling program was implemented; in 54% of the clinics no action was taken to reduce waste generation. However, waste separation was carried out at all the studied clinics. In a study conducted in four dental clinics in Tehran, Iran, waste separation was also carried out in all clinics.[21] Nevertheless, separating infectious from domestic waste was conducted in only 10.9% of dental clinics in Shiraz, Iran.[22] In a study conducted in Yasouj, Iran, 64% of the clinics did not have a plan to reduce

waste generation; only 17% performed waste recycling, and in 83% of the clinics the waste produced was separated.[23] Considering the presence of different types of materials with special characteristics and potential risks in dental waste, a special program should be implemented to reduce the generation, separation, and recycling of the waste.

We found that 71.4% of the amalgam separated from the patient's teeth and 5.7% of the additional amalgam left in the office were discharged directly into the sewage system. About 50% of amalgam weight is mercury, which is a toxic substance;[24] if it directly enters the sewage system, it can cause water pollution.[21] In Thessaloniki, Greece, mercury-bearing dental waste was properly managed by only 20% of dentists.[25] Based on a study done in Yasuj, Iran, 90% of the amalgam separated from the patient's teeth and 10% of the additional amalgam left in the office were directly discharged into the sewage system.[23]

Different methods are used to control the discharge of dental mercury into the sewage system. One of these methods is using units equipped with amalgam filter.[23] According to the present research, 57% of the studied dental clinics employed such units. Compared to Yasuj, where 24% of dental units were equipped with amalgam filter,[23] Birjand dental clinics had a better performance. Another method for the management of amalgam is its collection and preservation by means of mercury spill kit. Based on the results of this study, 66% of dental clinics in Birjand did not use this kit and recycling empty amalgam capsule was performed in only 23% of these centers. In Yasuj, 76% of the dental clinics disposed empty amalgam capsules in the trash, and only 19% of the clinics used mercury spill kits.[23]

Use of puncture-proof containers (safety box) as the standard method for collecting sharp and cutting waste was administred in all dental clinics in Birjand, while 60% of Shiraz dentistry centers complied with the standard.[22]

Fixing and developer solutions are commonly used in dental radiology. Due to the high concentration of silver in fixing solution, it has been classified as a hazardous substance and should not be directly discharged into the sewage system or disposed in trash. The best way to handle the solution is to recycle silver. We found that 60% of studied dental clinics discharged fixing solution directly into the sewage system without any recycling. Majlesi, *et al*, showed that 50% of the studied dental clinics recycled fixing solutions within the office; the other half discharged them directly into the sewage system.[21] In Yasuj, only 10% of the clinics recycled silver to manage the fixing solution.[23] In India 45% of developer and fixing solutions were disposed into the sewer, 49.4% of them were diluted before disposal into sewer, and only 5.6% of them were returned to the supplier.[26]

Autoclave was used in 97% of the studied clinics to sterilize dental tools and equipment; a combination of different methods including use of oven, autoclave, and disinfectants were used in 23% of the clinics for this purpose (Table 2). Based on the results of a study conducted in Sydney, all 14 dental offices in the city used autoclaves for sterilizing equipment; 12 had chemical disinfectants for disinfection of surfaces.[27] Ensuring the proper function of these devices for sterilization can be an effective step to control infections transmitted through dental instruments and equipment.

The maximum coverage of dental clinics by present study was the strength point of this study. Determining the composition of waste, which is one of the key components of a material identification program, was another strength point of the present research. This study had some limitations.

It was not conducted in different seasons; while the high consumption of snacks and sweets at the beginning of the spring (due to the new-year holidays) can affect the health of teeth and, consequently, the referral of individuals for receiving dental care services. Lack of attention to using personal protective equipment by personnel involved in waste management was another limitation of this study.

This study showed a remarkable share of recyclable material such as paper and plastic in the composition of dental waste and lack of special approach to manage the waste generated in dental clinics. With respect to the presence of semi-household waste alongside the unfavorable ingredients including toxic, infectious, chemical-pharmaceutical, and sharp and cutting waste, it is necessary to plan for waste minimization, separation, and recycling at generation source.

Conflicts of Interest: None declared.

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Erratum

In some points in an article recently published in *The IJOEM*, Confirmatory Factor Analysis of the Finnish Job Content Questionnaire (JCQ) in 590 Professional Musicians (doi: 10.15171/ijoem.2017.1055), the “repetitive work” should have been read “opinions influential.” The current version of the article on the Journal Web site and the MEDLINE records are correct.