

# Analysis of the health and environmental status of sterilizers in hospital waste management: a case study of hospitals in Tehran

Pooyaneh Aghapour<sup>1</sup>, Ramin Nabizadeh<sup>2</sup>, Jafar Nouri<sup>3</sup>, Masoud Monavari<sup>3</sup> and Kamyar Yaghmaeian<sup>1</sup>

## Abstract

According to the first article of the waste management rule ratified in 2004, healthcare facilities are responsible for sterilizing their own infectious wastes. Nowadays non-incineration techniques are preferred internationally owing to toxic emissions caused by incinerators. Surveys have been conducted in Iran, resulting in ratification of an executive code by the Iranian Board of Ministers, which imposed a ban on incinerators; furthermore, it emphasized, instead, the use of sterilizers. The main objective of this research was evaluating the present status of these facilities to figure out which ones have less effect on the community, personnel and on the environment. A questionnaire was used to collect the data. The results showed that biological tests had not been conducted for most of the sterilizers. As biological testing is the most important factor in assessing autoclave accuracy, a comprehensive program should be initiated to perform these tests to improve functioning of the sterilizers so that the best treating process can be achieved.

## Keywords

Sterilizers, healthcare wastes, waste management, health and environmental rules, non-incineration technologies, biological tests, treating process

## Introduction

Recovery from a homeland security incident will likely involve the management of waste (EPA, 2011). Healthcare activities lead to production of waste that may cause adverse health effects (WHO, 2004). In 2004, the Stockholm convention on persistent organic pollutants came into force and the World Health Organization (WHO) released its policy paper on safe healthcare waste management (Healthcare Without Harm, 2007). The policy requires medical waste treatment options to be non-combustible, less toxic and cost-effective (Healthcare Without Harm, 2000). Before that, most medical waste was incinerated—a practice that is short-lived because of environmental considerations (Gautam et al., 2010). Healthcare waste management continues to present an array of challenges for developing countries (Mbowngwe et al., 2008). Unfortunately, most economically developing countries suffer a variety of constraints to adequately managing these wastes (Diaz et al., 2005). Ogbonna (2011) showed that both hospital waste generators and handlers treat hospital wastes as normal domestic waste in Nigeria. Li et al. (2006) showed that management, disposal and treatment technologies for healthcare wastes in China are still behind the status of developed countries. In 2007, a law was ratified by the Iranian Board of Ministers ordering a ban on incinerators. Furthermore, the waste management law held ministers, organizations and institutions responsible for comprehensive healthcare waste management. The

healthcare facilities implementing the non-incinerator methods have been surveyed in this research. The main objective of this study was to assess the present status of these facilities in hospitals in Tehran.

## Materials and methods

In this study, 39 hospitals containing 44 sterilizers in Tehran city were investigated in order to evaluate the sterilizers' operational process by observing health and environmental issues. A 71-item questionnaire was used to collect the data. The questionnaire was revised by experts in order to improve the investigation. It should

<sup>1</sup>Department of Environmental Management, Graduate School of the Environment and Energy, Tehran Science and Research Branch, Islamic Azad University, Tehran, Iran

<sup>2</sup>Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

<sup>3</sup>Department of Environmental Science, Graduate School of the Environment and Energy, Islamic Azad University, Tehran, Iran

## Corresponding author:

Ramin Nabizadeh, Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, 1415564460, Iran.  
Email: rnabizadeh@tums.ac.ir

**Table 1.** Hospital waste management ranking criteria.

Range	Rank
91–100	Excellent
71–90	Good
51–70	Medium
26–50	Poor
0–25	Very poor

be noted that the questionnaires were completed from May to August 2011.

To convert the collected data to a quantitative measure, score 1 assigned the answers compatible to the standards and score 0 was assigned to those not complying with the standards. The standards were basically the available standards of the Ministry

of Health based on the WHO guidelines. In each category, scores were scaled up to set a quantitative measure from 0 to 100. These scaled-up measures were used as the basis of descriptive statistical analysis. The measures of ranking the scores are presented in Table 1.

Table 2 shows the questionnaire used in this study. Frequency tables, and central and dispersion indices of descriptive statistics were used to analyze the available data.

## Results and discussion

### General information

Eight and a half million people live in Tehran, the capital city of the Islamic Republic of Iran, which is about 16% of Iran's urban population. Tehran city has 152 hospitals. Thirty-nine hospitals

**Table 2.** Questionnaire used in the study for data collection.

#### Hospital general information

What is the name of the hospital?

What is the address and telephone number of the hospital?

What is the number of active beds?

What percentage of beds is in use?

What are the names of the wards in the hospital?

When was the hospital established?

What is the type of ownership of the hospital?

Public  Private  Charity  Military  Social security

What is the hospital's main function? Educational  Non-educational

What is the hospital's rank based on the last evaluation?

Excellent  First level  Second level  Third level  Substandard

What is the number of personnel?

Does the hospital have environment health job position? Yes  No

Does the hospital have an environment health expert? Yes  No

What is the degree of an environment health expert?

Associate degree  BSc  MSc

Is the hospital environment health expert a member of the health and hospital infection control committee? Yes  No

Does the hospital hold any waste management training course documents? Yes  No

#### Treatment and disposal

Have the volume and weight of each waste stream been measured? Yes  No

How much is the volume of infectious waste?

How much is the volume of non-infectious waste?

Which treatment technology is used? Thermal  Chemical

Which type of thermal technology is used? Autoclave  Hydroclave  Dry Thermal  Microwave

If chemical technology is used, which kind of chemical substance and how much of it is used?

What is the name and model of sterilizer?

Does the sterilizer have microbial inactivation efficacy? Yes  No

Is any hazardous by-product produced during the time of treatment? Yes  No

Does the hospital have any document about hazardous by-product produced during the time of treatment? Yes  No

Does the hospital have any document about the treatment process and accuracy of the sterilizer's function? Yes  No

Could the output of sterilizer be disposed easily? Yes  No

Does the security of the system operate during the total process? Yes  No

Is the use of sterilizer economic? Yes  No

Does the sterilizer have any hazardous impact on the personnel and operators? Yes  No

#### The sterilizer's general information

When was the sterilizer established?

When was the sterilizer exploited for the first time?

- How many cycles does the sterilizer work each day?  
 What is the nominal capacity of the sterilizer in each cycle?  
 What is the real capacity of the sterilizer in each cycle?  
 What are the dimensions of the sterilizer?  
 How much does the sterilizer weigh?  
 Is waste fed into the treatment system automatically (by machine) or by hand (stop feed)?  
 The easiness of sterilizer using: Mechanical  Manual   
 The easiness of sterilizer discharge: Mechanical  Manual   
 Is any specialist needed while using the sterilizer? Does your facility currently have the labor and staff expertise to maintain the equipment, or would additional training be needed? Does your facility have staff on-site trained and certified to fulfill the testing requirements, time, etc. involved in these permits? Yes  No   
 What is the essential degree for the operator? High school  Diploma   
 Associate degree  BSc  Others   
 Of what type is the sterilizer's pollutant? Noise  Odor  Sewage  None   
 What kind of ancillary equipment does the sterilizer need? Does the technology require ancillary equipment such as shredders? Softener  Boiler  Special packet for waste   
 Chemical substance  Others   
 How much is the expenditure for the sterilizer's equipment?  
 How many failures of the sterilizer occur annually?  
 more than 5 times  4 times  3 times  2 times  1 time   
 How many times does the sterilizer stop working because of any failure? How long is the down-time of the technology?  
 More than 15 days  12 days  9 days  6 days  3 days   
 Is the capacity of sterilizer suitable for the amount of waste? Yes  No   
 How much of the volume of waste is reduced per cycle? What volume of waste can the technology treat?  
 How much is the capacity of the sterilizer for waste?  
 What is the maximum external temperature of disposed waste?  
 What is the dimension of disposed waste?  
 Powder  Less than 20 mm  More than 20 mm  Very big   
 How are the hygiene and safety conditions of the personnel and operators?  
 Does the hospital have guidelines for doing chemical and biological tests?  
 Has the vendor delivered the sterilizer on time considering the commitments of contract?  
 How long does it take the treatment technology vendor to visit the sterilizer to service it?  
 Less than 3 days  6 days  9 days  12 days  15 days

#### The sterilizer's information

- If the autoclave is used answer the following questions:  
 Is the sterilizer equipped with shredder? Yes  No   
 If the answer above is yes, what kind of shredder is used?  
 Is the used technology also used for sharps? Yes  No   
 Is the used technology also used for chemical and pharmaceutical wastes? Yes  No   
 Can the waste packet be treated?(for the sterilizers without shredder)  
 Yes  No   
 Is the amount of waste suitable for sterilizer capacity?  
 Yes  No   
 How many times is the sterilizer calibrated annually?  
 Are there any documents for annual calibration?  
 Yes  No   
 Is any chemical indicator used in each cycle?  
 Yes  No   
 Is the biological test (*Bacillus stearothermophilus*) used monthly?  
 Yes  No   
 If the answer to the pervious question is yes, is there any documentation for monthly biological testing?  
 Yes  No   
 How long are the documents maintained for? 1 year  less than 1 year   
 How much is the temperature?  
 How much is the pressure?  
 How long is the remaining time? Nominal  real   
 Is the autoclave equipped with printer? Yes  No

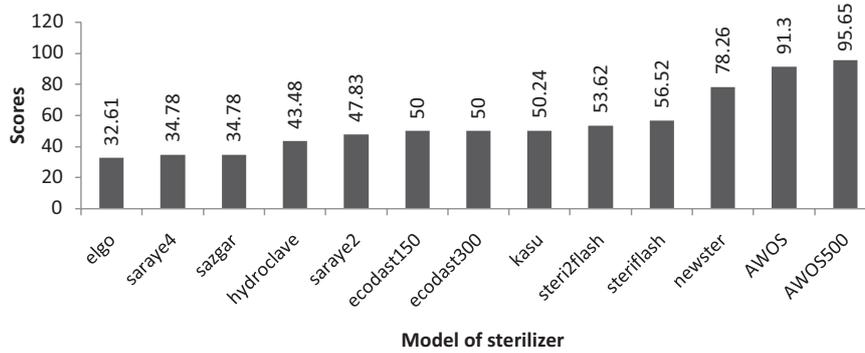


Figure 1. Scores of different models of sterilizers used in Tehran hospitals.

equipped with sterilizers during the time of study were investigated in order to reveal the current status of non-incineration technologies used in Tehran city (Amar, 2012; Tehran, 2012).

One of the initial steps in the process of developing a reliable waste management plan is a comprehensive understanding of the quantities and characteristics of the waste (Maksud Alam et al., 2008). The average waste generation rates ranged from 2.41 to 3.26 kg/bed/day for general medical wastes and from 0.19 to 0.88 kg/bed/day for infectious wastes in Taiwan (Cheng et al., 2008). Whereas, in Tehran, infectious waste generation per day was found to be 1.11 kg/bed, sharps generation per day was found to be 0.1 kg/bed and domestic waste generation was found to be 2.4 kg/bed.

The safe management of infectious healthcare waste is gaining increasing importance worldwide (Stolze and Kuhling, 2009), so treatment technology should be evaluated to ensure proper management of infectious waste.

*Disposal and sterilizer ranking*

Figure 1 compares the scores obtained for different sterilizers based on the specific details of the sterilizers. As shown in the figure, an autoclave AWOS500 has the highest score and elgo, which is a chemical technology, has the lowest.

Figure 2 shows sterilizing ranks. Most of the sterilizers are ranked as poor. Although the role of sterilizing infectious waste is very important in disposal processes, there are many steps that should be followed for adequate medical waste treatment. For instance, The North Carolina Medical Waste Rules require autoclaves to be monitored weekly under conditions of full loading for effectiveness through the use of biological indicators (University of North Carolina, 2012). Although there are companies that provide efficient sterilizing equipment, irregular use of biological tests in practice increased the related penalty scores and therefore lowered the score of the sterilizers and affected the ranking.

Figure 3 presents the status of waste disposal. As can be seen clearly, most of hospitals are ranked in poor condition. If this part is not performed correctly, efforts in other parts of waste management cannot achieve the required result. It seems that disposal processes should be improved in hospitals in Tehran.



Figure 2. Share of each sterilizing rank in this study.

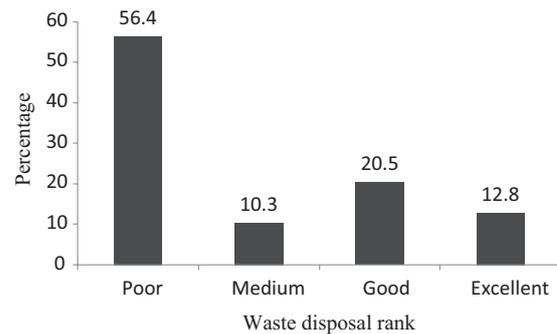


Figure 3. Share of each waste disposal rank in this study.

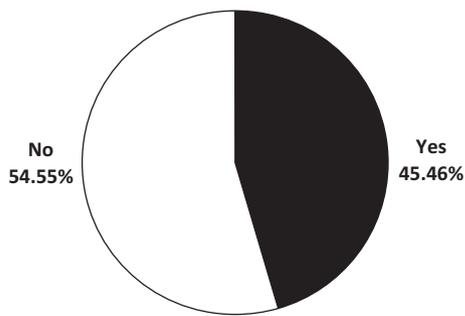
*Sterilizer-specific information*

Most of the sterilizers did not produce any pollution, but a large number failed more than five times annually.

Figure 4 presents the data for biological tests. As many hospitals did not perform this test, the accuracy of the sterilizers' function cannot be ensured. The Occupational Safety and Health Association and Center for Disease Control and Prevention recommended the use of biological indicators for monitoring steam sterilization cycles in autoclaves (Le Richard et al., 2005).

**Conclusion**

As the implementation of biological testing is the most important factor to assess autoclave accuracy, the desired performance of using these technologies in healthcare facilities will only be achieved by performing the biological tests. Although recently



**Figure 4.** Proportion of hospitals performing biological tests to assess the accuracy of sterilizer function.

developed alternative treatment technologies are becoming increasingly popular, the results show that biological tests have not yet been implemented for most of the sterilizers. Therefore, a comprehensive program should be initiated to implement these tests to improve the functioning of the sterilizers and to achieve the best treating process. Furthermore, it is suggested that hospitals hold training courses strictly in order to comply with an adequate treatment program.

### Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

### Acknowledgements

The authors would like to acknowledge department of Environmental Health Engineering, Science and Research University, Ministry of Health, and all those hospitals in Tehran who participated and helped in the present research.

### References

Amar (2012) Iran at a glance. Available at: [www.amar.org.ir](http://www.amar.org.ir) [in Persian].

- Cheng YW, Sung FC, Yang Y, Lo YH, Chung YT and Li K-C (2008) Medical waste production at hospitals and associated factors. *Waste Management* 29: 440–444.
- Diaz LF, Savage GM and Eggerth LL (2005) Alternatives for the treatment and disposal of healthcare wastes in developing countries. *Waste Management* 25: 626–637.
- Environmental Protection Agency (2011) Waste management for homeland security incidents. Available at: <http://www.epa.gov/osw/homeland/options.htm> (accessed 14 November 2012).
- Gautam V, Thapar R and Sharma M (2010) Biomedical waste management: incineration vs. environmental safety. *Indian Journal of Medical Microbiology* 28: 191–192.
- Healthcare Without Harm (2000) Medical waste treatment technologies: evaluating Non-incineration alternatives. Available at: [www.noharm.org](http://www.noharm.org) (accessed 13 December 2012).
- Healthcare Without Harm (2007) A global inventory of alternative medical waste treatment technologies. Available at: [www.noharm.org](http://www.noharm.org) (last accessed 13 December 2012).
- Le Richard N, Hicks AL and Dodge J (2005) Autoclave testing in a university setting. *Applied Biosafety* 10: 248–252.
- Li R-D, Nie Y-F, Raninger B and Wang L (2006) Options For health care waste management in China. *The Chinese Journal of Process Engineering* 6: 261–266.
- Maksud Alam M, Sujauddin M, Mohammad G and Mohammad Shamsul Huda S (2008) Report: Healthcare waste characterization in Chittagong Medical College Hospital, Bangladesh. *Waste Management & Research* 28: 291–296.
- Mbongwe B, Mmerekhi BT and Magashula A (2008) Healthcare waste management: Current practices in selected healthcare facilities, Botswana. *Waste Management* 28: 226–233.
- Ogbonna DN. (2011) Characteristics and waste management practices of medical wastes in healthcare institutions in Port Harcourt, Nigeria. *Journal of Soil Science and Environmental Management* 2: 132–141.
- Stolze R and Kuhling J-G (2009) Treatment of infectious Waste: development and add-on set for used gravity displacement autoclaves. *Waste Management & Research* 27: 343–353.
- Tehran (2012) Urban environment/living in Tehran. Available at: [www.tehran.ir](http://www.tehran.ir) (accessed 13 December 2012).
- University of North Carolina (2012) *Environment, Health and Safety, Biological Waste Disposal Policy*. Chapel Hill: University of North Carolina.
- WHO (World Health Organization) (2004) *Policy paper. Safe health-care waste management*. Geneva: WHO.