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Original Article

Investigating the performance of on-site infectious wastes decontamination equipments in hospitals affiliated with Babol University of Medical Sciences

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Abstract

Background: The proper functioning of the hydroclave, a critical device in the sterilization of medical instruments, is essential. This study aimed to assess the performance of hydroclave devices in decontaminating infectious waste at hospitals affiliated with Babol University of Medical Sciences in 2023.

Methods: This cross-sectional descriptive study utilized a questionnaire that collected data on monthly *Geobacillus stearothermophilus* (Class 6) and Bovidic vial test results, the number of active beds, the average daily weight of infectious solid waste, as well as the name, age, and capacity of the hydroclave devices, and their operating parameters, including temperature, pressure, and sterilization time.

Results: In 2023, hospitals affiliated with Babol University of Medical Sciences produced an average of 250.46 kg of infectious waste per day, with an average of 181.28 active beds. The performance accuracy of the hydroclave devices, based on *G. stearothermophilus* (Class 6) and Bovidic vial tests, was as follows: *G. stearothermophilus* test—77.8% negative, 1.4% positive; Class 6 test—72.2% negative, 1.4% positive; Bovidic test—73.2% negative, 0% positive. Data for the remaining tests were unavailable. On average, the devices had a lifespan of 7.83 years, a capacity of 1133.33 liters, operated at 133 °C and 2.59 bar, with an average sterilization time of 25.16 minutes.

Conclusion: This study has shown that the performance of hydroclaves in hospitals in 2023 was generally effective in the decontamination of infectious waste. It is recommended that indicators of the proper performance of hydroclaves be routinely monitored to ensure effective sterilization of hospital infectious waste.

Keywords: *Geobacillus stearothermophilus*; Decontamination; Medical Waste Disposal; Hospitals; Hydroclave

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Introduction

The rapid growth of the population and the increase in health and medical needs in the society have led to the development and expansion of various health service centers, such as hospitals, resulting in an increase in the production of medical waste [1]. Additionally, the emergence of new and diverse diseases has caused changes in medical equipment, materials and therapeutic techniques. One of these changes is the increased use of single-use drugs and medical devices in hospital surgeries [2].

Improper disposal of hospital solid waste poses a serious threat to human health and the environment. The most common health risks associated with mismanagement of hospital waste include the occurrence of hospital-acquired infections and the spread of infectious diseases such as AIDS, hepatitis B, and other viral and non-viral infections among healthcare workers. Studies indicate that each year, approximately 2.5 million people, most of whom are children die from diseases related to hazardous wastes [3]. A WHO-supervised survey across 55 countries representing four WHO regions (Europe, Eastern Mediterranean, South-East Asia, and Western Pacific) found that an average of 8.7% of hospitalized patients acquired nosocomial infections, and more than 1.4 million people suffered complications from these infections at any given time. Moreover, hospital-acquired infections increase economic costs due to extended hospital stays [4].

Consequently, proper management of hospital waste and improvement of disposal systems are considered essential public health measures [5]. A major challenge in hospital solid wastes management is the lack of awareness regarding the quantity and types of waste generated [6]. In order to properly manage waste in the stages of generation, storage, collection, transportation, and disposal, all hospitals must have very accurate and complete information on the location of waste production and its various types, the density and weight of waste generated, the length of time solid waste is stored in the wards and hospital grounds. It is also important to know the number of workers responsible for waste collection, the number and type of waste collection and transportation equipment [7].

Hospital solid wastes are divided into two groups, hazardous and nonhazardous wastes. Hazardous wastes include infectious, chemical, biological wastes, and etc., which account for about 10 to 25 percent of total hospital solid wastes. Infectious solid wastes are the most important component of hospital solid wastes, accounting for about 10 to 15% [8]. Also, determining the management method and physical characteristics of solid waste, such as per capita generation, density, and physical analysis, plays a very influential role in designing the correct management of hospital solid wastes [9].

Today, in waste management around the world, the issue of reducing waste production is very important, and significant studies and research have been conducted in this field. According to the waste management law, hospital wastes must be decontaminated before they leave the hospital to prepare for final disposal [10]. Iran Islamic Consultative Assembly approved a law in 2003, according to which it has placed the responsibility of eliminating and disposing of infectious wastes on producers [11]. Collection, treatment, and disposal of hospital waste are very important in terms of public health and prevention of environmental hazards [12, 13].

One of the important measures to prevent hospital infections is the use of the sterilization process. Sterilization is a process designed to kill all microbes, including microbial spores, which are very resistant forms. To evaluate the sterilization process, there are three types of monitoring: physical or mechanical, chemical, and biological methods [14]. The most reliable way to monitor the performance of the sterilization process is biological monitoring. In biological monitoring, bacterial spores are selected as the most resistant type of microbes [14, 15].

Hospital waste ranks as the second most hazardous waste after radioactive materials. The proper functioning of autoclaves is critical for the sanitary disposal of infectious hospital waste, effectively reducing disease transmission and environmental contamination. Since detailed data on the management of infectious waste and the performance of hydroclaves in Babol hospitals are lacking, this study aimed to evaluate the performance of hydroclaves in decontaminating infectious waste in hospitals affiliated with Babol University of Medical Sciences (BUMS) in 2023.

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Methods

In this descriptive cross-sectional study, the performance of hydroclave devices for the decontamination of infectious wastes in hospitals affiliated with BUMS in 2023 was investigated. Data were obtained from information recorded in the environmental health units of the studied hospitals during 2023. For this purpose, the required information has been collected by referring to the hospitals affiliated to BUMS, including Rouhani, Shahid Beheshti, Yahainejad, Marzikola, Amirkola Children's and Shahid Rajaee hospitals in Babolsar.

The results of bacteriological (*G. stearothermophilus* vial), chemical (Class 6 test), and biomedical tests (measurement of autoclave steam) tests were investigated and reviewed from the infectious and sharps wastes decontamination declaration form. By visiting the hospitals under study, information regarding the amount of wastes produced, the number of hospital's active beds, the age of the autoclave, the temperature, pressure, and sterilization time of the device were obtained and recorded in an Excel file. The data were analyzed using SPSS version 23 software.

Results

The present study has shown that the average amount of infectious solid wastes produced in the studied hospitals was 250.46 kg/day. The highest average amount of infected solid wastes produced in Shahid Beheshti Hospital was 650 kg/day and the lowest amount was related to Shahid Rajaei Hospital in the amount of 7 kg/day. The maximum, minimum, mean, and standard deviation of infectious waste generation (kg/day) in the studied hospitals are presented in Table 1. Additionally, the frequency percentages of positive and negative results for the *G. stearothermophilus* bacterial vial test, the Class 6 autoclave sterilization indicator test, and the Bowie-Dick test cycle in the studied hospitals are shown in Tables 2, 3, and 4, respectively.

Table 1: The maximum, minimum, mean and standard deviation index of the of infectious wastes (kg/day) in the studied hospitals

Hospitals	Maximum (kg/day)	Minimum (kg/day)	Mean (standard deviation) (kg/day)
Rouhani	580	530	552.5 (14.22)
Shahid Yahainejad	175	145	150.0 (11.67)
Shahid Beheshti	650	550	635.0 (30.30)
Amirkola	155	135	143.75 (6.44)
Shahid Rajaee	7	5	5.75 (0.72)
Marzikola	20	15	15.75 (1.48)

Table 2: The percentage of positive and negative vial tests for *G. stearothermophilus* in infectious solid wastes in the studied hospitals

Index / Hospitals	*G. stearothermophilus* Bacteria Vial Test		
	Positive No. (%)	Negative No. (%)	Missing data No. (%)
Rouhani	0 (0.0)	6 (50)	6 (50)
Shahid Yahainejad	1 (8.3)	9 (75)	2 (16.7)
Shahid Beheshti	0 (0.0)	10 (83.3)	2 (12.67)
Amirkola	0 (0.0)	12 (100)	0 (0.0)
Shahid Rajaee	0 (0.0)	7 (58.3)	5 (41.7)
Marzikola	0 (0.0)	12 (100)	0 (0.0)

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Table 3: Frequency of positive and negative test of Class 6 in decontaminated wastes in the studied hospitals

Index / Hospitals	*G. stearothermophilus* Bacteria Vial Test		
	Positive No. (%)	Negative No. (%)	Missing data No. (%)
Rouhani	0 (0.0)	6 (50)	6 (50)
Shahid Yahainejad	1 (8.3)	9 (75)	2 (16.7)
Shahid Beheshti	0 (0.0)	10 (83.3)	2 (12.67)
Amirkola	0 (0.0)	12 (100)	0 (0.0)
Shahid Rajaee	0 (0.0)	3 (25)	5 (41.7)
Marzikola	0 (0.0)	12 (100)	0 (0.0)

Table 4: Frequency of positive and negative of Bovid test in decontaminated solid wastes in the studied hospitals

Index / Hospitals	Bowie-Dick Test Cycle		
	Positive No. (%)	Negative No. (%)	Missing data No. (%)
Rouhani	0 (0.0)	6 (50)	6 (50)
Shahid Yahainejad	0 (0.0)	10 (83.3)	2 (16.7)
Shahid Beheshti	0 (0.0)	10 (83.3)	2 (12.67)
Amirkola	0 (0.0)	12 (100)	0 (0.0)
Shahid Rajaee	0 (0.0)	3 (25)	9(75)
Marzikola	0 (0.0)	12 (100)	0 (0.0)

The lifespan of the hydroclave devices, temperature, pressure, time per cycle, and capacity of the hydroclave devices in hospitals affiliated with BUMSare shown in Figures 1 to 5, respectively.

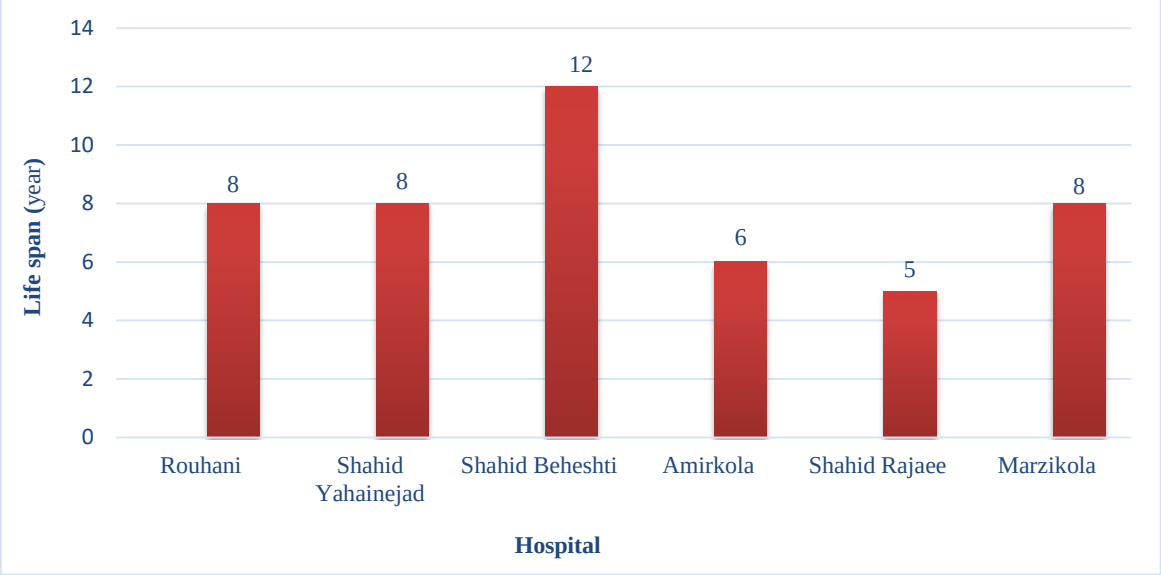

Figure 1: Lifespan of hydroclave in hospitals affiliated with Babol University of Medical Sciences

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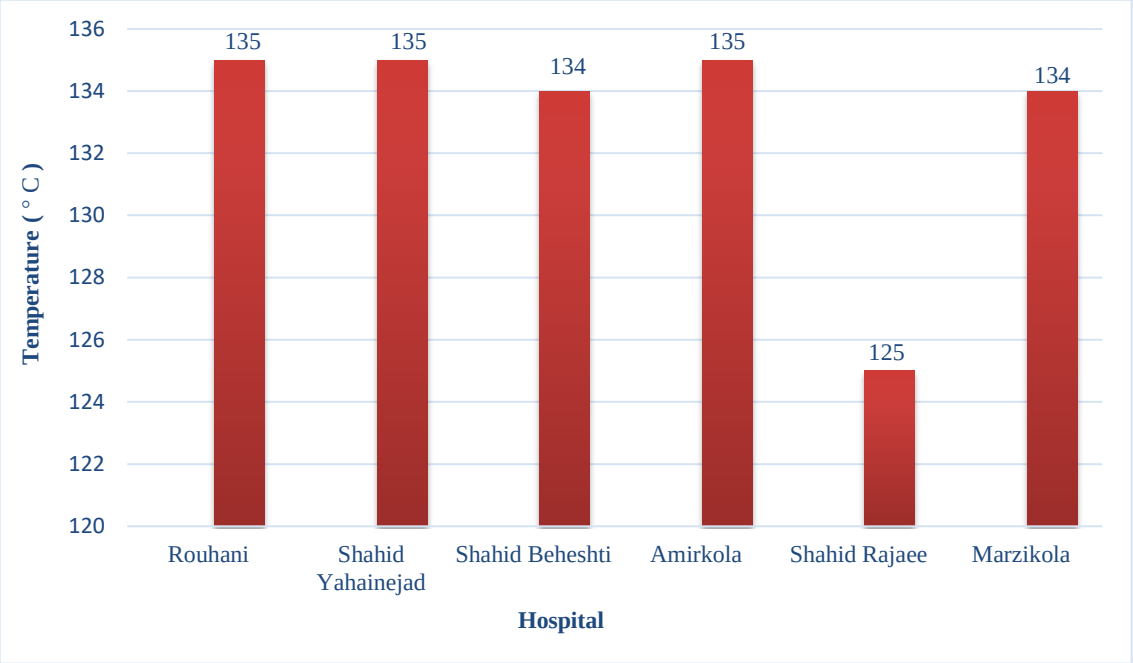

Figure 2: Hydroclave temperatures of hospitals affiliated with Babol University of Medical Sciences

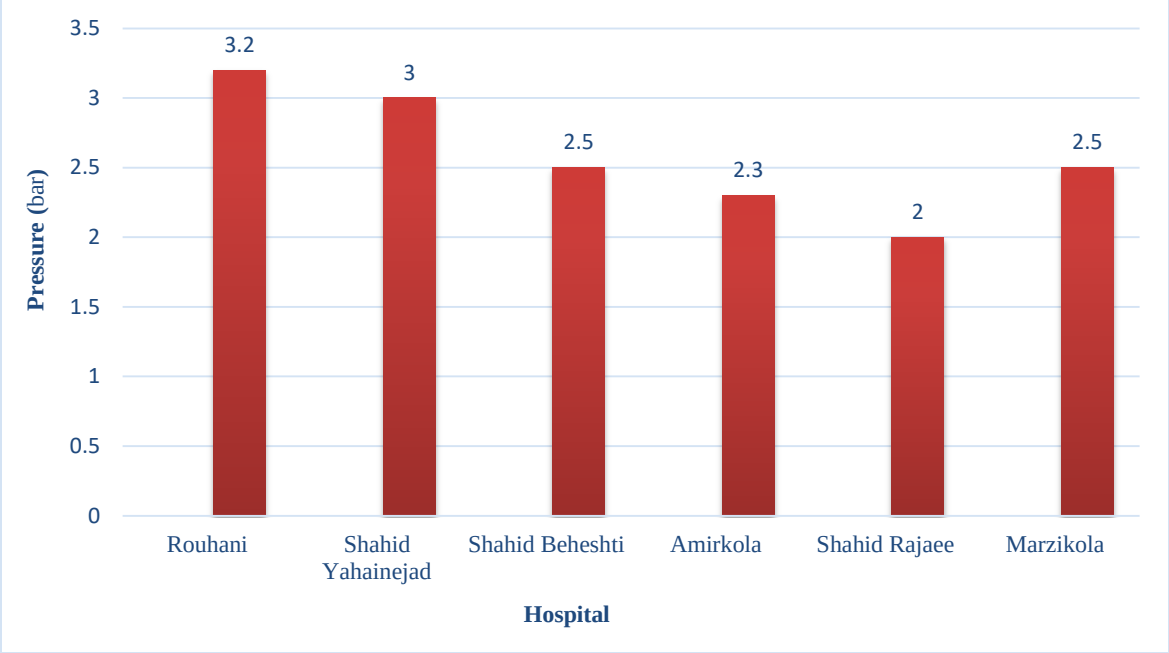

Figure 3: Hydroclaves pressures of hospitals affiliated with Babol University of Medical Sciences

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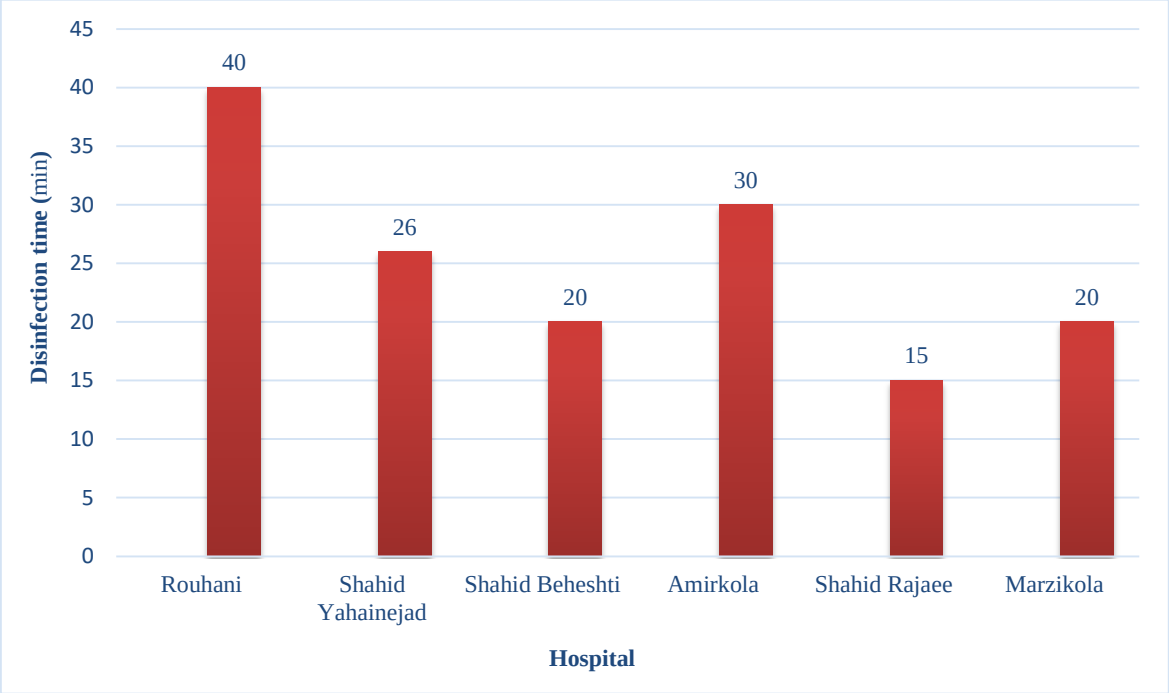

Figure 4: Times of each hydroclave cycle in hospitals affiliated with Babol University of Medical Sciences

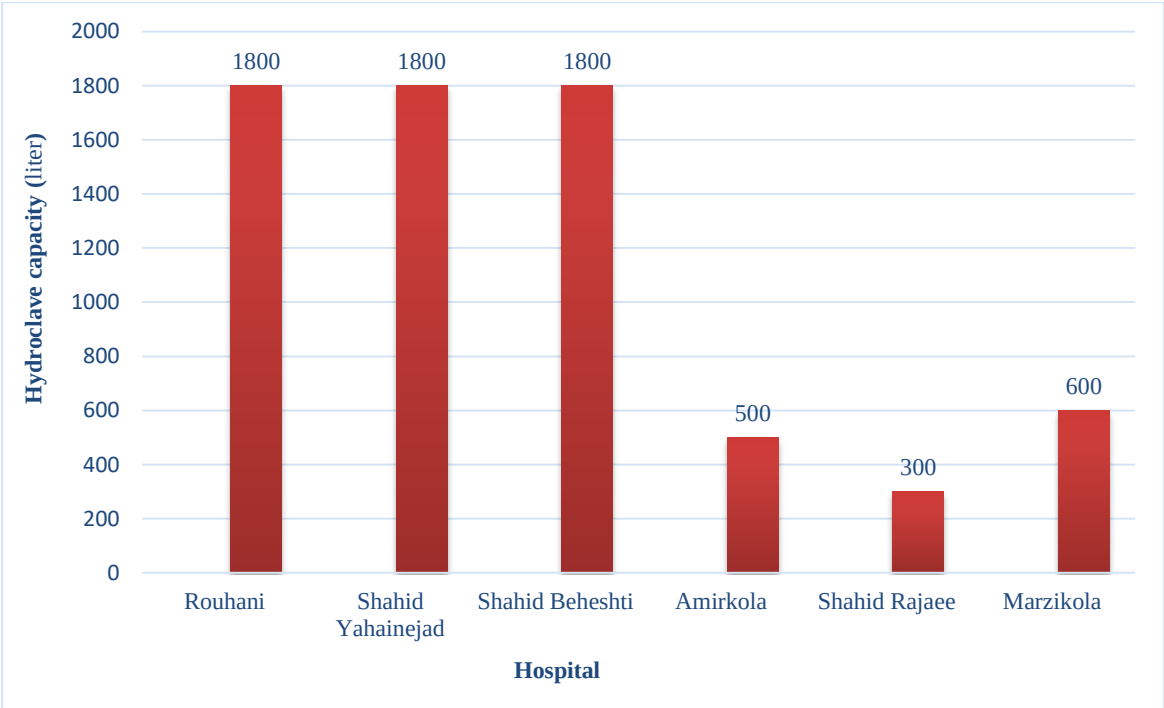

Figure 5: Hydroclaves capacities of hospitals affiliated with Babol University of Medical Science

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Discussion

Hydroclave devices can be considered the most suitable option among various infectious waste management technologies due to their good performance in terms of mechanical and biological indicators, as well as their lower pollution production and lower decontamination costs if operated by skilled and capable operators [15]. This study aimed to investigate the accuracy of the performance of hydroclave devices for the decontamination of infectious waste in hospitals affiliated with BUMS in 2023 by measuring three indicators: the *G. stearothermophilus* bacterium vial test, the Class 6 test, and the Bovidic test. The parameters of temperature, pressure, and time are important factors in the correct operation of the hydroclave, which should be 121 °C, 15 psi, and 20 minutes, respectively [16].

The results of this study show that all six hospitals affiliated with BUMShad adequate hydroclaves. The indicators of the *G. stearothermophilus* bacterium vial test was 77.8% negative and 1.4% positive, the Class 6 test results were 72.2% negative and 1.4% positive, and the Bowie-Dick test results were 73.2% negative and 0% positive. However, no information was available for the remaining data. In a study conducted by Rafiei et al. in 2019 which aimed to evaluate the performance of infectious waste decontamination devices in public hospitals affiliated with Khoi University of Medical Sciences, the performance of all examined waste decontamination devices was reported as100% satisfactory from both mechanical and biological perspectives [17].

Also, Saeb et al. conducted a study in 2017 with the aim of evaluating the hospital wastes management system, with an emphasis on decontamination methods, in all hospitals in Sari. They concluded that 46% and 36% of infectious wastes in hospitals were disposed of by incineration and decontamination, respectively. Biological monitoring showed that the performance of decontamination devices in hospitals was mostly acceptable, with an average destruction rate of 80% of microorganisms [18]. In a study by Taghipour et al. (2015), the performance of medical waste sterilization devices in Tabriz (Iran) was investigated. In this study, 38.9% of the autoclaves examined using the Bowie-Dick test had problems related to pre-vacuum operation, air leakage, and reduced steam penetration into medical wastes. In terms of biological indicator testing, 55.5% of the samples were positive, and most of the decontamination devices were not suitable for anatomical, pharmaceutical, cytogenetic, and chemical wastes [15]. In a study by Akbari et al. conducted in 2019 on evaluating the performance of autoclave devices in dental clinics in Birjand city using biological methods it was shown that only 12% of all clinics surveyed evaluated the performance of medical waste sterilization devices using biological testing, and most of them demonstrated adequate performance [19].

In this study, all hospitals under the coverage of BUMS were equipped with a hydroclave sterilization device. However, Fahiminia et alconducted a study in 2015 with the aim of monitoring the safety of infectious wastes and their optimal management in Qom hospitals, they concluded that out of 9 active hospitals in Qom province, only 3 hospitals were equipped with an infectious wastes safety device [20]. In 2021, Yosefi et al. conducted a study to investigate the quality control status of sterilization units in hospitals in Sabzevar city. They reported that the sterilization rate of devices and equipment was up to 76.66% [12]. Razavi et al. conducted a study in 2008 to investigate the performance of hospital sterilization devices using biological methods and the factors affecting them in hospitals affiliated with Tehran University of Medical Sciences. They concluded that the performance of 14 out of 135 devices studied (4.1%) was unsatisfactory [16].
In this study, the lack of data from hospitals not affiliated with Babol University of Medical Sciences is one of the limitations of this study.

Conclusion

The findings of this study indicate that the *G. stearothermophilus* vial, Class 6, and Bovidic test results, as well as the performance of hydroclave devices in hospitals in 2023, were generally effective in decontaminating infectious waste. Given that proper sterilization of hospital infectious waste reduces healthcare-associated infections and associated costs, it is essential for hospital management to prioritize this process. Therefore, it is recommended that indicators for assessing the correct functioning of hydroclave devices be routinely monitored to ensure effective sterilization of hospital infectious waste.

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Data availability

Not applicable.

Author's contribution

Conceptualization: A.I.A., S.M.M.; Methodology: H.A.N., A.I.A., S.M.M., S.F.M.; Sampling: Z.R.F., N.N.; Laboratory Work: Z.R.F., F.A., N.N.; Statistical analysis and investigation: H.A.N., A.I.A., S.M.M..; original draft preparation: Z.R.F.; review and editing: A.I.A., S.M.M.

Conflicts of interest

There are no conflicts of interest.

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Ethical Statement

The study was carried out following approval from the Ethics Committee of the BUMS (ethics code number IR.MUBABOL.HRI.REC.1403.074) and all ethical requirements were followed in all stages of the research.

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