Environmental Energy and Economic Research 2020 4(1): 43-56
DOI 10.22097/eeer.2020.197686.1103

Research Article

Application of Delphi Method and Fuzzy Analytic Hierarchy Process in Modeling Environmental Performance Assessment in Urban Medical Centers

Nazak Shahbod [a], Mansour Bayat [b], Nabiollah Mansouri [a,*], Jafar Nouri [c], Jamal Ghoddusi [a]

[a] Faculty of Natural Resources and Environment, Science and Research Branch, Islamic Azad University, Tehran, Iran
[b] Faculty of Veterinary Specialized Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran
[c] School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

Received: 19 July 2019 /Accepted: 2 November 2019

Abstract

Medical centers (that is, hospitals and clinics) in metropolitan areas produce substantial amounts of hazardous waste in both solid and liquid (wastewater) forms. Unless medical centers manage their waste with appropriate care, the significant hazards posed to urban residents and areas far outweigh the benefits of their services. Therefore, comprehensive environmental management programs need to be developed in order to minimize the associated impacts and improve environmental performance. In addition to identifying the environmental consequences, developing a comprehensive performance assessment program requires a deep understanding of the factors involved and their corresponding shares. Thus, the aim of this paper is to model environmental performance assessment in urban medical centers. Firstly, relevant criteria, sub-criteria and indicators were identified using the Delphi method. Next, Fuzzy Analytical Hierarchy Process (AHP) was applied to rank the factors and a balanced scoring was established to model the environmental performance assessment in medical centers. The adequate consistency index confirms Fuzzy AHP accuracy and consequently, the scores. The model was applied in Sarem Specialized Hospital in Tehran, Iran. The results indicate that the hospital has good environmental performance. The results show that the waste disinfection indicator, was rated the highest and most important index with a score of 84.The other indicators were ranked in terms of treated sewage and source separation of waste and application of mechanisms to control water consumption respectively with scores of 38, 26.5 and 25.

Keywords: Delphi Method, Environmental Management Performance, Urban Health Centers.

Introduction

The earth has a very limited capacity in recovering from short- and medium-term consequences of activities resulting in the occurrence of environmental hazards. Although, environmentalists have stressed this issue for years, more recently, the health and safety condition of the environment has become a challenge due to the increasing population in different parts of the

* Corresponding author E-mail: nabiollahmansouri@yahoo.com

world and the diversity of human activities without adapting them to natural capacity and environmental resilience.

In other words, today's world distinguishes organizations from decades ago as an unsustainable and complex environment, increasing competition, rapid changes and dramatic changes in management knowledge (Sheikhzadeh and Bahramzadeh, 2008).

Today's organizations live in a socially and environmentally sensitive world, which in addition to meeting customer's satisfaction, need to give significant importance to protecting the environment (Naseri et al., 2014). Medical centers (that is, hospitals and clinics) are among the most important institutions in this area.

In fact, health centers are classified as service sectors, with the difference that they have a wide range of activities that are operated in a complex environment (Zamparas et al., 2019; Lin et al., 2013; Zhao 2003). Hospitals today have adopted an approach that has transformed them into health care centers with innovative and compassionate patient care, with high standards of quality aligned with cost-effective practices (Chassin and Loeb, 2013).

The World Health Organization (WHO) states: We know that climate change can have profound consequences for human health, and we also know that the health sector can play a key role in helping countries around the world, So that they can adapt to these serious consequences. These statements demonstrate the global importance and desire for the best environmental practices in health care (Frow et al., 2016).

The existence and increase in the number of medical centers (both hospitals and clinics) are essential and unavoidable in urban communities. Despite providing invaluable services, they generate large amounts of pollutants that can lead to hazardous outcomes in the event of inappropriate management practices and poor performance, which ultimately endangers the health condition of people and the safety of the urban environment. For instance, health centers use materials, tools and medical equipment that produce solid and liquid wastes with significant effects on environmental health on one hand and health and safety of the environment on the other hand (Karliner and Guenther, 2011). According to Mohammad Azmal (2014), waste from health centers is one of the major sources of contaminants with significant environmental impact around the world. In general, health centers are considered as large units that have high energy and water consumption costs and are faced with the management of huge volume of hazardous wastes, but in most cases, their environmental impacts are often overlooked (IGEL, 2015). Accordingly, managers of such centers need to put on their agenda, the development of management plans for the conservation of energy and water, the proper disposal of wastes with the aim of reducing harm to patients, increasing the health and safety of staff and visitors, etc. in health centers and the environment outside them (Reller, 2008). Research results suggest that protection of the environment can result in significant savings in costs associated with infrastructural institutions and leads to reduction and control of pollutants. Hospitals are mainly concerned with improving health and alleviating disease; however, this cannot be achieved without considering urban environments (Azmal et al., 2014). This is because, as long as medical centers are responsible for the treatment, they are also responsible for their performance, especially in the comprehensive and efficient management of produced pollutants for the protection of the environment and promotion of the health of the patients, employees and stakeholders (Harris et al., 2009).

Research on the topic requires assessment of current environmental performance as well as monitoring and improving the quality of relevant services in health centers (Lin et al., 2013). This is because assessment is an integral part of management and one of the key management factors (Rajaiyan, 2004). In the process of performance assessment, the aim is basically to know the extent and approximation of the predicted goals achieved by comparing the current situation with the past process and standards (Farzianpour, 2000). Indeed, performance assessment is a critical exploration of the various activities in an organization. It is analogous to a health

checkup: in order to achieve good results, organizations must monitor their performance on a regular basis (Mollazadeh et al., 2012). This requires performance measurement systems which aim to improve and enhance overall performance.

In this regard, in a research on the performance evaluation of Health, Safety and Environment (HSE) units of organizations, it was pointed out that for accurate evaluation, it is necessary to provide a template that describes the status of HSE management performance in the work processes (Padash et al., 2015; Yang and MacLean, 2004). Nouri et al. (2005) based on their research results, underscored the necessity of creating performance assessment models in environmental issues. Chang et al. (2008) used a balanced scorecard approach to strengthen competitive performance in hospitals. Working on qualitative evaluation in HSE, Omidvari and Lashgary (2014) highlighted the influence of individual judgments. The authors argued that engineering and mathematical structures may be used to improve HSE performance assessment as a component of environmental performance in organizations. Zhao (2003) also called for the adoption of measures for assessing environmental performance in the health and medical sector by selecting a set of indicators for the environmental performance of the hospital. Therefore, in the research, the reasons and advantages of using environmental performance indicators for the evaluation of environmental performance were introduced for the first time. The environmental performance indicators were based on the environmental status analysis of the University Hospital of Norfolk and Norwich, England (Zhao, 2003). Also, in the microbiological assessment of indoor air quality in different parts of the hospital, the indoor air quality index was also examined from a biological point of view (Cabo Verde et al., 2015). Regarding green hospitals, ten comprehensive criteria including chemicals, waste, leadership, energy, water, transportation, food, buildings, pharmaceuticals and purchasing have been identified in the comprehensive environmental health agenda for health centers around the world. Each includes a series of measures that hospitals can implement in their own organization. The guidelines state that hospitals can initially focus on two or three criteria, and do the necessary planning to achieve the desired goals (Karliner and Guenther, 2011). In another study entitled "Assessment of Environmental Sustainability in Health Care Organizations", water consumption, energy efficiency, waste production, greenhouse gas consumption, consumption of materials, recycling, environmental accidents and biodiversity criteria were considered as indicators for environmental assessment (Carnero, 2015). In 2014, an article titled "Towards Green Hospital Standards in Yazd Educational Hospitals" was published. The findings of the research showed that insufficient attention on environmental protection strategies, lack of adequate environmental education, inappropriate waste management and inadequate allocation of funds for sewage management and emission of air pollutants, are the most important obstacles in achieving standards of Green Hospital in educational hospitals of Yazd, and the development of managerial strategies and their implementation with continuous education seems necessary (Ali Taleshi et al., 2014). In another study, the safety, health and environmental risks in Shahid Beheshti University hospitals was prioritized and evaluated using FANP and FMEA. In this research, biological, chemical, ergonomic, physical, electrical, psychological and mechanical indices were evaluated (Omidvari and Shahbazi, 2015).

Therefore, the aim of this research is to model environmental performance assessment in urban medical centers to determine their environmental situation.

In Iran, there is still no careful consideration of environmental indicators for hospitals, and therefore, these indicators may need to be initiated for scientific environmental management of hospitals. The innovation of this study is to provide better and more practical indicators with an environmental management approach for hospitals. Therefore, numerous studies and investigations have been carried out in accordance with national and international laws and standards.

Material and Methods

This research was carried out in four stages with the aim of providing a model for evaluating the status of environmental protection of health centers through a case study in the specialized hospital of Sarem located in Tehran metropolitan area of Iran. The research was conducted using the Delphi method and based on MCDM approach by applying the Fuzzy Analytical Hierarchy Process (FAHP) method (Wang et al., 2020; Intharathirat, and Salam, 2020; Parveen, and Kamble, 2020; Yücenur et al., 2020; Padash and Ataee, 2019).

In this research, Delphi method was used to screen the criteria, sub-criteria and indicators, and the FAHP technique was used to rank them (Kheybari et al., 2020; Prato, 2020; Li et al., 2020; Di Cesare et al., 2020; Padash, 2017; Chen and Honda, 2020; Tran et al., 2020; Musyoki et al., 2020; Kumar et al., 2020).

Initially, a comprehensive review of extant literature on environmental performance assessment in medical centers was conducted to extract a list of potential criteria, sub-criteria and indicators.

In the second step, a checklist of the criteria, sub-criteria and indicators was compiled and submitted to domain experts to be screened using the Delphi method. Given the use of a convenience population, Cochran's formula was used to determine the number of surveyed experts. Furthermore, item reliability was established through Cronbach's alpha coefficient. It is noteworthy that it was not necessary to examine validity since expert opinions were harnessed to obtain the items. The third step involved the statistical analysis of data provided by the participants. By applying the Mod statistic, a second questionnaire was developed to rank the criteria, sub-criteria and indicators using Fuzzy AHP.

Finally, individual scores were calculated. The model was generated using a balance scoring approach with 1000 scores equally distributed among the criteria (according to the numbers).

Environmental performance assessment scores in medical centers were calculated as follows:

$$(EPS)_i = (W_i)\,(S_i) \quad (1)$$

Where, $(EPS)_i$ is the environmental performance score, W_i represents the normalized weights, and S_i denotes index scores.

It should be noted that, Relation (2) yields the sum total score to determine environmental performance in urban medical centers.

$$EPS=\sum(W_i)(S_i) \quad (2)$$

In this relation, the normalized weight of each indicator (W_i) was calculated using Fuzzy AHP by summing the balanced scores. If the criterion included only sub criteria, the balanced score was calculated using the sub criteria. To assess environmental performance, the normalized weights yielded by Fuzzy AHP were multiplied by 1000 to determine the weighted score of each criterion (W_i). Then, the normalized subcriteria weights were individually multiplied by the corresponding criterion weights. Similarly, normalized index weights were multiplied by the corresponding sub criterion weights.

Finally, percentages of the final index weights were calculated to find the domains of indicator scores (S_i). As a result, upper and lower bounds were established for each environmental performance indicator.

Results and discussion

A. Identification of the criteria, sub-criteria and indicators

MCDM criteria, sub-criteria and indicators were typically extracted from previous studies and screened using the Delphi method (Üsküdar et al., 2019; Dožić, 2019; Hasanzadeh et al., 2013;

Jozi et al., 2010). In this research, as explained earlier, a checklist of criteria, sub-criteria and indicators was compiled using the sources in Table 1.

Table 1. Sources for identifying criteria, sub-criteria and indicators for environmental performance assessment in urban medical centers

Reference	Year	Factors		
		Criteria	Sub-criteria	Indicator
United Nations Officer for the Coordination of Humanitarian Affairs	2001	-	E3	-
Ministry of the Environment (Japan Government)	2003	-	A3, E1, A4	F11, B13, E11, E24, E26
EPA	2005	-	-	C12
Kinsella et al.	2007	-	-	D31
Emergency and Humanitarian Action, World Health Organization	2007	-	-	B31, B32
Reller	2008	A, D, B	-	-
Stockholm Environment Institute (SEI), and NHS Sustainable Development Unit	2008	-	C1	-
Chaerul et al.	2008	-	A2, A5, A6, A7	-
Aquaterra	2008	-	-	B11
Institute for Ecopreneurship (IEC), University of Applied Sciences Northwestern Switzerland (FHNW), School of Life Sciences (HLS), Sustainable Business Associate (sba), Royal Scientific Society (RSS).	2010	-	D1, D2, B1	D23, D32, E42
Karliner and Guenther	2011	E	-	D25, D24
Forest Production Commission Western Australia	2011	-	-	E25
World Health Organization	2011	-	-	E33, E34
International Organization for Standardization	2013	-	-	E21, E22
Simona Ganassi Agger	2013	-	D4	-
Ahmed Shah	2013	-	-	D21
Chalise	2014	-	-	B22, B21, B23, C11
Iranian Society for Green Management	2014	-	-	B12, C31, C13, E41, E43, D12, D22
Rahimi et al.	2014	-	-	F23
Paille´ et al.	2014	-	-	F22
DNV GL	2015	-	E2, E4, F2	E23, E12
Figueroa Gallo and Olivera	2015	-	C3	-
Ravindra et al.	2016	-	-	C32
Yousefli et al	2017	-	-	F12
Adding Experts Group of Research*	-	F, C	C2, F1, A1, D3, B2	C21, C22,B24, B25, F21, F15, F13, F14, F24

A: Waste management; A1: waste disinfection (percentage); A2: source separation of waste; A3: waste volume; A4: waste recycling (percentage); A5: waste storage; A6: waste collection; A7: waste transportation.
B: Water and sewage management; B1: water consumption and control; B2: sewage generation and control; B11: reduction of water consumption per capita; B12: application of mechanisms to control water consumption; B13:

water sources for non-drinking consumption; B21: sewage volume; B22: treated sewage (percentage); B23: monitoring output sewage; B24: sewage treatment system type; B25: treated sewage burial site.
C: Pollution management; C1: air pollution; C2: soil pollution; C3: noise pollution; C11: monitoring exhaust pollutants; C12: measures to control air pollution; C13: monitoring indoor air quality; C21: monitoring soil contamination; C22: measures to control soil contamination; C31: monitoring noise pollution in external environments; C32: measures to control environmental noise pollution.
D: Energy and materials management; D1: electricity consumption and control; D2: fuel consumption and control; D3: material consumption; D4: application of renewable energy sources; D11: reducing electricity consumption (percentage); D12: application of mechanisms to control electricity consumption; D21: reduction of fuel consumption per capita (percentage); D22: application of mechanisms to control fuel consumption; D23: adhering to heating and cooling standards set by the Ministry of Health and Medical Education; D24: types of vehicles in the organization; D25: transportation system for the personnel; D31: reduction of paper consumption per capita; D32: application of chemicals (poisons, disinfectants, detergents, pesticides, etc.).
E: Leadership and management; E1: environmental management system of activities and services in the hospital; E2: hospital management focusing on environmental issues; E3: environmental emergencies management in the hospital; E4: hospital management assigning an environmental officer; E11: environmental management system certification; E12: an approach to identify, evaluate and mitigate environmental risks; E21: financial resources allocated to environmental issues (percentage); E22: creating and executing operational goals pertaining to environmental issues; E23: execution of corrective and preventative environmental measures in management review meetings (percentage); E24: employees trained on environmental issues (percentage); E25: resolving environmental complaints (percentage); E26: participation, awards and certifications pertaining to the environment; E31: environmental maneuvers (percentage); E32: organizational readiness in environmental emergencies; E33: preventative and corrective measures to address the inconsistencies observed in maneuvers (percentage); E34: corrective measures pertaining to emergency environmental issues (percentage); E41: environmental officer work experience; E42: presence of a department in charge of environmental issues; E43: environmental officer's education;
F: Physical resources and stakeholders management; F1: hospital specifications; F2: hospital stakeholders; F11: area (m^2); F12: presence of maintenance system; F13: window types; F14: green space development (percentage); F15: hospital age; F21: number of patient admissions; F22: environmental performance assessment of workers; F23: number of outpatients; F24: environmental performance assessment of contractors.
*It should be elucidated that the criteria for F and C, and the sub-criteria for C2, F1, A1, D3, B2 and the indicators C21, C22, B24, B25, F21, F15, F13, F14 and F24 are factors suggested by experts specialized in the subject matter of the research, who are working in hospitals within the country at the time of screening for the contents of Table 1.

B. Assigning scores to the environmental performance criteria, sub-criteria and indicators

Based on the Delphi and Fuzzy AHP results, a total of 6 criteria, 22 sub-criteria and 48 indicators were found to contribute to environmental performance in medical centers. These can be exploited to present a comprehensive model of environmental performance assessment in medical centers. Pertinent scores are shown in Tables 2 to 7.

Table 2. Waste management sub-criteria and corresponding weights

Criterion	Normalized Weight	Sub-criteria	Normalized Weight
Waste management	0.301	Waste disinfection (percentage)	0.279
		Source separation of waste	0.179
		Waste volume	0.171
		Waste recycling (percentage)	0.165
		Waste storage	0.076
		Waste collection	0.074
		Waste transportation	0.057

Table 3. Wastewater management sub-criteria, indicators and corresponding weights

Criterion	Normalized Weight	Sub-criterion	Normalized Weight	Indicators	Normalized Weight
Water and sewage management	0.265	Water consumption and control	0.456	Reduction of water consumption per capita	0.454
				Application of mechanisms to control water consumption	0.378
				Water sources for non-drinking consumption	0.168
		Sewage generation and control	0.544	Sewage volume	0.310
				Treated sewage (percentage)	0.287
				Monitoring output sewage	0.169
				Sewage treatment system type	0.118
				Treated sewage burial site	0.116

Table 4. Pollution sub-criteria, indicators and corresponding weights

Criterion	Normalized Weight	Sub-criterion	Normalized Weight	Indicators	Normalized Weight
Pollution management	0.213	Air pollution	0.530	Monitoring exhaust pollutants	0.472
				Measures to control air pollution	0.315
				Monitoring indoor air quality	0.215
		Soil pollution	0.270	Monitoring soil contamination	0.516
				Measures to control soil contamination	0.484
		Noise pollution	0.200	Monitoring noise pollution in external environments	0.513
				Measures to control environmental noise pollution.	0.487

Table 5. Energy management sub-criteria, indicators and corresponding weights

Criterion	Normalized Weight	Sub-criterion	Normalized Weight	Indicators	Normalized Weight
Energy and materials management	0.106	Electricity consumption and control	0.285	Reducing electricity consumption (percentage)	0.544
				Application of mechanisms to control electricity consumption	0.456
		Fuel consumption and control	0.320	Reduction of fuel consumption per capita (percentage)	0.276
				Application of mechanisms to control fuel consumption	0.275
				Adhering to heating and cooling standards set by the Ministry of Health and Medical Education	0.221
				Types of vehicles in the organization	0.166
				Transportation system for the personnel	0.062
		Material consumption	0.231	Reduction of paper consumption per capita	0.729
				Application of chemicals (poisons, disinfectants, detergents, pesticides, etc.)	0.271
		Application of renewable energy sources	0.165	-	-

Table 6. Leadership and management sub-criteria, indicators and corresponding weights

Criterion	Normalized Weight	Sub-criterion	Normalized Weight	Indicators	Normalized Weight
Leadership and management	0.083	Environmental management system of activities and services in the hospital	0.568	Environmental management system certification	0.516
				An approach to identify, evaluate, and mitigate environmental risks	0.484
		Hospital management focusing on environmental issues	0.196	Financial resources allocated to environmental issues (percentage)	0.281
				Creating and executing operational goals pertaining to environmental issues	0.261
				Execution of corrective and preventative environmental measures in management review meetings (percentage)	0.127
				Employees trained on environmental issues (percentage)	0.152
				Resolving environmental complaints (percentage)	0.118
				Participation, awards, and certifications pertaining to the environment	0.061
		Environmental emergencies management in the hospital	0.144	Environmental maneuvers (percentage)	0.346
				Organizational readiness in environmental emergencies	0.274
				Preventative and corrective measures to address the inconsistencies observed in maneuvers (percentage)	0.231
				Corrective measures pertaining to emergency environmental issues (percentage)	0.149
		Hospital management assigning an environmental officer	0.092	Environmental officer work experience	0.429
				Presence of a department in charge of environmental issues	0.309
				Environmental officer's education	0.269

Table 7. Physical resources and stakeholder management sub-criteria, indicators and corresponding weights

Criterion	Normalized Weight	Sub-criterion	Normalized Weight	Indicators	Normalized Weight
Physical resources and stakeholders management	0.032	Hospital specifications	0.649	Area (m^2)	0.245
				Presence of maintenance system	0.217
				Window types	0.197
				Green space development (percentage)	0.165
				Hospital age	0.178
		Hospital stakeholders	0.351	Number of patient admissions	0.275
				Environmental performance assessment of workers	0.265
				Number of outpatients	0.254
				Environmental performance assessment of contractors	0.206

C. Determination of the variation domains of indicators scores

Domain variations of the environmental performance indicators are shown in Table 8. According to the results, environmental performance in medical centers can be measured in five levels: very poor, poor, medium, good and very good.

Table 8. Environmental performance in medical centers

Environmental performance	Total score domain	Description
Very good	700 – 1000	700 to 1000
Good	300 - <700	300 to below 700
Medium	110 - <300	110 to below 300
Poor	50 - <110	50 to below 110
Very poor	0 - <50	0 to below 50

D. Environmental performance assessment results in the studied center

Sarem Specialized Hospital was founded in 2006 in West Tehran in an area of $16{,}000\ m^2$ and a foundation of $14{,}000\ m^2$. This private-sector hospital has treatment, education, research and support departments as well as many patients' rooms, operation rooms and a maternity ward. The building has six floors with various departments and wards located on different floors.

The proposed model was applied to Sarem Specialized Hospital and the results are presented in Table 9 The results show that the waste disinfection indicator, was rated the highest and most important index with a score of 84. The issue of hospital waste disinfection is of the utmost importance; as identified by this modeling and evaluation, it is a top priority; between 10 and 52 percent of hospital waste is, according to global statistics. Waste that is highly hazardous, according to the World Health Organization, can even spread contagious diseases even if recycled. The situation of hospital waste in Iran is such that in 72.2% of the waste production per capita is higher than the standards of the World Health Organization and more important and dangerous is the production of infectious waste per capita which in 90% of the regions of the country exceeds the world standards (Askarian et al., 2004; Taghipour and Mosaferi, 2009). Therefore, attention to this issue is very important and requires special attention.

Special Waste According to the Waste Management Act, the June 9, 2004, Resolution contains several main groups (MehriAhmadia et al., 2013). The most important of these wastes are hospital wastes which have a significant role in endangering the health of citizens. The correct principles of these practices are in environmental monitoring and environmental protection standards such as the US EPA standard and the European Union EC guidance (Windfeld and Brooks, 2015; Liu et al., 2015). Therefore, special attention to this issue and implementation of environmental management requirements and strategies based on the principles of health, safety and environment are suggested.

The other indicators were ranked in terms of treated sewage and source separation of waste and application of mechanisms to control water consumption respectively with scores of 38, 26.5 and 25.

One of the most important sources of community wastewater production are hospitals, other health care providers, medical diagnostic laboratories, and medical research laboratories, which are called hospital wastewater. Due to the presence of dangerous contaminants such as pathogenic microorganisms, pharmaceuticals, heavy metals, chemicals used in laboratories, disinfectants, radioisotopes, etc. in hospital wastewater, its proper management is of great importance and if not Proper management is a major threat to community health. In this regard, the National Guide for Hospital Wastewater Management has been provided by the Ministry of Health, Workplace Health Unit.

Table 9. performance assessment results in Sarem Specialized Hospital

Indicator/ Sub-criteria	Score	Indicator/ Sub-criteria	Score	Indicator/ Sub-criteria	Score
Waste disinfection (%)	84.000	Measures to control soil contamination	14.000	Resolving environmental complaints (%)	0.000
Source separation of waste	26.500	Monitoring noise pollution in external environments	0.000	Participation, awards, and certifications pertaining to the environment	0.000
Waste volume	0.000	Measures to control environmental noise pollution.	10.500	Environmental maneuvers (%)	0.000
Waste recycling (%)	0.000	Reducing electricity consumption (%)	0.000	Organizational readiness in environmental emergencies	0.000
Waste storage	11.500	Application of mechanisms to control electricity consumption	7.000	Preventative and corrective measures to address the inconsistencies observed in maneuvers (%)	0.000
Waste collection	22.000	Reduction of fuel consumption per capita (%)	0.000	Corrective measures pertaining to emergency environmental issues (%)	0.000
Waste transportation	17.000	Application of mechanisms to control fuel consumption	4.000	Environmental officer work experience	0.000
Reduction of water consumption per capita	0.000	Adhering to heating and cooling standards set by the Ministry of Health and Medical Education	3.500	Presence of a department in charge of environmental issues	1.250
Application of mechanisms to control water consumption	25.000	Types of vehicles in the organization	0.000	Environmental officer's education	0.000
Water sources for non-drinking consumption	11.000	Transportation system for the personnel	0.000	Area (m^2)	0.000
Sewage volume	0.000	Reduction of paper consumption per capita	0.000	Presence of maintenance system	2.250
Treated sewage (%)	38.000	Application of chemicals (poisons, disinfectants, detergents, pesticides, etc.)	3.000	Window types	2.000
Monitoring output sewage	23.000	Application of renewable energy sources	0.000	Green space development (%)	0.000
Sewage treatment system type	16.000	Environmental management system certification	0.000	Hospital age	2.500
Treated sewage burial site	15.000	An approach to identify, evaluate, and mitigate environmental risks	11.500	Number of patient admissions	0.000
Monitoring exhaust pollutants	0.000	Financial resources allocated to environmental issues (%)	2.250	Environmental performance assessment of workers	0.000
Measures to control air pollution	18.000	Creating and executing operational goals pertaining to environmental issues	4.000	Number of outpatients	0.000
Monitoring indoor air quality	0.000	Execution of corrective and preventative environmental measures in management review meetings (%)	0.000	Environmental performance assessment of contractors	1.000
Monitoring soil contamination	0.000	Employees trained on environmental issues (%)	1.250	**SUM**	**377**

Conclusion

According to the results of this research and considering that the model of accreditation provided by the Ministry of Health and Medical Education of Iran has been used to evaluate the overall performance of hospitals in Iran, and since in this model, the environmental performance of hospitals is not comprehensively assessed, the model introduced in this research (with emphasis on environmental indicators) can be used to evaluate the environmental performance of hospitals in the country, so that, by using this model, while it is possible to determine the existing environmental status by examining and measuring the indicators that have been evaluated, necessary actions are taken to address the weaknesses in improving the status of the environmental performance of the health centers. In other words, the model has the capacity to access the applied strategies for improving the medical status of the medical centers and is an effective tool for managing change towards being "eco-friendly". As revealed from the results of this study, the issue of hospital waste management and hospital wastewater management is of particular importance. In this regard, numerous management programs and guidelines based on the principles of health, safety and environment have been provided by the Iranian Environmental Protection Agency and the Iranian Ministry of Health and Medical Education.

Accordingly, with regards to implementation of the evaluation model presented for the specialized women delivery, fertility and infertility wards of Sarem Hospital located in Tehran, the final score of the hospital's environmental performance was 377, which according to Table 8, is in the range of 300 to 700, and it is possible to assess the performance status of the hospital as "good" based on the final score.

Finally, in view of the different hospitals' expertise and in order to generalize the model, the presented model is recommended to be adopted in future researches.

Consistent with the results of this study, the importance of considering environmental management issues with emphasis on the management of special and hazardous waste and hospital wastewater management was of the highest importance. Important cases and measures recommended for proper environmental management of hospitals include a set of:

1. Quality control of hospital drinking water
2. Disinfection of Hospital for Infectious Diseases
3. Supervision of hospital waste disposal
4. Monitor how the sections are cleaned
5. Toilet disinfection and patient disposal
6. Control of kitchen environment and hospital utensils

References

Ahmed Shah, B. (2013). Development and implementation of environmental key performance indicators (KPIs) in Swedish manufacturing industry. Master thesis, Mälardalen University Sweden.

Ali Taleshi, M.S., Nejadkoorki, F., Azimzadeh, H.R., Ghaneian, M.T., and Namayandeh, SM. (2014). Toward Green Hospital Standards in Yazd Educational Hospitals in 2013. Scientific Journal of Ilam University of Medical Sciences, 22(5), 114-127. [In Persian]

Aquaterra. (2008). Water and environment, international comparisons of domestic per capita consumption. Bristol, United Kingdom: Rio House (Environment Agency).

Askarian, M., Vakili, M., & Kabir, G. (2004). Results of a hospital waste survey in private hospitals in Fars province, Iran. Waste management, 24(4), 347-352.

Azmal, M., Kalhor, R., Dehcheshmeh, N., Goharinezhad, S., Asadollahi Heidari, Z. and Farzianpour, F. (2014). Going toward green hospital by sustainable healthcare waste management: segregation, treatment and safe disposal. Scientific Research , 6(11), 2632-2640.

Cabo Verde, S., Marta Almeida. S., Matos, J., Guerreiro, D., Meneses, M., Faria, T., Botelho, D., Santos, M and Viegas, C. (2015). Microbiological assessment of indoor air quality at different hospital sites. Research in Microbiology, 166(7), 1-7.

Carnero, M.C. (2015). Assessment of Environmental Sustainability in Health Care Organizations. Sustainability, 7, 8270-8291; doi:10.3390/su7078270.

Chaerul, M., Tanaka, M., and Shekdar, A.V. (2008). A system dynamics approach for hospital waste management. Waste management, 28, 442-449.

Chalise, A.R. (2014). Selection of sustainability indicators for wastewater treatment technologies. A thesis in the Department of Building, Civil and Environmental Engineering Presented in Partial Fulfilment of the Requirements for the Degree of Master of Applied Science (Civil Engineering) at Concordia University Montreal, Quebec, Canada.

Chang, W.C., Tung, T.C., Huang, C.H., and Yang, M.C. (2008). Performance improvement after implementing the balanced scorecard: A large hospital's experience in Taiwan. Total Quality Management, 19(11), 1143–1154.

Chassin, M. R., & Loeb, J. M. (2013). High-reliability health care: getting there from here. The Milbank Quarterly, 91(3), 459-490.

Chen, T. C. T., & Honda, K. (2020). Nonlinear Fuzzy Collaborative Forecasting Methods. In Fuzzy Collaborative Forecasting and Clustering (pp. 27-44). Springer, Cham.\

Di Cesare, S., Cartone, A., & Petti, L. (2020). A New Scheme for the Evaluation of Socio-Economic Performance of Organizations: A Well-Being Indicator Approach. In Perspectives on Social LCA (pp. 25-34). Springer, Cham.

DNV GL. (2015). ISO 14001:2015 Environmental management systems – Requirements guidance document.

Dožić, S. (2019). Multi-criteria decision making methods: Application in the aviation industry. Journal of Air Transport Management, 79, 101683.

Emergency and Humanitarian Action, and World Health Organization. (2007). Benchmarks, standards and indicators for emergency preparedness and response.

EPA. (2005). Healthy Air: a Community and Business Leaders Guide.

Farzianpour, F. (2000). Control mechanisms of performance evaluation. Tehran; Second Conference on Performance Evaluation Aspects of State Country Executive Agencies. [In Persian]

Figueroa Gallo, LM., and Olivera, JM. (2015) Noise pollution control system in the hospital environment. Journal of Physics: Conference Series, 705, conference 1,

Forest Production Commission Western Australia. (2011). Policy statement NO. 7, Complaints management framework.

Frow, P., McColl-Kennedy, J. R., & Payne, A. (2016). Co-creation practices: Their role in shaping a health care ecosystem. Industrial Marketing Management, 56, 24-39.

Harris, N., Pisa, L., Talioaga, S., and Vezeau, T. (2009). Hospitals going green: A holistic view of the issue and the critical role of the nurse leader. Holistic Nursing Practice, 23(2), 101-111.

Hasanzadeh, M., Afshin Danehkar, A., and Azizi, M. (2013). The application of Analytical Network Process to environmental prioritizing criteria for coastal oil jetties site selection in Persian Gulf coasts (Iran). Ocean & Coastal Management, 73 (2013), 136-144.

Initiative for Global Environmental Leadership (IGEL). (2015). Greener hospitals: Building consensus for health care sustainability.

Institute for Ecopreneurship (IEC), University of Applied Sciences Northwestern Switzerland (FHNW), School of Life Sciences (HLS), Sustainable Business Associate (sba), Royal Scientific Society (RSS). (2010). Best environmental practices in the healthcare sector, A guide to improve your environmental performance.

International Organization for Standardization. (2013). Environmental management- environmental performance evaluation guidelines.

Intharathirat, R., & Salam, P. A. (2020). Analytical Hierarchy Process-Based Decision Making for Sustainable MSW Management Systems in Small and Medium Cities. In Sustainable Waste Management: Policies and Case Studies (pp. 609-624). Springer, Singapore.

Iranian Society for Green Management. (2014). Green management manual in hospitals & non hospitals. [In Persian]

Jozi, S. A., Hosseini, S. M., Khayatzadeh, A., & Tabibshushtari, M. (2010). Analyses of physical risks in Khozestan dam using Multi Criteria Decision Method (MCDM). Journal of Environmental Studies, 36, 25-38.

Karliner, J., and Guenther, R. (2011). A comprehensive environmental health agenda for hospitals and health systems around the World.

Kheybari, S., Rezaie, F. M., & Farazmand, H. (2020). Analytic network process: An overview of applications. Applied Mathematics and Computation, 367, 124780.

Kinsella, S., Gleason, G., Mills, V., Rycroft, N., Ford, J., Sheehan, K., and Martin, J. (2007). The State of the Paper Industry. A collaborative report by the Steering Committee of the Environmental Paper Network.

Kumar, S., Kumar, A., Kothiyal, A. D., & Bisht, M. S. (2020). Selection of Optimal Performance Parameters of Alumina/Water Nanofluid Flow in Ribbed Square Duct by Using AHP-TOPSIS Techniques. In Intelligent Communication, Control and Devices (pp. 95-103). Springer, Singapore.

Li, C., Yi, J., Wang, H., Zhang, G., & Li, J. (2020). Interval data driven construction of shadowed sets with application to linguistic word modelling. Information Sciences, 507, 503-521.

Lin, Q.L., Liu, L., Liu, H.C., and Wang, D.J. (2013). Integrating hierarchical balanced scorecard with fuzzy linguistic for evaluating operating room performance in hospitals. Expert Systems with Applications 40, 1917–1924.

Liu, A., Ren, F., Lin, W. Y., & Wang, J. Y. (2015). A review of municipal solid waste environmental standards with a focus on incinerator residues. International Journal of Sustainable Built Environment, 4(2), 165-188.

MehriAhmadia, H. S. H., Mohameda, A. F., & Shamshiria, N. M. E. (2013). Status of Waste Governance System in Iran-An Overview. World Applied Sciences Journal, 25(4), 629-636.

Ministry of the Environment (Japan Government), (2003). Environmental performance indicators guideline for organizations.

Mollazadeh, E., Alimohammadi Asl, E., and Zemestani, Gh. (2012). Fuzzy Tree Model for Evaluating Employee Performance Evaluation System and Selection Evaluation System for Branch of University of West Azarbaijan. (Journal of Instruction and Evaluation) Journal of Educational Sciences, (4)16, 13 – 32. [In Persian]

Musyoki, D., Moslehpour, M., & Wong, W. K. (2020). Simultaneous Adaptation of AHP and Fuzzy AHP to Evaluate Outsourcing Service in East and Southeast Asia. Journal of Testing and Evaluation, 48(2).

Naseri, A., Sepehri, M., and Mahmoudi, Sh. (2014). Strategic performance evaluation of health, safety and environment (HSE) based on balanced scorecard (BSC), the case study of a corporation in energy industry. Iran Occupational Health, 11(1), 79-94.

Nouri, J., Abbaspour, M., Roayaei, E., and Nikoomaram, H. (2005). Comparison environment performance HSEQ management systems, regarding the international and Iranian of oil and gas general contractors. American Journal of Applied Sciences, 2(1), 447-451.

Omidvari, M., and Lashgary, Z. (2014). Presenting a model for safety program performance assessment using grey system theory. Grey Systems. Theory and Application, 4(2), 287- 298.

Omidvari, M., and Shahbazi, D. (2015). Assessing and Prioritizing Health Safety and Environment Risk in Hospitals (Case Study: Shahid Beheshti University). Scientific Journal of Ilam University of Medical Sciences, 24(1), 43-54;

Padash, A. (2017). Modeling of Environmental Impact Assessment Based on RIAM and TOPSIS for Desalination and Operating Units. Environmental Energy and Economic Research, 1(1), 75-88.

Padash, A., & Ataee, S. (2019). Prioritization of Environmental Sensitive Spots in Studies of Environmental Impact Assessment to Select the Preferred Option, Based on AHP and GIS Compound in the Gas Pipeline Project. Pollution, 5(3), 671-685.

Padash, A., Bidhendi, G. N., Hoveidi, H., & Ardestani, M. (2015). Green strategy management framework towards sustainable development. Bulgarian Chemical Communications, 47, 259-268.

Paille´, P., Chen, Y., Boiral, O., and Jiafei Jin, J. (2014).The impact of human resource management on environmental performance: An employee-level study. Journal of Business Ethics, 121(3), 451–466.

Parveen, N., & Kamble, P. N. (2020). Decision-Making Problem Using Fuzzy TOPSIS Method with Hexagonal Fuzzy Number. In Computing in Engineering and Technology (pp. 421-430). Springer, Singapore.

Prato, T. (2020). Framework for Identifying Preferred Sustainable Management Actions with Application to Forest Fuel Treatment. In Sustainability Perspectives: Science, Policy and Practice (pp. 19-39). Springer, Cham.

Rahimi, H., Khammar-nia, M., Kavosi, Z., and Eslahi, M. (2014). Indicators of hospital performance evaluation: A systematic review. International Journal of Hospital Research, 3(4), 199-208.

Rajaiyan, M.M. (2004). Applying balanced scorecard in Information Technology (IT) company evolution and performance. Tehran; Second National Conference on Performance Management. [In Persian]

Ravindra, K., Singh, T., Tripathy, J.P., Mor, S., Munjal, S., Patro, B., and Panda, N. (2016). Assessment of noise pollution in and around a sensitive zone in North India and its non-auditory impacts. Science of the Total Environment, 566–567 (2016), 981–987.

Reller, A. (2008). Greener hospitals, improving environmental performance. Environment Science Center, Augsburg, Germany With support from Bristol-Myers Squibb Company; 1-52.

Sheikhzadeh, RA., and Bahramzadeh, MM. (2008). Role of human resources strategic management in improving business performance. Iran Manag Consultant Soc. 18(8), 21-6. [In Persian]

Simona Ganassi Agger, A. (2013). Towards Zero Carbon Hospitals with Renewable Energy Systems.

Stockholm Environment Institute (SEI), and NHS Sustainable Development Unit (2008). NHS England carbon emissions: carbon foot printing report.

Taghipour, H., & Mosaferi, M. (2009). Characterization of medical waste from hospitals in Tabriz, Iran. Science of the total environment, 407(5), 1527-1535.

Tran, T. M. T., Yuen, K. F., Li, K. X., Balci, G., & Ma, F. (2020). A theory-driven identification and ranking of the critical success factors of sustainable shipping management. Journal of Cleaner Production, 243, 118401.

United Nations Office for the Coordination of Humanitarian Affairs. (2001). Establishing a national environmental emergency response mechanism.

Üsküdar, A., Türkan, Y. S., Özdemir, Y. S., & Öz, A. H. (2019, March). Fuzzy AHP-Center of Gravity Method Helicopter Selection and Application. In 2019 8th International Conference on Industrial Technology and Management (ICITM) (pp. 170-174). IEEE.

Wang, L., Wang, Y. M., & Martínez, L. (2020). Fuzzy TODIM method based on alpha-level sets. Expert Systems with Applications, 140, 112899.

Windfeld, E. S., & Brooks, M. S. L. (2015). Medical waste management–A review. Journal of environmental management, 163, 98-108.

World Health Organization. (2011). Hospital emergency response checklist, An all-hazards tool for hospital administrators and emergency managers. Copenhagen, Denmark: WHO Regional Office for Europe.

Yang, Y., and MacLean, R. (2004). A template for assessing corporate performance: Benchmarking EHS organization. Environmental Quality Management, 13(3), 11–23.

Yousefli, Z., Nasiri, F., and Moselhi, O. (2017) Healthcare facilities maintenance management: a literature review. Journal of Facilities Management,

Yücenur, G. N., Çaylak, Ş., Gönül, G., & Postalcıoğlu, M. (2020). An integrated solution with SWARA&COPRAS methods in renewable energy production: City selection for biogas facility. Renewable Energy, 145, 2587-2597.

Zamparas, M., Kapsalis, V. C., Kyriakopoulos, G. L., Aravossis, K. G., Kanteraki, A. E., Vantarakis, A., & Kalavrouziotis, I. K. (2019). Medical waste management and environmental assessment in the Rio University Hospital, Western Greece. Sustainable Chemistry and Pharmacy, 13, 100163.

Zhao, X. (2003). Developing environmental performance indicators the case of Norfolk & Norwich university hospital. Thesis presented in part-fulfilment of the degree of Master of Science in accordance with the regulations of the University of East Anglia.