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Design and Development of Hospital Waste Management Strategies Using Quantitative Strategic Planning Matrix Technique: A Case Study in Iran

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ABSTRACT

Introduction: This study developed a strategic management plan for hospital waste in selected public hospitals using quantitative strategic planning matrix (QSPM) model.

Materials and Methods: This research was conducted in three stages. First, strengths, weaknesses, opportunities, and threats (SWOT) matrix of waste management was extracted and scored in public hospitals in Yazd. Then, the matrix of internal and external factors along with the obtained strategies were developed using the SWOT model. Finally, using the QSPM model, the attractiveness table was prepared for weighting the prioritized strategies.

Results: The final score of SWOT analysis showed that the studied hospitals were in a competitive position (WT strategy). According to the results, 14 prioritized strategies were proposed. According to the QSPM matrix, the strategy of "green management indicators improvement" was prioritized.

Conclusion: The competitive position of the studied hospitals indicates a situation where hospitals should promote their strengths and reduce their weaknesses in order to take advantage of opportunities.

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Introduction

Health care waste includes blood, sharp materials, contaminated blood, body parts and tissues, chemicals, drugs, and radioactive materials, which are often produced in hospitals and increased with the outbreak of COVID-19 [1]. A large percentage of health care waste (85%) is not hazardous, while 10% of them are infectious and 5% are dangerous due to toxic pollutants such as mercury, chlorinated plastics, solvents, and some toxic substances [2]. The main factors influencing the increase of hospital waste production ratio include high population growth rate, increased number of health care providers, easy access of the population to health centers, and excessive use of disposable products, along with inadequate and inappropriate hospital waste management, which are of significant concern in many developing

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countries [3].

Hospital waste management should be cost-effective, easy, and eco-friendly, which can be achieved by cooperation between different government agencies [4]. However, there are many technical, economic, social, and educational problems and inadequate management and disposal methods in transmitting and disposing of waste in most health care centers of developing countries, leading to increased health risks and environmental pollution [5]. Major problems of hospital waste management include lack of proper segregation, collection, and storage, weakness in waste minimization, simultaneous collection and disposal of normal and hazardous waste, and lack of waste incinerators which can control the emission of particles and air pollution. Moreover, general disposal of chemical waste through the public sewerage system and lack of effective training programs for personnel [6], necessitate the existence and preparation of a waste management system resulting in safe and secure health care [7].

National standards such as hospital accreditation, strategic planning at the national level, and World Health Organization (WHO) guidelines determine the major practices of hospital waste management [8].

Medical (hospital), agricultural, industrial, ordinary, and special wastes are known as production wastes in Iran. The Waste Management Law of 2004 states that based on the standards set by the Department of the Environment (DOE), all processes of storage, mixing, collection, transportation, sale, and disposal of waste must be carried out with the interdepartmental partnership of the ministries health, treatment and medical education, industry, mining and trade, and other related organizations [9]. In a study conducted by the WHO, the results showed that waste and its management can contribute to 32 environmental problems [10]. Unfortunately, in developing countries, methods such as open burning or unsanitary burials are used for waste disposal, which are completely destructive for humans and the environment. These countries use almost no other method to manage their waste. [11].

Per capita waste produced per hospital bed in North America was 7-10 kg, Western Europe 3-6 kg, Latin America 1-4.5 kg, Africa 0.5-1.3 kg, and in high-income countries of Asia it was 4-4 kg. The risk ratio of hospital waste for each occupied bed was 0.2 kg in undeveloped countries and 0.5 kg in developed countries [12].

According to the results of the study conducted in Pakistan, private hospitals had a better situation in terms of hospital waste management, and most of them had a good management system (about 67% of hospitals). Public hospitals were also better than small private hospitals. [8].

The results of a study conducted in Iran showed that there is no waste management in Iran, since the personnel have not received enough training in this field. [6]. Depending on the environmental situation, the type of specialization, the number of referrals, and the production of hospital waste, it is possible to evaluate and develop specific programs at regional or hospital levels [13].

Different models and techniques can be used to evaluate hospital waste management. The SWOT and the quantitative strategic planning model (QSPM) are among the most famous models. The SWOT is used to determine the current position of the organization and help to improve its performance by determining strategies. The QSPM also helps to prioritize strategies [10].

Despite the importance of the issue, problems related to proper budget allocation and staff awareness in field visits have been identified. On the other hand, due to the need for cooperation of various organizations in solving problems and limited number of research with a macro perspective on hospital waste management in Yazd, the present study seeks to formulate hospital waste management strategies using the QSPM and then prioritize them in the selected government hospitals of Yazd city in 2021. The findings of this study can be effective in future decision making and planning to improve the quality of hospital services.

Materials and Methods

This cross-sectional study was developed in

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2021 based on the strategic planning approach and SWOT model and was evaluated and prioritized using QSPM. The study population was public hospitals in Yazd, including the Social Security Hospital of Yazd (hospital A) and a hospital under the supervision of the University of Medical Sciences (hospital B).

The mentioned hospitals were selected, since they were involved in the process and had more familiarity and cooperation with the research team. Moreover, factors that could affect hospital waste management were not significantly different from each other in the hospitals. Due to ethical considerations, the names of the hospitals were kept confidential.

Research data were collected by completing a checklist, reviewing existing reports, documents, waste management plans, interviews with managers and waste management experts, and field visits of hospital waste management activities. Field visits, reports of relevant experts, and a review of waste management criteria were used for data collection.

In order to conduct this study, two environmental health experts of hospitals, an expert in charge of waste management due to health care in the province, experts supervising environmental health of selected hospitals in the city health center and health centers in the area of selected hospitals were chosen.

A list of factors affecting waste management from health care concerning each stage of waste management was prepared by interviewing them and studying the documents. Then, a checklist of SWOT for each hospital was developed separately through field visits and surveys of environmental health experts.

The SWOT was scored based on importance coefficient (0-1) and priority (1 to 4). In the second stage, the SWOT matrix was designed by external factor evaluation (EFE) and internal factors evaluation (IFE) and how hospital managers reacted using the checklist and the Delphi method.

Delphi technique was used to score the strategies. Thus, a score of 1 (very weak) to 4 (very strong) was used for each factor of the matrices. For each factor, a weighted score was calculated and the final score was calculated based on the multiplication of internal and external factors in the normalized weight. X axis shows internal factors and Y axis shows external factors. The final score of less than 2.5 indicates the poor condition of hospital waste management for internal and external factors.

This step aims to determine the status of hospitals under study using SWOT in the first four areas, i.e., offensive (strength-opportunity strategies (SO)), conservative area (weakness-opportunity strategies (WO)), competitive area (strength-threat strategies (ST)), and the defensive area (weakness-threat strategies (WT)), and then strategies related to each area were also determined.

In the third stage, a four-column matrix was developed. In the first column, external factors and internal factors, in the second column, weighted scores, in the third column, the strategy obtained from the SWOT matrix, and in the fourth column, attractiveness scores were determined. In order to determine the score of attractiveness, scores of 1 (without attractiveness), 2 (somehow attractive), 3 (attractive and reasonable), and 4 (very attractive) were used. The number of attraction scores of each qualitative matrix column was determined, and each strategy final score was developed and prioritized. This method was performed based on QSPM analysis.

Results

By aggregating the SWOT in each hospital, scoring them, and extracting the SWOT matrix, the state of waste management in the studied hospitals were placed in a strategic defensive position (weakness-threat). By separating the stages of waste management, the strategic position of transportation (defensive), decontamination (competitive), and temporary storage (competitive) stages were found to be identical for two hospitals, while this position was different only in the production phase (Table 1).

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Table 1: Determining the strategic situation of the studied hospitals regarding the stages and total hospital waste management

Stages of hospital waste management of the hospitals variable		Production	Transportation	Decontamination	Temporary storage	Total
Hospital A	Axis X	2.73	2.27	2.55	2.65	2.55
	Axis Y	2.53	1.43	2.20	1.80	2
	Strategic position	Offensive (SO strategy)	Defensive (WT strategy)	Competitive (WT strategy)	Competitive (ST strategy)	Competitive (ST strategy)
Hospital B	Axis X	2.43	2.36	2.72	2.65	2.54

Totally, 14 strengths, 16 weaknesses, 10 opportunities, and 15 threats were extracted from the two hospitals. Based on the SWOT matrix, four area strategies were developed, and three strength-opportunity (SO) strategies, four strength-threat (ST) strategies, three weakness-opportunity (WO) strategies, four weakness-threat (WT) strategies, and a total of 14 strategies were extracted for prioritization in the QSPM phase (Table 2).

The findings of prioritizing the developed strategies for the studied public hospitals are presented in Table 3.

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Table 2: Strategy development of public hospitals

Threats	Opportunities	
1. Lack of specialized training of environmental and municipal experts in the field of waste management 2. Failure to hold specialized courses on waste management by the occupational organizations 3. Lack of government policy-making in order to reduce the waste from the origin 4. Lack of transparency of law and having different interpretations 5. Lack of strict implementation of the rules 6. Increasing the volume of waste with the advancement of technology 7. Absence of a national guideline for separating normal and hazardous pharmaceutical waste 8. The high price of eco-friendly products and the priority of economic issues 9. Absence of legal requirements and guidelines to limit the use of disposable materials 10. Lack of a single guideline for waste disposal 11. Limitation in the number of trained personnel for disinfection processes 12. Absence of macro policies to recycle valuable waste 13. Unfavorable climatic conditions and improper conditions in storage rooms in case of a power outage 14. Lack of a standard pattern for building a storage room 15. Lack of segregated waste purchasing systems	1. Detailed executive regulations 2. Cleaning the environment and equipment using eco-friendly methods 3. Using long-term usable materials instead of disposable appliances with the aim of optimal energy and resource consumption 4. Using mass media and cyberspace for training in the realm of production and proper waste segregation 5. Continuous monitoring of organizations supervising the waste management process 6. Manufacturing advanced domestic equipment for waste transportation 7. Upgrading new technologies for decontamination and localization of manufacturing industries 8. Ability to recycle and recover valuable parts of waste 9. Supervision of supervising organizations in establishing waste management departments 10. Appropriate waste collection schedule by the waste management organization	**Qualitative objectives**

Threats	Opportunities	
Competitive: Strength-Threat Strategies (ST) ST 1. Using experienced environmental health professionals for specialized training of environmental experts, municipalities, and others ST2. Providing specialized and experienced waste management experts' opinions to the government to correct legal deficiencies ST3. Benefiting from experienced experts in the field of health care waste to establish the central site of waste decontamination ST4. Segregation of components of infectious waste and decontamination of recyclable components in order to provide recycling conditions	**Offensive: Strength-Opportunity (SO) Strategies** SO1. Improving green management indicators in the waste management SO2. Increasing the recycling rate of valuable waste by separating waste more accurately SO3. Using eco-friendly methods in cleaning the environment and equipment using environmental health professionals' opinions	**Strengths** 1. Getting points for green management in the new hospital accreditation system 2. Having an environmental expert and specialist in waste management 3. Using the opinions of environmental health experts to buy equipment and materials 4. Segregation of sharp wastes at the source 5. Having adequate utensils and equipment and proper decontamination according to instructions 6. Registration of waste information (amount and type) 7. Collecting waste with appropriate equipment and decontamination according to instructions (No contamination) 8. Collection in three shifts 9. Appropriate decontamination method along with checking with standard indicators 10. Signing an inter-hospital agreement if autoclave gets broken 11. Sending a treatment declaration by the hospital 12. Existence of temporary storage in accordance with the standards (suitable location, ventilation, multi-section, suitable floor, and walls) and the possibility of easy decontamination 13. Having enough space to prevent the accumulation of waste 14. Observing the appropriate time for waste disposal

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Threats	Opportunities	Weaknesses
Defensive: Weak-Threat (WT) Strategies WT1. Use of non-expert and surplus forces from other departments WT2. Training specialized personnel to manage waste decontamination systems WT3. Proper placement of waste storage containers with appropriate volume and color	**Conservative: Weakness-Opportunity (WO) Strategies** WO1. Appropriate training of resources of waste management by experienced experts at the begging of their job WO2. Reducing the amount of waste produced by using durable materials instead of disposable materials WO3. Preparing a detailed waste segregation guide for all hospital staff and clients WO4. Reducing land required for waste burial with proper segregation and recovery of waste at the production site	1. Lack of proper training of company employees at the beginning of their jobs 2. The increase in the volume of production waste due to lifestyle changes 3. Lack of accuracy and sufficient attention for segregation by manufacturers 4. The number and volume of storage containers are not commensurate with the amount of waste 5. Not considering the necessary measures to increase the amount of waste during epidemics 6. Mixing normal waste with infection and increasing the volume of this type of waste in some sections 7. Classifying ordinary chemicals and safe drugs in the special waste category 8. Employing incompetent staff in waste transportation 9. Improper waste transportation time in some shifts 10. Inefficient use of waste incinerator due to improper separation of waste 11. Lack of replacement device in case of device failure 12. Sending treated waste to the landfill without recycling 13. Lack of proper supervision and poor maintenance management due to high workload 14. Inadequate attention while storing waste 15. Not using personal protective equipment 16. Leakage in the storage area due to breakage of some containers

Table 3: Prioritized strategies in the studied hospitals

Row	Strategy	Score	Priority
1	SO1. More attention to green management	6.00	First priority
2	ST2. Attention to the opinions of experts in waste management	5.93	Second priority
3	WO3. Preparing a detailed waste segregation guide for all hospital staff and clients	5.57	Third priority
4	WO1. Appropriate training of resources of waste management by experienced experts at the beginning of their job	5.34	Fourth priority
5	ST4. Segregation of infectious waste components and decontamination of recyclable components in order to provide recycling conditions	5.11	Fifth priority
6	SO3. Using eco-friendly methods in cleaning the environment and equipment using environmental health professionals' opinions	4.94	Sixth priority
7	SO2. Separation of waste at source with the aim of recycling valuable waste	4.88	Seventh priority
8	WO2. Reducing the amount of waste produced by using durable materials instead of disposable materials	4.80	Eighth priority
9	ST3. Benefiting from experienced experts in the field of health care waste to establish the central site of waste decontamination	4.01	Ninth priority
10	WO4. Reducing land required for waste burial with proper segregation and recovery of waste at the production site	3.81	Tenth priority
11	WT3. Proper placement of waste storage containers with appropriate volume and color	3.78	Eleventh priority
12	ST 1. Using experienced environmental health professionals for specialized training of environmental experts, municipalities, and others	3.42	Twelfth priority
13	WT1. Use of non-expert and surplus forces from other departments	3.24	Thirteenth priority
14	WT2. Training specialized personnel to manage waste decontamination systems	2.65	Fourteenth priority

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Based on the results, improving the status of green management in waste management with a score of 6, taking advantage of experts' opinions to solve existing legal problems with a score of 5.93, and preparing a detailed waste segregation guide for all hospital staff and clients with a score of 57.5, were the first three priorities, respectively.

The last three priorities in the hospital waste management included 'using experienced environmental health professionals for specialized training of environmental experts, municipalities, and others' with a score of 3.42, 'not using incompetent and dismissed workers from different departments of waste management' with a score of 3.24, and 'a strategy of training specialized personnel to manage waste decontamination systems' with a score of 2.65, respectively.

Discussion

In the present study, appropriate strategies were developed and prioritized using the QSPM approach by extracting SWOT. Based on the findings, 14 internal strengths and 16 internal weaknesses, 10 opportunities, and 15 external threats were identified in the public hospitals. Given that the score of internal factors evaluation matrix (strengths-weaknesses) of waste management in hospitals A (2.55) and B (2.54) was higher than 2.5, the resulting hospital waste management system in these hospitals has more strengths than weaknesses in terms of internal factors.

Considering the score of EFE matrix (opportunity-threat) in these hospitals, number 2 was obtained, which means that the hospital waste management system cannot use opportunities against threats very well in the current situation. In the waste management stages, the transportation stage in both hospitals showed the dominance of weaknesses over strengths and threats to opportunity, which did not indicate an appropriate situation at this stage. Studies have evaluated the healthcare waste management of health centers using the SWOT approach. Jozi et al. conducted a study in Bandar Abbas using a SWOT matrix and analytic hierarchy process (AHP) [14].

The results showed that considering the offensive strategic position, the studied hospitals successfully overcame weaknesses by strengths and opportunities against threats. They could exploit the opportunities by getting the most out of their strengths [14], which is not consistent with the present study findings. The lack of inter-departmental cooperation of organizations and the correct implementation of environmental standards as the most important opportunities and the lack of proper separation of waste at source of production are the most important weaknesses of this study.

Jozi et al. conducted a study using SWOT and QSPM matrices. The situation of hospitals in Bandar Abbas considering waste management in the offensive area (overcoming strengths over weaknesses and opportunities over threats) was evaluated, which was a better situation than the hospitals studied in the present study [10]. In another study carried out in Iran, Banai Ghahfarkhi et al. changed the situation of safe disposal of medical waste from moderate to good with the intervention of SWOT analysis [15].

In the study by Mirsha et al. in India, the status of hospital waste management in medical institutions showed the dominance of weakness-threat (obstacles) over strengths-opportunities (assets), indicating a more unfavorable situation compared to the present study [16]. In Indonesia, Putra et al., using the SWOT analysis, reported that outpatient and primary care clinics waste management situation was inadequate and had multiple threats [17].

Although the numerical scale was not used to assess the situation in the study by Putra et al., it is possible to understand the inappropriate situation and possible placement in the defensive area considering many weaknesses and threats [17]. This discrepancy could be due to different case studies and particular situations. Comprehensive cooperation of organizations, implementation of health and environmental standards, like a key in the segregation and proper waste disposal, can be different in various health care centers, different cities, and countries. It could be due to the differences in manpower, financial and human

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resources and inter-departmental cooperation.

According to findings, improving the status of green management, taking advantage of experts' opinions to eliminate legal deficiencies, and preparing a detailed waste segregation guide for all hospital staff and clients, were the first three priorities in the strategies, respectively.

Obtaining a green management certificate and complying with its related standards by hospitals is one of the necessary requirements in this field. In all the proposed models, it is important to pay attention to waste management.

Using experienced environmental health professionals for specialized training of environmental experts, municipalities, and others, not using inefficient and dismissed human resources of other departments in different waste management departments, and training specialized personnel to manage waste decontamination systems, were the last three priorities in healthcare waste management of the studied hospitals, respectively. Azmal et al. also emphasized green management and its role in the stages of segregation and disposal of sustainable waste management in the hospital environment [18]. This shows the special importance of waste management in the hospital and the social responsibility of hospitals towards the environment.

In line with the importance and priority of using green management indicators in hospital waste management, Liu et al. in China also stated the use of green hospitals elements, especially during the COVID-19 crisis [19]. Joshi et al. conducted a study on the impact of green management indicators on waste management in a private hospital and a public hospital in India. They indicated the improvement of the hospital status after considering these indicators [20].

Given the maximum consensus on the impact of using green management indicators and standards, which have been referred to under various titles in different countries, it seems that if hospitals use them, it can lead to a change in the strategic position of these hospitals to get to the desired position.

It is necessary to prioritize compliance with these standards in order to help them in better waste management.

Another high-priority strategy in the present study was to provide an accurate waste segregation guide for all hospital staff and clients, which can play an effective role in the waste management segregation phase [21].

The findings of Saheldengel's study in Southeastern Ethiopia also showed the important role of informing hospital staff in the segregation of hospital waste [22]. In another hospital study in Uganda, individuals' awareness of waste segregation was introduced as part of a comprehensive systemic approach to hospital waste management [22].

This study showed the SWOT and QSPM approach related to hospital waste management in four stages of waste production, transportation, decontamination, and storage in the two public hospitals in Yazd.

The analysis of the EFE and IFE of hospital waste management showed that the strategic situation of waste management in public hospitals is in the competitive area, and the organization needs to use its strengths to eliminate or reduce the effects of threats.

Conclusion

The process of waste management of public hospitals in Yazd was in a competitive situation in the stages of production, decontamination, and temporary storage, and a defensive position in the stage of waste transportation. This position means a situation in which hospitals must be able to exploit opportunities by reducing weaknesses and using strengths to achieve a capable system.

Important strategies were selected based on attractiveness table and using the QSPM. Therefore, with the cooperation of the Hospital Performance Improvement Committee and the support of senior hospital managers and the organization, measures can be taken to move towards applying green management standards and indicators in hospital waste management.

Considering their competitive position, hospitals should be able to make the most of environmental opportunities in order to reduce their weaknesses.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [M.M], [R.A] and [R.K]. The first draft of the manuscript was written by [F.P] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that they have no conflict of interest.

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