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Analyzing Effective Factors in Green Information Systems (ISs) Adoption in Health Care Centers Using Interpretive Structural Modeling

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KEYWORDS

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ABSTRACT

Health care centers as an important part of health care industry, in addition to following their major mission, that is, providing high quality health service, can gain environmental and even socioeconomic advantages through reducing environmental effects resulting from their activities. With the aim of gaining these advantages, health care centers can increase their environmental performance through adopting a systematic and proper approach in application of information systems (ISs). The Green information systems (ISs) that indicate a novice approach in application of ISs are considered as necessary tools to realize the goals of environmental sustainability. Health centers are able to achieve sustainability through adopting green information systems. The present research aimed to identify model factors that play roles in the adoption of green information systems by Health care centers. Factors were first identified through literature reviews and theoretical principles, and they were then revised and approved by health industry experts of Kerman province (Iran). Relationships of 12 factors were studied through the interpretive structural modeling. According to the obtained model, the research and development, senior manager's insight and commitment, and the social investment volume were the most important factors in adopting green information systems in health centers. Therefore, health centers should use their past experiences of using information systems to adopt green information systems and expand their green organizational knowledge of this subject. Senior managers also need to resolve challenges of adopting green information systems in health centers by their commitment and insight. Finally, these centers should not only increase the social investment volume, but also take into account relationships of the investment and social considerations in the process of investment in green information systems in order to gain great social benefits with a financial return through the adoption of green information systems.

1. Introduction

Attention to the sustainability and its dimensions in health care centers not only increases the quality of service delivery, but also reduces environmental effects due to their activities because they should effectively use their resources [1]. In addition to reducing environmental effects, managers of these centers are also looking for proper opportunities and solutions for economic savings [2]. On the other hand, they should provide medical service in some cases such as rural areas where it is more difficult to provide services; hence, they should be economically sustainable [3]. However, the economic sustainability occurs when harming the environment is minimal [4]. Therefore, an important issue is the environmental sustainability of health centers is how to develop the healthcare service management towards the environmental sustainability and provide sufficient health services [5, 6].

Despite various initiatives and projects for achievement of environmental sustainability goals [7, 8, and 9], the answer to the above question depends on methods of using green information systems by health centers to achieve the environmental sustainability [10, 11].

The concept of Green IS is taken from the relations between ISs and sustainability, especially organizations' environmental issues [12, 13, 14].

Such systems utilize all capabilities and tools available in the information and communication technology, such as the automation systems, groupware, and telephone conferences, in order to achieve environmental sustainability goals [15].

According to Jenkin et al. [10], Green ISs are used in energy, transportation, logistic and manufacturing sectors with the goal of gaining environmental and social advantages. In addition, they provided competitive advantage through saving the costs. Therefore, they are also considered as a proper option to gain economic advantages [17, 18]. Based on studies by Braa et al. [5], Kimaro and Nhampos [6], and Unhelkar [10], roles of green information systems are very important in facilitating environmental sustainability of health centers. In "Green health" chapter of Unhelkar's book [10], it is explained that health centers are rapidly growing as an important sector of the healthcare industry. Environmental effects accompany this growth; hence, the available capacity of green information systems should be used to reduce and control these effects. The electronic patient record is one of these capacities. The electronic patient record should consider the replicated data, speed of access to them, privacy, and remote access. The social health information network is another type of these capacities. This network can be designed and supported using the information and communication technologies based on principles of environmental sustainability. In this case, costs of health centers can be reduced and a general view of social health can be obtained. Finally, we can refer to hospital information systems. When such systems are efficient for the environment, they will help make medical centers greener due to their nature.

The above-mentioned cases indicate the importance of adopting green information systems in health centers to achieve the environmental sustainability; however, none of previous studies has comprehensively identified and modeled factors contributing to the adoption of these systems in medical centers. However, the first step is to identify and model these factors for the full utilization of green information systems [6, 10, 13, and 19]. Accordingly, the present study aimed to identify and model effective factors in the adoption of green information systems in health centers.

Analyzing the factors through interpretive structural approach not only prioritizes the factors, but also results in the identification of the level of the driving and dependence power of each factor. This kind of analysis makes it possible to understand complex relations between factors so that it creates a correct way and understanding for these organizations to use Green ISs. In other words, the interpretive structural modeling analysis provides an opportunity to focus on underlying factors and determining the starting point of adopting green information systems in healthcare centers. This research is organized as follows: in the first part of the review of the literature, first, the sustainability and relationships between environmental sustainability with the health care industry- health care centers- are discussed. In the second part, the concept of Green IS is explained. Finally, the factors affecting Green ISs adoption in health care centers are identified and modeled.

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2. Review of the Literature

2-1. Environmental sustainability in health care centers

Sustainable development was defined in 1987 as "development that meets the current needs without compromising the ability of future generation to meet their needs" [20]. Sustainability is considered in three social, economic, and environmental dimensions [9]. Considering the social dimension of sustainability increases the Corporate Social Responsibility (CSR). The CSR is considered as the commitment of organization's management to goals and values of the society [21]. The reduction of costs, profitability, and return on investment turn up in economic sustainability [22, 23]. The environmental dimension indicates the reasonable use of natural resources and maximization of the positive environmental effects in organization's activities. For this reason, organizations develop some strategies to improve ecologic performance and reduce environmental effects [23, 24]. Numerous studies have confirmed this issue that moving toward environmental sustainability has some advantages including reducing organization's cost and respect for the environment. In other words, a large part of advantages of sustainability is achieved with realization of environmental sustainability [25, 26].

Health centers should also move towards the environmental sustainability [27]. In an ideal situation, when people need to access to health care, the demand increases and resources are limited; thus, medical centers should meet needs of the present time by taking into account future needs. In this case, a set of interactive processes can be achieved to manage and optimize the human and social health, and there will not be any unfair or indirect effect on the environment [28].

To determine how far environmental sustainability has been studied in health care centers and its key issues for policy, practice, and research, seventy-six studies between 1990 to 2013 were reviewed by McGain& Naylor [29]. The results have identified research areas about environmental sustainability in hospitals: hospital design, direct energy consumption, procedure, movement, psychology and behavior. The research by Pisters et al. [30] is another study on the sustainability of hospitals. In this study, it has been stated that using sustainability approach provides numerous financial and environmental advantages for the health care centers. Porter [31] argued that increasing the environmental performance in the health care industry was required to define a common goal between beneficiaries. According to the research by Goh & Marimuth [32], factors such as education, leadership, effective management practices, readiness to adaptability, and willingness to cooperation related to the human's behaviors and attitudes are effective in realizing sustainability in healthcare.

Despite the fact that different models and studies have been conducted to lead health centers towards the sustainability, especially the environmental sustainability [1, 30], roles of green information systems are very important in facilitating the sustainability of health centers [10]. In the next section of the literature review, the concept of the green information system is examined.

2-2. Green information system (IS)

The Green ISs as a new attitude and application of ISs provide an opportunity for organizations to realize environmental goals [33, 34, 35, 36]. Various definitions have been proposed for Green IS: Green ISs indicate development and use of IS to support and enable environmental sustainability initiatives and, thus, tend to have an indirect and positive impact [16]. The Green ISs refer to the interactional use of IT to create targeted systems in order to help organization develop ecological sustainability [13].

The Green information technology (IT) is one of the terms that is often proposed along with Green IS [16, 37]. According to Dedrick [12], Green IS refers to the use of ISs to achieve environmental goals, while Green IT refers to the reduction of environmental effects of IT production and its use. According to Tushi et al. [14], the term 'Green IS' refers to ISs that can develop with or without Green IT in order to support sustainability plans of the environment.

The difference between Green IT and Green IS can be searched in the difference between IT and IS. Considering Merriam-Webster Dictionary (online version), IT refers to the technology related to development, maintenance and using computer systems, software and network to process and distribute the data; therefore, IT emphasizes technical infrastructures. On the other hand, IS has been defined as an integrated and coordinated set of individuals, processes, software and IT to support individual, organizational or social goals (Watson et al., (2010), cited in Brooks, Wang & Sarker [38]);

therefore, information system is a branch that proposes Green IS which includes all kinds of possible plans to support sustainable business procedure. In addition, Green IT is defined as part of Green IS [38]. The definition of Green IS can be presented as follows: Green IS refers to the application of IS as well as IT with internal interactions that creates a purposeful system to help an organization develop environmental sustainability [13].

The Green IS has various applications [39, 40]. In a wide application, Ghosh and Siddique [41] used Green IS to create a virtual space to support on-line deliberative democracy processes. This wide application is proposed at the level of society for realization of sustainability. The Green IS is used in different ways in health care industry, especially health care centers. For example, the telemedicine technology is applicable in this industry [42]. The telemedicine technology was mentioned in research by Akman and Mishra [24]. They believe that what is important in application and adoption of IT is the way to use it in order to realize environmental goals of sustainability. The concept of 'Green Health' describes applications of green IT and Green IS in health care industry and those organizations that operate in this industry [10]. In a beautiful analogy, Maruster [43] stated that environmental sustainability of ISs is the same as the stems of a broader sense known as sustainability that is applicable in different areas including health and care area.

The health information system is another example of information systems that can be used in hospitals.

These kinds of systems have brought about many benefits including increased productivity, decreased costs, decreased drug mistakes, and reduced stress on human labor [44]. Considering advantages of attention to the environmental sustainability, it should not be expected that all advantages resulted from the application of HIS to be available for both health care centers and patients. By adopting environmental sustainability in ISs, it is possible to begin a serious movement in health care centers to achieve different advantages [5, 6]. In the developing countries, some of challenges in sustainability related to HIS are as follows [6]:

- IT development processes based on HIS
- Lack of human resources
- Inefficient system design
- Designing and developing sustainable IS
- Human resource development

According to the idea of Garde et al. [45], HISs are rarely sustainable in their current form. To make the HIS and health system sustainable, it is necessary to focus on definition and maintenance of the components of HIS. These components should be easily updated when the knowledge (everything else) is changing; they should be easily adapted to the change in needs and business processes and should be easily changed when technological developments are made.

A number of studies have dealt with the study of the reasons and incentives of Green ISs adoption in organizations, i.e., what factors lead organizations to use such techniques and initiatives [37, 46]. The study conducted by Esfahani et al. [37] investigated Green IS adoption from the viewpoint of social responsibility of the company and environmental responsibility through analyzing the studies on Green IS in three micro, meso, and macro levels. The belief-action-outcome framework investigates Green ISs adoption from the viewpoint of managers [46]. Melville [47] first proposed this framework in an article titled as "innovation of ISs for environmental sustainability". According to belief-action-outcome framework, coercive pressure has a positive effect on the attitude of managers towards Green IS adoption, while the mimetic pressure does not have such an effect [46].

The effect of cultural, cognitive, normative and regulative factors on Green IS was studied in an integrative model of institutional theory and sense-making perspective [48]. The political-economic framework deals with the role of IT and Green IS in realization of eco-sustainability of Chinese industries. In this framework, the public concerns, regulatory forces, cost reduction, and differentiation are factors that affect adoption of green methods like Green IS in Chinese industries [7]. A study conducted by Dalvi-Esfahani et al. [49] considered the identification and prioritization of psychological drivers affecting the Green IT/IS adoption. In the proposed interpretive structural model, three factors of self-transcendent, positive effect and openness-to-change at the last level have been recognized as the most important factors. In the same study on the analysis of psychological factors affecting managers' attitude to adopt Green IS, the effect of Green IS Attitude, Subjective Norms, and Perceived Behavioral Control have been studied [19].

The review of the literature shows the importance of eco-sustainability in health care centers, Green ISs adoption and identification of effective factors in its adoption to achieve environmental sustainability. Health care centers can take advantage of different environmental, economic, and social advantages through adoption of Green ISs. Identifying and modeling the factors affective in Green IS adoption will determine the correct way of adaption of environmental sustainability with IS. Accordingly, the effective factors in Green IS adoption in health care centers are recognized and analyzed in this study. The factors influencing Green IS adoption in health care centers are listed in Table 1.

3. Research Method

The interpretive structural modeling has been used in this study to analyze the relationship between twelve identified factors affecting Green ISs adoption in health care centers. The importance of ISM approach and steps for ISM is described below.

Interpretive structural modeling

Warfield [50] proposed the interpretive structural modeling approach to investigate the conceptual relationship between the elements or variables of a system. The conceptual relationship means the content relationship that exists between the components of a system related to the goal of the system. Therefore, in the interpretive structural approach that is an interactive learning process, a set of components is found in a comprehensive structured systematic model. The basis of interpretive structural approach is to use the experiences and knowledge of experts about a complex system [51]. In addition, the interpretive structural modeling is the best approach to resolving the existing complexity in communications between different components [52]. Many studies have used an interpretive structural approach to analyze complex relations between different elements. For example, Luthra and Haleem [26] used this approach to analyze barriers of implementation of sustainable supply chain management. Jia et al. [52] analyzed the sustainable supply chain management practices in mining and mineral industry using the interpretive structural approach. In a research by Dalvi-Esfahani et al. [49] , the psychological factors affecting the Green IT/ Green IS adoption have been analyzed through the interpretive structural approach.

Tab. 1. Effective factors in Green IS adoption in health care centers

Factor	Description	Reference
1. Domain of provided services	Providing information technology-based services and IS to health care centers makes it possible for these health care centers to expand their services domain	[10, 42, 45, 53, 54, 55]
2. Business ethics	Ethics are recognized as the protection from the ethical right of beneficiaries, and it should be extended beyond legal responsibility. When there is ethics in the organization, that organization respects honesty with having ethical codes and proper norms in its relation with customers and staff. The ethical codes and norms that an organization should respect in its relation with beneficiaries include transparency, fight against corruption and bribery, and protection of customers' confidential information	[56, 57, 58, 59, 60, 61, 62, 63]
3. Senior management's insight and commitment	The insight as one of the affective characteristics of senior managers indicates the degree of their interest in Green IS; they are responsible against them	[25, 64, 65, 66, 67, 68]
4. Staff's skill and creativity power	The sense of responsibility of the staff forces organizations to adopt Green ISs. The extent to which the staff responds to the social expectation against different issues of sustainability depends on	[25, 58, 67, 69, 70, 71]

	the level of their skills and creativity.	
5. Customer's value-added	The customers' value-added indicates what the customer expects from product and/or services and willingness to pay their costs. In other words, for a customer, value-added results from tangible needs and intangible demands, and it shows customer's expectations of the purchase.	[72, 73, 74]
6. Quick response to the society's health care needs	Quick response to the health needs is rooted in the concept of agility. An organization that is agile and institutionalizes mobility in itself is able to move quickly and easily with a thoughtful approach. The agile organization successfully discovers and implements competitive strategies through available resources and developing technologies. The prerequisite of quick response of health care centers depends on how ISs are used to move the organization	[57, 58, 75]
7. Environmental responsibility	Environmental responsibility means that organizations should have plans to achieve environmental goals in different ways and develop necessary policies. Environmental responsibility plays a role in ISs sustainability, because it is not possible to adopt these kinds of initiatives without having responsibility.	[59, 66, 76, 77]
8. Research and development	Research and development are said to those activities that are done in the organization to produce new knowledge and initiatives. The research and development activities maybe done continuously and independent of real demand to create or improve technology. When the research and development activities are continuous, it means that a certain number of staff are merely allocated to research and development.	[70, 78, 88]
9. Organization's sustainability strategy	Sustainability is a link that is made between business activity with innovation and following regulations and respecting the society. With the adoption of sustainable strategy at the present time, organization will be able to respond to its needs and shareholders' needs while considers the protection, maintenance and enhancement of human and natural resources that are needed in the future. A good sustainability strategy is one that is considered as part of the main values of the company. It also has a correct relationship with staff, management, executive managers and different parts of the organization; everybody knows his role in this strategy.	[79, 80, 81, 82]
10. Environmental legitimacy	When activities of an organization are valued by shareholders, their suitability is measured. Indeed, the legitimacy of the organization is evaluated. Of a variety of legitimacy, environmental legitimacy indicated the general perceptions or a hypothesis that claims the performance and behavior of a desired organization are appropriate with the shareholders' expectations for environmental	[83, 84]

	sustainability.	
11. Providing significant cost advantages	The adoption of sustainable methods like environmental sustainability in information system has positive effect on the reduction of costs. For example, using Green IS has positive direct effect on the improvement of processes and it thus leads to the organization's reduced costs.	[7, 58, 72, 81, 85]
12. Volume of social investment	When an organization in investment process specifies the future social and environmental negative and positive effects in a precise financial analysis framework, it has considered social investment. In the other words, social investment is a strategy for investment that seeks to combine environmental benefits and advantages with financial return and it is created as the result of a relationship between investment and social, ethical, environmental and economic considerations.	[86, 87]

ISM steps are described below (Adopted from Jia et al., 2015)

Step 1: Factors (criteria) considered for the system under consideration are listed.

Step2: From factors identified in Step 1, a contextual relationship is established among factors to identify which pairs of factors should be examined.

Step 3: A structural self-interaction matrix (SSIM) is developed for factors, indicating pair-wise relationships among the factors of the system under consideration.

Step 4: Reachability matrix is developed from SSIM and the matrix is checked for transitivity. Transitivity of contextual relation is a basic assumption in ISM. It states that if variable A is related to B and B to C, then A is necessarily related to C.

Step 5: The reachability matrix obtained in Step 4 is partitioned into different levels.

Step 6: Based on the relationships stated in the reachability matrix, a directed graph is drawn and transitive links are removed.

Step7: The resultant digraph is converted into an ISM by replacing variable nodes with statements.

Step8: The ISM model developed in Step 7 is checked for conceptual inconsistency and necessary modifications are made. The above steps are shown in Fig. 1.

Questionnaire development

Twelve factors were considered to analyze the effective factors in Green IS adoption in health care centers. These factors were identified through the review of literature and theoretical principles. Then, these factors were evaluated and confirmed by scientific experts and experts in health care industry. These experts are from junior managers, executives, supervisors, and senior managers in health care area. To select experts, the concept of Green IS and eco-sustainability in health care industry and research goals were first explained for health care experts from 25 health care industries in the province of Kerman, Iran, by telephone, email, and face-to-face meeting. After continuous pursuits in health care centers and discussing with experts, 12 health care centers announced their interest in this research. More than 5 individuals from each health care center participated in the research process.

Data collection

The interpretive structural approach suggests the use of a variety of management techniques, such as brain storming and nominal techniques, to expand contextual relationship among variables. Therefore, two experts from each health care center and three scientific experts were consulted in order to identify the contextual relationship among the factors. A contextual relationship of "leads to" type was selected to analyze the factors. It means that a factor leads to another one. Accordingly, the contextual relationship between effective factors in adoption of Green ISs in health care centers was developed.

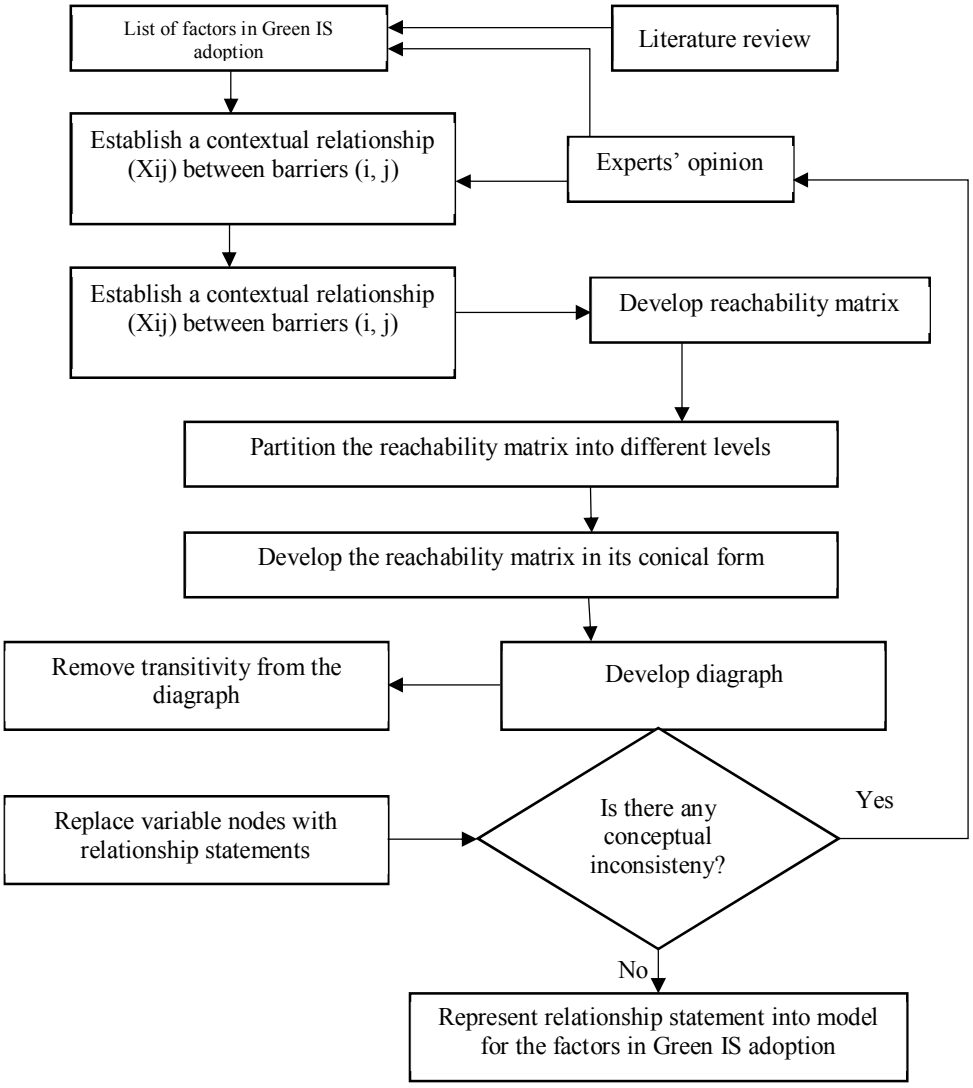

Fig. 1. Flow diagram for preparation of ISM model for Factors (modified from Jia et al., 2015)

A step-by-step procedure in ISM methodology (adopted from Jia et al., 2015):
Step1: Attributes for the system under consideration are listed.
Step2: Contextual relationship is established among attributes regarding which attributes pairs are to be examined.
Step3: A Structural Self-Interaction Matrix (SSIM) is developed for attributes, indicating pair-wise relationships among attributes of the system under consideration.

Structural self-interaction matrix (SSIM)
Keeping in mind the contextual relationship for each variable, the existence of a relation between any two factors (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the fctors (i and j):

V: Barrier i will help achieve factor j;
A: Barrier j will help achieve factor i;
X: Barrier i and j will help achieve each other;
O: Factors i and j are unrelated.
SSIM is shown in Table 2 for effective factors in adoption of green information systems in health care centers.

Initial reachability matrix
In this step, a reachability matrix is developed from SSIM. The SSIM format is converted into an initial reachability matrix format by transforming information from each SSIM cell into binary digits (i.e., ones or zeros). This transformation is done with the following rules:

- If the entry in the cell (i, j) in the SSIM is V, then the cell (i, j) entry becomes 1 and

the cell (j, i) entry becomes 0 in the initial reachability matrix.

- If the entry in the cell (i, j) in the SSIM is A, then the cell (i, j) entry becomes 0 and the cell (j, i) entry becomes 1 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is X, then the entries in both the cells (i, j) and (j, i) become 1 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is O, then the entries in both the cells (i, j) and (j, i) become 0 in the initial reachability matrix. Following these rules, the initial reachability matrix is given in Table 3.

The final reachability matrix for the Factors, as shown in Table 4, is obtained by incorporating the transitivities as enumerated in Step 4 of the ISM methodology. The final reachability matrix will then consist of some entries from the pair-wise comparisons and some inferred entries.

Level partitions

The reachability and antecedent set ("Developing Interconnection Matrices In Structural Modeling" 1974) for each barrier is obtained from the final reachability matrix. The reachability set for a particular variable consists of the variable itself and the other variables, which it may help achieve. The antecedent set consists of the variable itself and the other variables, which may help achieve them. Subsequently, the intersection of these sets is derived for all variables. The variable for which the reachability and the intersection sets are the same is given the top-level variable in the ISM hierarchy, which would not help achieve any other variable above their own level. After the identification of the top-level element, it is discarded from the other remaining variables. In this paper, 14 effective factors in adoption of green information systems in health care centers with their reachability set, antecedent set, intersection set, and levels are given in Table 5.

Tab. 2. Structural self-interaction matrix

Factors	12	11	10	9	8	7	6	5	4	3	2
1	A	A	V	A	A	V	X	V	A	A	O
2	A	V	V	X	A	O	O	X	X	A	
3	X	V	V	V	V	V	V	V	V		
4	A	V	V	X	A	X	O	V			
5	A	O	A	A	A	A	A				
6	A	V	V	A	A	A					
7	X	A	X	X	A						
8	X	V	V	V							
9	A	V	V								
10	A	A									
11	A										

Tab. 3. Initial reachability matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
F1	1	0	0	0	1	1	1	0	0	1	0	0
F2	0	1	0	1	1	0	0	0	1	1	1	0
F3	1	1	1	1	1	1	1	1	1	1	1	1
F4	1	1	0	1	1	0	1	0	1	1	1	0
F5	0	1	0	0	1	0	0	0	0	0	0	0
F6	1	0	0	0	1	1	0	0	0	1	1	0
F7	0	0	0	1	1	1	1	0	1	1	0	1
F8	1	1	0	1	1	1	1	1	1	1	1	1
F9	1	1	0	1	1	1	1	0	1	1	1	0
F10	0	0	0	0	1	0	1	0	0	1	0	0
F11	1	0	0	0	0	0	1	0	0	1	1	0
F12	1	1	1	1	1	1	1	1	1	1	1	1

Formation of ISM based model

From the final reachability matrix, the structural model is generated and is given in Fig 2. The relationship between factors j and i is shown by an arrow pointing from i to j. The resulting graph is called a digraph. By removing the transitivities as described in the ISM methodology, the digraph is finally converted into the ISM model.

Tab. 4. Final Reachability Matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
F1	1	*1	0	*1	1	1	1	0	*1	1	*1	*1
F2	*1	1	0	1	1	*1	*1	0	1	1	1	0
F3	1	1	1	1	1	1	1	1	1	1	1	1
F4	1	1	0	1	1	*1	1	0	1	1	1	*1
F5	0	1	0	*1	1	0	0	0	*1	*1	*1	0
F6	1	*1	0	0	1	1	*1	0	0	1	1	0
F7	*1	*1	*1	1	1	1	1	*1	1	1	*1	1
F8	1	1	*1	1	1	1	1	1	1	1	1	1
F9	1	1	0	1	1	1	1	0	1	1	1	*1
F10	0	*1	0	*1	1	*1	1	0	*1	1	0	*1
F11	1	0	0	*1	*1	*1	1	0	*1	1	1	*1
F12	1	1	1	1	1	1	1	1	1	1	1	1

Tab. 5. Level partition

Factors	Reachability set	Antecedent set	Intersection set	Iteration no. and level
F5	2 4 5 9 10 11	1 2 3 4 5 6 7 8 9 10 11 12	2 4 5 9 10 11	I
F10	2 4 5 6 7 9 10 12	1 2 3 4 5 6 7 8 9 10 11 12	2 4 5 6 7 9 10 12	I
F1	1 2 4 6 7 9 12	1 2 3 4 6 7 8 9 11 12	1 2 4 6 7 9 12	I I
F6	1 2 6 7 11	1 2 3 4 6 7 8 9 11 12	1 2 6 7 11	I I
F7	1 2 3 4 6 7 8 9 11 12	1 2 3 4 6 7 8 9 11 12	1 2 3 4 6 7 8 9 11 12	I I
F11	1 4 6 7 9 11 12	1 2 3 4 6 7 8 9 11 12	1 4 6 7 9 11 12	I I
F2	2 4 9	2 3 4 8 9 12	2 4 9	I II
F4	2 4 9 12	2 3 4 8 9 12	2 4 9 12	I II
F9	2 4 9 12	2 3 4 8 9 12	2 4 9 12	I II
F3	3 8 12	3 8 12	3 8 12	IV
F8	3 8 12	3 8 12	3 8 12	IV
F12	3 8 12	3 8 12	3 8 12	IV

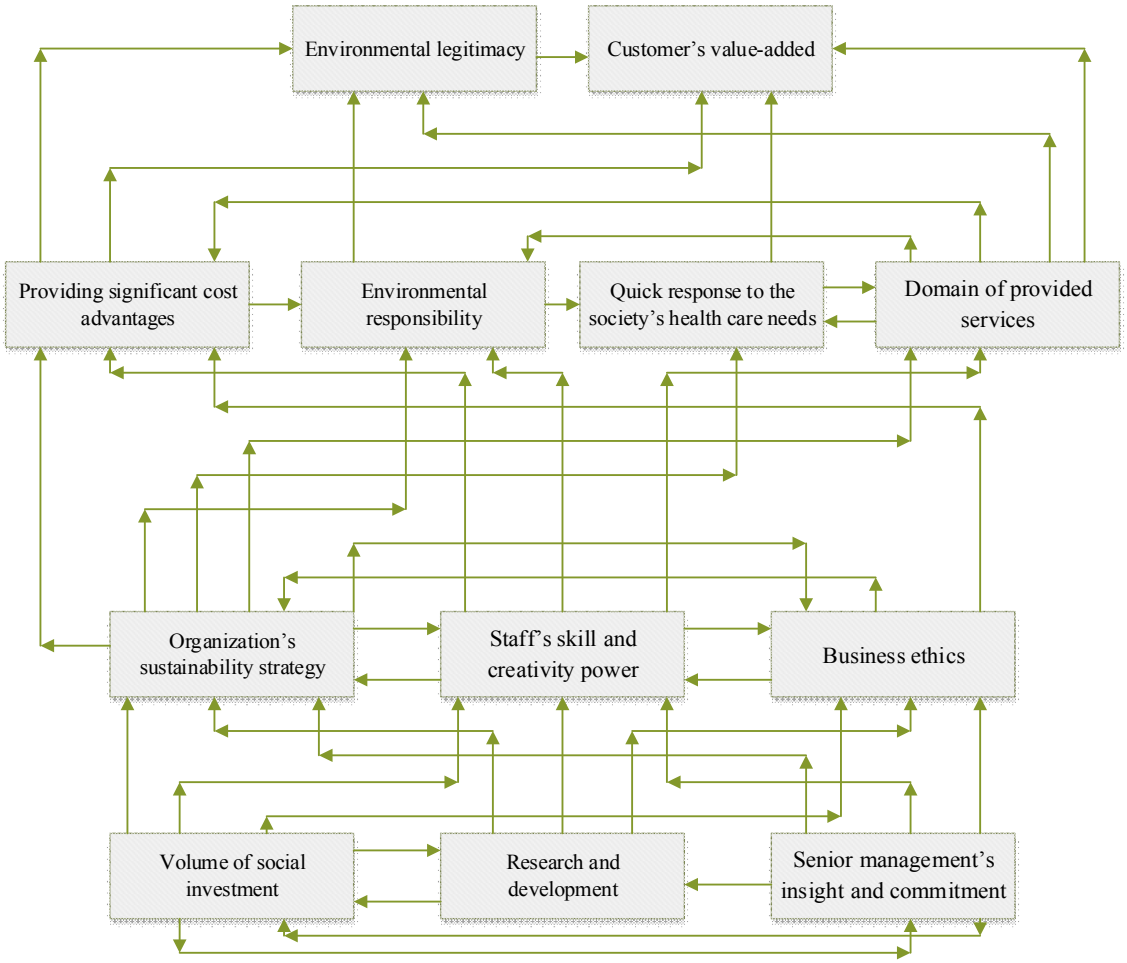

Fig. 2. ISM framework for effective factors in Green IS adoption in health care centers.

MICMAC analysis

Matrices Impacts 'Croises Multiplication Applique' and Classment (cross impact matrix multiplication applied to classification) is abbreviated as MICMAC. The MICMAC principle is based on the multiplication properties of matrices (Jia, Diabat & Mathiyazhagan, 2015). The purpose of MICMAC analysis is to analyze the driving power and dependence power of enablers. This is done to identify the key enablers that drive the system in various categories. Based on their drive power and dependence power, the enablers, in the present case, have been classified into four categories as follows (Mathiyazhagan et al., 2013):

1. Autonomous Quadrant: This Quadrant has weak driving power and weak dependence. They are relatively disconnected from the system, with which they have few links. The links may be very strong. This is represented in Quadrant-I.
2. Dependent Quadrant: This category includes enablers with weak driving power, but strong dependence power. They are placed in Quadrant-II.
3. Linkage Quadrant: These have strong driving power and dependence power and are placed in Quadrant-III. They are unstable and so taking action upon them will affect others and include a feedback effect on them
4. Independent Quadrant: These have strong driving power, but weak dependence power and are represented in Quadrant-IV. It is observed that a variable with a very strong driving power, called key variable, falls into the category of independent or linkage criteria. The driving power and dependence power of each of these factors are shown in Table 6. More details of the final full ISM model for the Factors are given in Fig. 3.

Tab. 6. Dependence power and drivingpower

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	Driving power
F1	1	*1	0	*1	1	1	1	0	*1	1	*1	*1	10
F2	*1	1	0	1	1	*1	*1	0	1	1	1	0	9
F3	1	1	1	1	1	1	1	1	1	1	1	1	12
F4	1	1	0	1	1	*1	1	0	1	1	1	*1	10
F5	0	1	0	*1	1	0	0	0	*1	*1	*1	0	6
F6	1	*1	0	0	1	1	*1	0	0	1	1	0	7
F7	*1	*1	*1	1	1	1	1	*1	1	1	*1	1	12
F8	1	1	*1	1	1	1	1	1	1	1	1	1	12
F9	1	1	0	1	1	1	1	0	1	1	1	*1	10
F10	0	*1	0	*1	1	*1	1	0	*1	1	0	*1	8
F11	1	0	0	*1	*1	*1	1	0	*1	1	1	*1	9
F12	1	1	1	1	1	1	1	1	1	1	1	1	12
Dependence power	10	11	4	11	12	11	11	4	11	12	11	9	

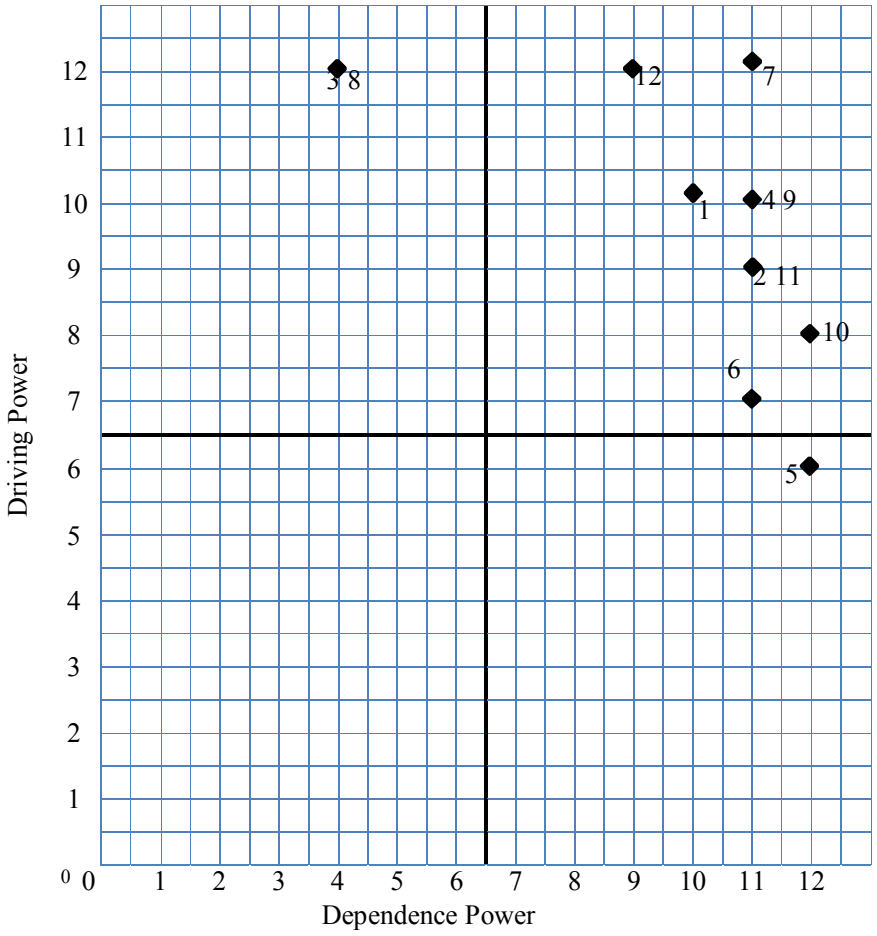

Fig. 3. MICMAC analysis

4. Results and Discussion

Despite the importance of Green ISs, organizations are still in infancy of responsiveness and Green ISs adoption. Therefore, identification of effective factors in Green ISs adoption helps organizations and their managers apply a clear roadmap in adoption of these kinds of systems. This article deals with identification and analysis of effective factors in adoption of Green ISs in health care centers. The

results are summarized in Figures 2 and 3. Figure 2 shows the interpretive structural models designed for twelve effective factors in Green IS adoption in health care centers. There are three levels in this model. Based on Table 6, the driving-dependence power diagram was drawn for each factor. This diagram is related to the MICMAC analysis through which the valuable insights in the relative importance and interdependencies are obtained among twelve effective factors in Green ISs adoption. The results and discussion of this study are summarized in four categories:

- There is not any autonomous factor (Quadrant-I): generally, the autonomous factors have weak driving and dependence power and do not affect the system a lot. The lack of such factors in autonomous quadrant shows that all identified factors for adoption of sustainable ISs in health care centers are of great importance.
- A dependent factor was identified (Quadrant-II): This kind of factors that comes after independent factors have high dependency and low penetration power. The only dependent factors in customer's value-added (F5) with penetration power (6) had the lowest penetration power among the factors affecting Green IS adoption. According to other studies, the customer's value-added is a factor in paying attention to customer's demands and leads to their satisfaction and loyalty as well as financial benefits [73]; hence, the adoption of a green information system leads to gaining financial benefits and customer satisfaction for healthcare centers.
- Nine linkage factors were identified (Quadrant- III); the identified factors in the linkage quadrant have relatively strong and almost the same driving and dependence power. The factor of a quick response to the society's healthcare needs (F6) has penetration power (7). With higher mobility and agility, healthcare centers are able to quickly respond to society's health care demands if requirements of environmental sustainability are also considered [23, 75]. The next factor that is placed in this quarter is the factor of environmental legitimacy (F10). Other research suggests that laws, exerting pressure by supply chain partners and other pressures, lead to the application of environmental initiatives that result in the environmental legitimacy [83, 84]. The use of green information system capacity is a method for creating the environmental legitimacy. For example, according to Chofreh et al. [22], precise and reliable information is necessary to achieve effective sustainability plans. However, organizations do not have the ability to access and manage data, information and sustainable processes. This shows bewilderment and inappropriateness between ISs and sustainability. Information systems, which facilitate sustainability designs, are necessary to solve these problems. This means that there is a correct relationship between stakeholders and organization in terms of sustainability, especially environmental sustainability. Another example is the use of capacity of Green ISs to reduce complexities of decision-making on environmental sustainability in relation to stakeholders [82]. The above-mentioned cases indicate that health centers can achieve the environmental legitimacy by adopting green information systems. Factors of business ethics (F2) and providing considerable cost advantage (F11) have the same penetration power. Both of these factors have penetration power equal to 9 and dependency power equal to 11. In a moral-oriented organization, it is possible to observe the correct work of system for shareholders out of the organization. The power is not used to achieve personal interests and or interest of any special group [58, 59]. In addition, some activities are carried out to maintain or create limitations in sharing information related to the patients [61]. The adoption of green information systems in health centers

creates transparency, anti-corruption and bribery, and finally ensuring the privacy of customers (patients). About factor (F11), other research studies show that healthcare centers are facing an increase in the cost pressures [2]. The adoption of green information systems is a useful solution for reduction of organizational costs. In other words, adoption of green information systems has positive effect on the reduction of costs, i.e., providing cost advantages [7, 81].

The factors of the range of provided services (F1), staff's power of creativity and skills (F4), and organization's sustainability strategy (F9) have the same penetration power (10). To provide services better in a health care center, it is critical to access different information [45, 55]. In addition, providing services with regard to the considerations of environmental sustainability and based on Green ISs enables health care centers to expand range of provision of services [10, 45].

About factor (F4), other research studies show that staff might suggest the adoption of green information system. They may also push the organization to adopt Green ISs [25, 67, 71]. These cases are due to the factors known as staff's power of creativity and skills that consider environmental sustainability. As previously mentioned, the last factor with the penetration power (10) is factor organization's sustainability strategy (F9). From the viewpoint of the Murugesan and Gangadharan [81], There is a need for information and technology systems to adopt green information systems. The evolution should be such that the alignment and integration are created between strategy related to ISs and sustainability strategy of the organization. The health care centers also need to align IS strategy with sustainability strategy of the organization that indicates the need for changes in organization's strategies for application of ISs.

Factors of environmental responsibility (F7) and volume of investment (F12) have penetration power (equal to 12), except that factor F7 has dependency power (equal to 11) and factor F12 has dependency power (equal to 12). In a research by Nascimento et al. [59], environmental responsibility has been recommended for sustainability of healthcare centers. The adoption of green information systems is a way for achieving the environmental responsibility [13, 66]. In this research, the environmental responsibility plays a role in adopting green information systems by health centers. Social investment volume is the last factor that should be taken into account in this section. Grade et al. [45] recommend investment in the field of sustainability, especially environmental sustainability of HISs. As it is clear, the amount of taking advantage from different benefits of environmental sustainability depends on the level of social investment, that is, all considerations should be taken both at present and in the future [33]. Health centers should increase the volume of social investment and consider the link between the investment and social considerations in information systems in order to achieve social benefits along with financial returns through the adoption of green information systems.

- There are two independent factors (Quadrant-IV): The factors of senior management's insight and commitment (F3) and research and development (F8) with influence power (12) and dependency power (4) have been placed in this quarter. In other words, these factors have the highest influence power and the lowest dependency power. The placement of these two factors at the fourth level of interpretive-structural model indicates that these two factors are considered as the fundamental components in Green IS adoption in health care centers.

In the field of senior managers' insight and commitment (F3), other studies indicate that changing business processes towards adopting innovations in green information systems makes different challenges for organizations; thus, senior managers' useful insight and commitment and support of these initiatives are important factors in adopting green information systems [25, 65, 66].

The managers who are interested in environmental issues of sustainability have great effect on Green IS adoption in organization and management of the next changes. In addition to behavioral characteristics, the level of senior management's understanding is also effective in the insight of senior managers to adopt Green ISs [19, 49]. The senior management's understanding indicates the sense of responsibility that management has against the environment. The last factor in Green ISs adoption in health care

centers is research and development (F8). Research and development lead to the creation of insight towards previous activities, effectiveness of those activities and future activities [88]. Therefore, Research and development expand storage of the organizational knowledge, and it is considered as a key factor in the organization's success. By research and development, the organization moves toward adopting new technologies [78]. Consideration of these two factors (senior managers' insight and commitment; research and development) indicates that the adoption of green information systems in health centers first requires the senior managers' commitment and development of the organizational knowledge about this field.

5. Conclusions

Health care centers as part of health care industry, in addition to their main activities, that is, providing high quality health care, can provide environmental and even social and economic advantages through reducing environmental consequences. In other words, health care centers that deal with the realization of environmental sustainability recognize the relationship between human health and environment and show this recognition through managing their strategy and operation. These types of health care industries link their needs with environmental measures. The role of Green ISs is inevitable considering their wide applications in environmental sustainability of health care centers. The health care centers with adoption of Green ISs realize moving toward environmental sustainability. In this research, the effective factors in Green ISs adoption were identified considering the importance of their adoption in health care centers.

The identification of factors was carried out through review of the literature. Since the relations between effective factors in ISs adoption are complex, a model was proposed to explain this complexity using an interpretive structural approach. By observing the proposed interpretive structural approach along with MICMAC analysis, the understanding of the complexity of relations between twelve factors becomes easier through their prioritization and classification of factors into four categories of independent, dependent, linkage and key independent. According to the results, the most important identified factors affecting Green ISs adoption in health care centers are respectively: volume of social investment, research and development along with the senior management's insight and commitment. Considering the proposed interpretive-structural model, these factors act as the components of the factors. In other words, to adopt green information systems in health care centers, it is necessary for these centers to focus on these factors.

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