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Research Article

Investigation of Short-term Scenarios of Infectious and Medical Waste Management (Case Study: Kerman, Iran)

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Abstract
Infectious and Medical Waste (IMW) management is one of the challenges of urban management in coronavirus pandemics. Many cities in Iran do not have the necessary infrastructure for rapid and emergency management of IMW in this time frame. Other challenges, such as increasing the generation rate of IMW and further contamination of this waste, increase the need for rapid and principled action. The IMW's sources were divided into concentration and production volume: large and concentrated sources include hospitals, and small scattered sources include clinics and laboratories. To evaluate and choose the most proper short-time solution, after wide-field visits, different waste management scenarios were predicted. The final was selected by examining different indicators by the Analytical Hierarchy Process model. The main problem of IMW management in Kerman city is collecting and disposing of IMW in small and scattered centers supervised by the Medical Council of the Islamic Republic of Iran. According to the obtained results, the private contractor company collects hazardous waste from the clinics and laboratories and sends them to the hospitals' decontamination units. Then, Kerman Municipality receives the decontaminated waste from hospitals and transfers it to the particular burial landfill. The proposed scenario can certainly lead to a short-term problem of improving Kerman's IMWM, especially in the coronavirus pandemic, relying on the available facilities. Moreover, based on the sensitivity analysis, social indicators have the highest level, and financial indicators have the lowest sensitivity for the proposed solution.
Keywords: Infectious and Medical Waste Management, Coronavirus Pandemic, Analytical Hierarchy Process, Kerman

Introduction

Infections and Medical Waste (IMW) include all waste generated by health care units, research institutes, and laboratories. Hospital waste is a significant source of hazardous waste in cities because it contains pathological wastes, radioactive wastes, pharmaceutical wastes, infectious wastes, chemical wastes, and sometimes pressurized containers.

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In Iran, hospitals usually manage IMW using neutralization and decontamination methods, including various autoclave equipment. Furthermore, the decontaminated IMW send to the landfills for particular treatments. Some other hospitals use waste incineration methods and send the residue to landfills.

Unfortunately, in some cities, there are cases where the waste is buried directly in urban landfills and causes many environmental and health problems. Municipal waste can be recycled and turned into fertilizer but mixing with IMW turns them into useless materials, which only can be buried in landfills (Ma et al., 2020). Therefore, the mixing of municipal and medical waste is a threat to the health of citizens and municipal services staff of municipalities and waste management organizations that are in contact with such waste. Also, the economic losses caused by mixing municipal waste with IMW are very significant. Recycled materials that need to be returned to the production cycle are discarded, and society moves away from sustainable development (Marinković et al., 2008). The circular flow of materials and energy becomes a linear flow whose many defects are not hidden from anyone.

In recent years, with the coronavirus pandemic, the importance and volume of waste generated by medical centers have become more critical. In Kerman, we are witnessing an increase of more than 50% in the production of infectious and medical waste collected from the city's medical centers in 2019-2020 compared to 2018-2019 (Abu-Qdais et al., 2020).

In recent years, the generation of hospital waste has increased significantly due to population growth, the number of health care centers, and disposable medical products (Arab et al., 2008). Many developed countries follow strict guidelines for the disposal of sanitary waste, on-site storage, and transportation in Coronavirus pandemic regards to the available infrastructures and local conditions (Ilyas et al., 2020; Yu et al., 2020). On the other hand, developing countries also have limited resources for hospital waste management (Caniato et al., 2015). Here, poor sanitation may mix hazardous waste with ordinary waste, increasing waste management problems by increasing processing and disposal costs (Patwary et al., 2011a). Besides, poor nutrition and inadequate health care can increase general susceptibility to diseases caused by hospital waste (Patwary et al., 2011b).

According to the World Health Organization, about 75 to 90% of the waste generated in health centers can be considered as non-hazardous, and only 10 to 25% cannot be considered as non-hazardous waste (Ali et al., 2017). According to studies, 630 types of chemicals and drugs are identified in hospitals, of which about 300 types are toxic and dangerous. These materials are in the form of medical waste, recycling is prohibited, and their proper disposal requires planning.

The importance of IMW from the perspective of the source of generation can be divided into two parts:

1. Large and cohesive centers for the generation of IMW such as hospitals
2. Small and scattered centers for the generation of IMW such as clinics, offices, and medical diagnostic laboratories

Waste management generation of large centers is done in all hospitals and medical centers in Kerman. According to the national regulations, all hospitals have decontamination and neutralizing equipment. After decontamination, Kerman Municipality waste trucks delivered the waste and transferred it to a landfill for infectious and medical waste. The main problem is the waste management of small and scattered centers. Almost all of these centers put their IMW in the municipal waste collection tanks. In a few cases, it is observed that medical complexes have coordinated with the municipality for separate collection. However, there is no supervision over it, and the process of transfer and burial will likely continue along with other municipal waste.

Due to the high volume of waste production, some of the city's extensive medical diagnostic laboratories have used autoclaves in person. They have installed a temporary storage system for the delivery of autoclaved waste to the municipality. Of course, the number of these centers is small, and their management status cannot be generalized to other major centers.

Supervision of the Infectious and Medical Waste Management (IMWM) system is responsible for various organizations such as the Medical System Organization, the Deputy Minister of Health, the municipality, and the Environment Organization. Each of these organizations has a part of supervision, but the main executive activities are the municipal waste organization's responsibility.

There are many differences of opinion between the oversight bodies. The joint executive plans and government opinions' primary failure is due to these differences of opinion and managerial tastes. The island and one-person performance of government agencies and the sluggishness in decision-making power, expertise, and little scientific knowledge of relevant experts have created much distrust in the hope of success of any investment in urban waste management and especially IMWM. Besides, the excessive power, wealth, and influence of the informal waste management stream is another reason for the government stream's weakness, the effects of which should not be underestimated.

There are no accurate statistics on the quantity and quality of Kerman's IMW. Some documents have been collected and presented in table 1 to provide an overview of the hospital waste generation rate. It is noteworthy that due to the corona pandemic from 2019 until now and major changes in the performance of hospitals and as a result of sudden changes in the quantity and quality of hospital waste, studies related to the management of infectious and medical waste until 2018 have been studied. Studies performed under COVID-19 conditions should take into account the similar period of the pandemic and should not be compared with data from previous years of the pandemic and should be the criterion for deciding or interpreting hospital waste conditions under normal conditions.

Different studies have reported the percentage of different compounds; for example, some articles have reported the percentage of compounds in only one category. Other studies have reported the classification of waste into two or three categories and the percentage of compounds. For this reason, comparing the results between two different studies is challenging. It is predicted that if the developing countries' methods are agreed upon, it could lead to a more straightforward comparison between different studies' results.

On average, hospital waste generation is higher in developed countries than in developing ones. In a developed country, hospital waste is separated into colored and labeled bags or containers (Marinković et al., 2008). In developing countries, local standards also require hospital authorities to separate the origin of different waste streams in labeled/colored bags and color labels. However, the implementation of standards varies from place to place. Relevant issues include lack of separation from the source (Farzadkia et al., 2009; Haylamicheal et al., 2011), lack of color-coding (Abdulla et al., 2008), and lack of recorded data on the composition and amount of waste generated (Bdour et al., 2007) different definitions of hospital waste components such as pharmaceutical and household waste (Abd El-Salam, 2010).

In some cases, nothing is done except to separate the sharp and winning components from other wastes (Stanković et al., 2008). Therefore, lack of segregation from the source, lack of color, lack of registration, and staff carelessness are known as some of the main issues that lead to poor segregation practices in hospitals in developing countries. The measures proposed mainly exist and are performed in Kerman hospitals, but the main issue is the quality control and accuracy of their implementation.

Table 1. Generation rate of hospital waste (2006-2017)

Country	IMW Generation Kg/bed-day	Number of centers surveyed	Reference
China	0.68	15	(Yong et al., 2009)
China	0.6-1.5	23	(Gai et al., 2009)
China	0.59-0.79	74	(Zhang et al., 2013)
China	0.77-1.22	6	(Ruoyan et al., 2010)
Serbia	1.9	3	(Stanković et al., 2008)
Turkey	0.63	192	(Birpınar et al., 2009)
Iran	3.48	10	(Taghipour & Mosaferi, 2009)
Iran	2.3-3	6	(Arab et al., 2008)
Iran	4.42	12	(Dehghani et al., 2008)
Iran	2.75	8	(Farzadkia et al., 2009)
Iran	2.76	14	(Bazrafshan & Kord Mostafapoor, 2011)
Iran	3.79	1	(Hadipour et al. , 2014)
Iran	2.98	837	(Eslami et al., 2017)
Jordan	1.88-3.49	4	(Bdour et al., 2007)
Jordan	0.83	21	(Abdulla et al., 2008)
Palestine	0.59-0.93	4	(Al-Khatib et al., 2009)
Egypt	0.85	8	(Abd El-Salam, 2010)
Sudan	0.87	8	(Saad, 2013)
Algeria	0.83	10	(Bendjoudi et al., 2009)
Ethiopia	3.46	9	(Haylamicheal et al., 2011)
Nigeria	0.57	4	(Longe & Williams, 2006)
El Salvador	0.37	1	(Johnson et al., 2013)
India	0.56	8	(Manar et al., 2014)
Bangladesh	1.58	69	(Syed et al., 2012)
Bangladesh	1.28	1	(Alam et al., 2008)
Pakistan	0.67	12	(Ali et al., 2016)

Another point to note is that the information gathered in this article is at the beginning of the Corona crisis, and certainly in the coming years the trend of hospital and medical waste will change significantly due to the changing pattern of hospitalization and treatment during the pandemic. In 2021, Kalantari et al. conducted studies on this trend in the quantity and quality of waste during the Corona virus pandemic (Kalantary et al., 2021). Therefore, these changes, along with the high intensity of virus spread through waste and high sensitivity to the transmission and disposal system, can change the management pattern in many large centers and densely populated cities.

The use of various mathematical methods and models in recent years in the management of hospital systems and especially in the management of medical waste has been considered (Belhadi et al., 2020; Govindan et al., 2021). Hierarchical analysis methods are an efficient and appropriate tool for prioritizing executive solutions to complex and multifaceted problems. For example, the AHP method was used to select medical waste management options in Myanmar (Aung et al., 2019). In this study, various operational aspects were examined and the weaknesses of the system that should be addressed immediately were discussed.

In this study, we try to select and propose the most appropriate solution by examining different IMWM scenarios in Kerman according to the existing infrastructure and local conditions in the coronavirus pandemic as an emergency and fast, practical solution. The choice of each scenario in the type of investment, monitoring, the executive share of each stakeholder, the degree of citizen satisfaction with the system's performance, and ultimately directly affects the quality of the environment and public health.

Materials and methods

Analytical Hierarchy Process (AHP)

In the AHP, first, the elements are compared in pairs, and the paired comparison matrix is formed; then, the relative weight of the elements is calculated using this matrix (Saaty, 2004). All comparisons in the AHP are made in pairs. These judgments are converted to small values between 1 and 9 by the hour, specified in table 2 (Fattahi & Khalilzadeh, 2018).

Table 2. Preference values for pairwise comparison

Value	Preferences (Oral judgment)
9	Extremely preferred
7	Very strongly preferred
5	Strongly preferred
3	Moderately preferred
1	Equally preferred
2 & 4 & 6 & 8	-

Once the even matrix is formed, we can calculate the weight of each option. Several methods have been proposed to calculate the weight of each option from the even matrix (relative weight), the most important of which are:

- Ordinary least squares method
- Logarithmic least-squares method
- Special vector method
- Approximate methods (such as the arithmetic mean)

Since the weight of the criteria reflects their importance in determining the goal and each option's weight relative to the criteria is the share of that option in the relevant criteria. It can easily be said that each option's final weight is the product of each criterion's weight multiplied by the option's weight. The corresponding criterion is obtained from that.

Almost all calculations related to the AHP are based on the decision maker's initial judgment, which appears in the form of a pairwise comparison matrix. The mismatch rate, which we will discuss in the following section, is a tool that identifies the mismatch and shows how much the priorities from the comparisons can be trusted. For example, suppose option A is more important than B (preferred value 5), and B is relatively more important (preferred value 3). In that case, A should be expected to be much more important than C (preferred value seven or more) or if preferred value A is proportional. B, 2, and B should be three, relatives to C, then the value of A over C should be the preferred value of 4. Comparing the two options may be easy, but it is not easy to ensure the comparisons' consistency when the number of comparisons increases. This confidence should be achieved by using the adjustment rate. Experience has shown that if the incompatibility rate is less than 0.10, the comparisons' consistency is acceptable; otherwise, the comparisons should be revised. The following steps are used to calculate the incompatibility rate:

Step 1. Calculate the total weight vector: Multiply the pairwise comparison matrix on the "relative weight" column vector, call the new vector you get this way the full weight vector.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{12} & \cdots & a_{1n} \\ \vdots & & \vdots & & \\ a_{21} & \cdots & a_{22} & \cdots & a_{2n} \\ \vdots & & \vdots & & \\ a_{n1} & \cdots & a_{n2} & \cdots & a_{nn} \end{bmatrix} \qquad a_{ii=1},\ a_{ji} = 1/a_{ij},\ a_{ij} \neq 0. \tag{1}$$

Step 2. Calculate the compatibility vector: Divide the elements of the full weight vector by the relative priority vector. The resulting vector is called the compatibility index.

Step 3. Obtaining max gives the average of the compatibility vector elements λmax.

$$A * w_i = \lambda_{\max} * w_i, \quad i = 1, 2, \ldots, n. \tag{2}$$

Step 4. Calculating the Compatibility Index: The Compatibility Index is defined as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{3}$$

n: Is the number of options available in the problem.

Step 5. Calculate the adjustment ratio: The adjustment ratio is obtained by dividing the adjustment index into a random index.

$$CR = \frac{CI}{CR} \tag{4}$$

CR expresses a compatibility ratio of 0.1 or less compatibility in comparisons, and The random index can be extracted from different sources (Saaty, 2004). The superior option is identified by combining the relative weights of the options and criteria.

Two faculty members initially monitored the validity and convergence of the pairwise comparison questionnaires. Finally, the final version was used to collect the opinions of ten experts in IMWM.

Results and discussion

First, it is necessary to study the generation of infectious and medical waste in Kerman. Table 3 presents some information on the status of waste generation in hospitals and major centers of the city.

Table 3. Status of decontamination of hospitals in Kerman in 2019

Hospital	Type of operation of decontamination	The capacity of one shift work Kg/8hr	Average daily decontamination (Kg)
Afzalipour	Wet autoclave	1000	1000
Shafa	Wet autoclave	1000	750
Bahonar	Wet autoclave	1000	850
Payambar Azam	Wet autoclave	500	250
Hazrat e Fatemeh	Hydro-clave	250	130
Seyed al-Shohada	Wet autoclave	500	170
579 military	Chemical	40	20
Mehregam	Wet autoclave	250	120
Raziyeh Firouz	autoclave	500	100
Arjomand	Chemical	160	120
Al-Zahra	Dry autoclave	100	10
Beheshti	-	0	0
Nouriyeh	-	0	0
Total		5300	3520

Reliable information on waste generation in small and scattered centers is not available. Therefore, based on field visits to some small centers and interviews with them, an estimate of the amount of waste generated is presented in table 4. According to a Kerman Municipality directive to identify small and scattered units, some medical specialties, such as pediatrics or internal medicine, do not have significant waste. So, they removed from the list of occupational and medical waste generators that need to be destroyed and decontaminated.

Based on the city's current situation and facilities, different possible scenarios for collecting safe and infectious and hospital waste from the city in three scenarios with the focus on Kerman municipal services are possible.

- **Scenario 1:** In this case, the waste organization's subcontractors must collect safe waste from the city and small and large generation units. In this case, decontamination is the manufacturer's responsibility, and all units must have essential standards equipment.
- **Scenario 2:** In this case, the private contractor company, after collecting hazardous waste from small units scattered in the city, such as clinics, laboratories, clinics, and other small medical centers, delivers them to the particular decontamination disposal unit of the contracted hospitals. Kerman Municipality receives the decontaminated waste from hospitals. They transfer it to the landfill for special burial due to particular instructions such as adding lime and creating soil layers for daily cover.
- **Scenario 3:** In this case, the private contractor company is responsible for collecting hazardous waste from small units scattered in the city such as clinics, laboratories, clinics, and other small medical centers and, after being transferred to a centralized decontamination center, delivered to the particular landfill of Kerman Municipality. Gives. In this case, the municipality's delivery of non-hazardous waste is done from the contractor safety site. Also, hospitals only dispose of their waste safely and do not receive waste from small units.

Table 4. Status of physicians involved in infectious and medical waste in Kerman (2019)

Expertise	Active clinics	Approximate weight of daily IMW generation (Kg/clinic)	Total daily IMW generation (kg)
Orthodontics	8	1	8
Pathology	31	5	155
Maxillofacial pathology	4	1	4
Dental prosthesis	9	1	9
Gingival surgeon	8	1	8
Root canal treatment	14	1	14
Restorative Dentistry	8	1	8
Pediatric Dentistry	11	1	11
General Dentistry	270	1	270
Total	311	-	487

The proposed scenarios of this study are mainly as short-term solutions for emergency management of medical and infectious wastes in the early years of the Corona pandemic. The changes and proposals presented in scenarios 2 and 3 are mainly based on the existing capacity of Iran's medium-sized municipalities with populations between 250,000 to 750,000 and the ability to use private contractors. It should be noted that these scenarios are to overcome the crisis, and ultimately city officials and managers must make fundamental decisions to improve the infrastructure and municipal hazardous waste management program.

The mentioned tasks for Kerman Municipality and the Waste Organization, two costs are defined for performing the tasks:

1) Special burial fee in the burial place of Kerman Municipality

2) The cost of collecting and transporting non-hazardous waste from the decontamination site/hospital

According to an inquiry made by the Kerman Municipality Revenue Unit, general practitioners, specialists, and subspecialists are not subject to special waste duties. On the other hand, only hospitals, clinics, laboratories, limited surgery centers, dentists, and any complex surgical and laboratory services are included in the payment of special waste management fees.

It should be noted that the list in table 4 does not provide information about clinics and clinics. After completing the information, the amount of waste generated and their costs and complications should be recalculated and presented to the entire system. According to table 5, the amount of infectious and hazardous hospital waste in the city of Kerman is approximately estimated.

The empty capacity of decontamination units in the city's leading hospitals (Table 3) is more than the total amount of waste generated in small generators. It is recommended that the clinics, laboratories, and minor medical center's waste collected by the relevant contractor and delivered to the operating decontamination units in hospitals. All of them should be delivered to the safe transport trucks of Kerman Municipality for transfer to a particular landfill. Chain of collection, transportation, decontamination, and disposal of IMW in Kerman is shown in figure 1.

Table 5. Approximate tonnage of infectious and hospital waste generation in Kerman

Waste Generators	Type of center	Daily IMW generation (Kg/day)	Infectious waste produced per month (Kg/month)	Daily IMW generation per year (Kg/year)	Percentage of total IMW generation
Hospitals	Large and focused	3,520	105,600	1,267,200	88%
Clinics and laboratories	Small and scattered	487	12,175	146,100	12%
Total		4,007	117,775	1,413,300	100%

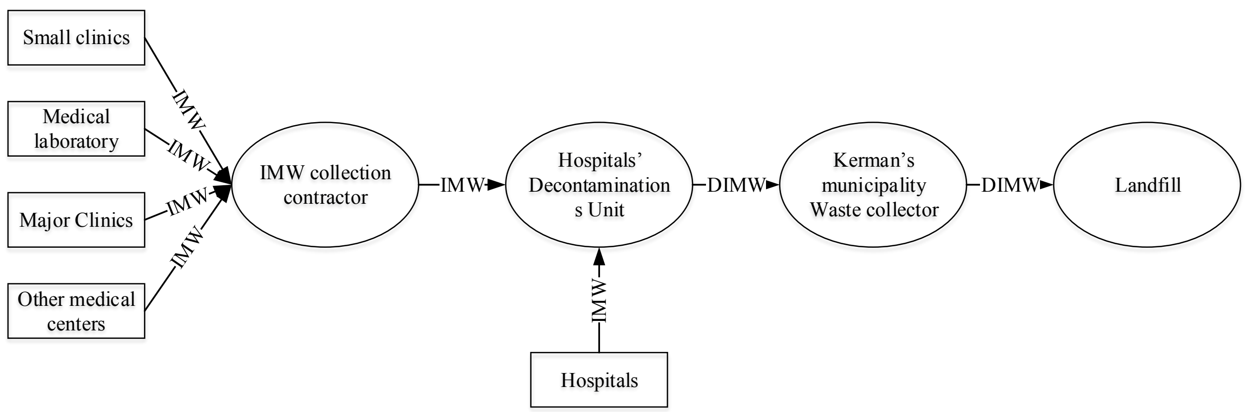

Figure 1. Chain of collection, transportation, decontamination, and disposal of IMW in Kerman

In the next section, using hierarchical analysis and pairwise comparison questionnaires, the three scenarios considered in the previous section are scored based on different indicators affecting them. The scoring and preference of each are identified. Paired comparison questionnaires with an hourly scoring system were used for scoring. Ten questionnaires, including three Kerman Municipality managers in the Waste Management Organization, one Medical Council of the Islamic Republic of Iran members and two people in municipal waste recycling companies, and four university professors with related specialties, have been used.

Finally, the average score is used in Expert Choice 11 software. The consistency of the comments was checked separately, and all values less than 0.1 were obtained. If the matrix is greater than 0.1, it has been referred to the surveyed expert for correction and re-examination. The results are presented below. In the beginning, the decision-making hierarchy structure in the IMWM scenario selection model of Kerman city should be specified, shown in figure 2. This structure is presented in 3 levels.

Eighteen criteria were used in 3 general categories to compare the options collected and presented in table 6.

In the next step, the pairwise comparison questionnaires were prepared based on the hourly standard and data entry framework of Expert Choice 11 software. The community of experts scored them. The final scores of the scenarios and the effectiveness of each indicator were obtained (Table 7).

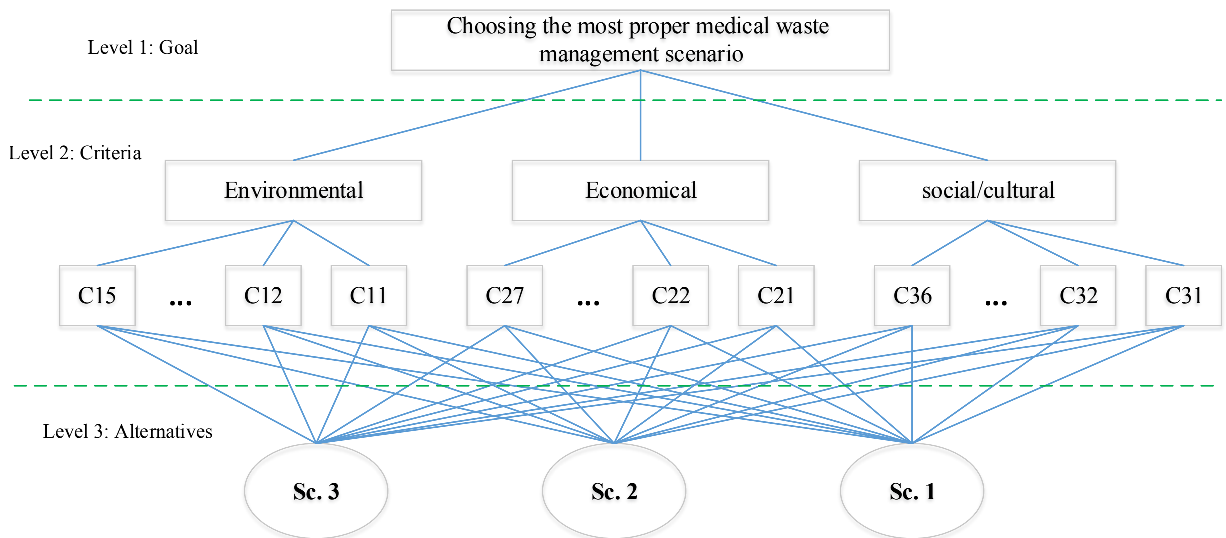

Figure 2. Structure of decision-making hierarchy in the selection model of infectious and medical waste management scenario in Kerman

Table 6. Indicators and sub-indices comparing infectious and medical waste management models in Kerman

Number		Criteria	Sub-criteria
1	C11	Environment	Remaining time at the generation site
2	C12		Quality of waste collection from the place of generation to the place of disposal
3	C13		Quality of waste disposal and decontamination
4	C14		Ability to monitor collection and disposal performance
5	C15		Quality of transportation of infectious waste in the city
6	C21	Economic	Compatibility of the existing infrastructure of the city with the proposed model
7	C22		Initial capital for the purchase of decontamination equipment
8	C23		Costs of operating the disposal and decontamination system
9	C24		Decontamination system maintenance costs
10	C25		Compatibility of the model with the municipal toll payment system and waste management costs
11	C26		Creating double work pressure on Kerman Waste Organization
12	C27		Compliance with the laws and sections of Kerman Municipality toll reduction letters
13	C31	Social/Cultural	Ability to monitor the waste management system online
14	C32		Possibility of providing special waste services due to coronary heart disease
15	C33		Employment
16	C34		Stability and longevity guarantee of system performance
17	C35		Ability to provide online services
18	C36		Accuracy and feasibility of monitoring the waste management system

Table 7. Summary of the weight of criteria and options concerning each other

Criteria & Sub-criteria		Alternatives weights			
Level 1	level 2	Scenario 1	Scenario 2	Scenario 3	Total
Economic (L: .333)	C21 (L: .143)	0.01	0.004	0.034	0.048
	C22 (L: .143)	0.012	0.004	0.032	0.048
	C23 (L: .143)	0.012	0.005	0.03	0.047
	C24 (L: .143)	0.012	0.005	0.03	0.047
	C25 (L: .143)	0.034	0.007	0.007	0.048
	C26 (L: .143)	0.031	0.007	0.009	0.047
	C27 (L: .143)	0.007	0.02	0.02	0.047
Economic (L: .333) Total		0.118	0.052	0.162	0.332
Environmental (L: .333)	C11 (L: .200)	0.042	0.017	0.007	0.066
	C12 (L: .200)	0.01	0.029	0.029	0.068
	C13 (L: .200)	0.005	0.048	0.014	0.067
	C14 (L: .200)	0.007	0.042	0.017	0.066
	C15 (L: .200)	0.049	0.013	0.005	0.067
Environmental (L: .333) Total		0.113	0.149	0.072	0.334
Social/Cultural (L: .333)	C31 (L: .167)	0.008	0.024	0.024	0.056
	C32 (L: .167)	0.006	0.035	0.014	0.055
	C33 (L: .167)	0.009	0.033	0.014	0.056
	C34 (L: .167)	0.014	0.035	0.006	0.055
	C35 (L: .167)	0.005	0.025	0.025	0.055
	C36 (L: .167)	0.008	0.024	0.024	0.056
Social/Cultural (L: .333) Total		0.05	0.176	0.107	0.333
Total		0.281	0.377	0.341	0.999

As shown from the model results, Model 2 obtains the highest score and is recommended for Kerman's development. In this scenario, the private sector contractor collects infectious medical waste from small units scattered throughout the city, such as clinics, laboratories, clinics, and other medical centers, and then delivers it to the hospital's special decontamination and disposal unit. Kerman Municipality receives the decontaminated waste and transfers them to a special burial landfill. This scenario has advantages and disadvantages that need to be addressed despite being chosen by experts.

One of this method's main advantages is Kerman Municipality services on hospitals and large medical centers, making it easier to monitor. There is less need for clinics and small centers to provide decontamination equipment such as autoclaves. As a result, more comprehensive medical satisfaction will result. Also, the possibility of better monitoring private sector contractors' performance in collecting and transferring the waste from small to large centers is responsible for regulatory agencies. According to the records searched, there has been a large difference between government agencies' coordination and implementation. This problem will be improved with the entry of the private sector.

On the other hand, the disadvantages of this scenario are significant. The entry of waste collected from small centers and clinics into the hospital decontamination units requires very high care in preventing the spread of pollution and environmental and health problems. Significant problems in the delivery, storage, and decontamination process are mainly considered. The increase in waste entering hospitals puts tremendous pressure on the surveillance and monitoring units, increasing the possibility of dissatisfaction and undesirable services. This possibility will cause the hospitals to become more sensitive and resist accepting waste over the hospital's domestic generation and the sensitivity of establishing these units in hospital environments. Therefore, great care should be expected in the design, implementation, and coordination between stakeholders and various regulatory and executive units in this scenario.

In general, it can be said that this scenario can be a medium and even short-term option for proper waste management, considering the current conditions of infectious and medical waste management in Iranian cities. Of course, it is necessary to consider fundamental and principled solutions for the long term.

Conclusion

IMW has always been one of the concerns of urban management to prevent the dangers posed by this waste. The city of Kerman has several large hospitals and many medical and paraclinical centers. Many general and specialized clinics and medical diagnostic laboratories have a significant daily volume of generation of infectious and medical waste. At present, no principled action is taken to collect and dispose of this waste in the city.

To complete the necessary information for designing and calculating the standard system of IMWM, identifying the generation status of IMW (website, sampling, face-to-face, questionnaire, etc.) is vital. However, simulating different collection and disposal scenarios with the most feasible approach and the lowest financial cost is necessary. Also, the economic evaluation methods of projects based on the standards of economic justification plans should be used for this purpose.

According to the obtained results, in the proposed scenario, the private contractor company collects hazardous waste from small and scattered units in the city, such as offices, laboratories, clinics, and other small medical centers. They were handed over to the special decontamination and disposal unit of the contracted hospitals. After decontamination of the IMW, Kerman Municipality transfers them to the landfill and buries them with special instructions.

Due to the coronavirus pandemic, it is preferable to use fast and primarily available implementation solutions over other medium-term options that require more investment. This issue creates acceptable executive measures according to Iranian cities' current needs to better manage waste in the urban environment and significantly improve small and scattered clinics in the city. Of course, the fundamental solutions should be planned and planned at the earliest opportunity, and the proposed solution in this article is only in the current situation in Iran.

According to the models' sensitivity analysis, the selected scenario has the highest sensitivity to social factors. It shows the lowest sensitivity and level of unforeseen changes to economic issues and financial indicators. This issue can be considered another advantage and strength of the proposed method, provided that the implementation of its stakeholders gains confidence. Otherwise, social issues can turn from an opportunity to a threat to the proposed solution.

It is suggested that in order to improve and accurate studies in the future, intelligent waste information registration systems should be established at the provincial or national scale, and it should be possible to track and monitor the production of waste storage and disposal.

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