Journal of Industrial and Systems Engineering
Vol. 11, No. 4, pp. 132-152
Autumn (November) 2018

JISE

Analysis of the barriers of implementing sustainable supply chain management in healthcare centers using interpretive structural modeling (ISM)

Hossein Sayyadi Tooranloo[1*], Sajad Rahimi[1]

Management Faculty, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran

h.sayyadi@vru.ac.ir, sajad.management@yahoo.com

Abstract

Regarding the sustainability considerations in the health care centers is critical to improve the quality of services, to decrease the costs and environmental issues. Of approaches that health care centers can use to achieve sustainability is sustainable supply chain management that improves environmental, social and economic effects of the organizations. In this research, after a review on the literature related to the sustainability in health care centers and sustainable supply chain management as well as interview with experts in these fields, 15 barriers of implementing sustainable supply chain management were determined in the health care centers. In addition, in another interview with experts, the relations and order of the importance of 15 identified barriers were determined according to interpretive structural modeling approach. The research results indicate that in addition to the Lack of an institutional support for integration, coordination and communication that is the most important barrier in implementing sustainable supply chain management in health care centers, the Lack of top management commitment to initiate sustainability efforts, the lack of knowledge among the members of supply chain, the lack of skilled human resources and Unawareness among society about social practices are also considered as other barriers in implementing sustainable supply chain management in the health care centers.

Keywords: Health care centers, sustainability, supply chain management, interpretive-structural modeling

1-Introduction

In recent years, organizations have improved their sustainable performance due to the increased environmental and social responsibility and to achieve their economic goals (Silvestre, Monteiro, Viana, & de Sousa-Filho, 2018). Sustainability as defined by the World Commission on Environment and Development (WCED, 1987) is the use of resources to meet needs of the present without comprising the ability of future generations to meet their own needs. (Barbosa-Póvoa, 2009). The first dimension, environmental dimension, is related to the rational use of natural resources and maximizing the positive environmental effects of providing products and services. The second dimension or economic dimension mentions to the profitability of organization and return on Capital.

*Corresponding author
ISSN: 1735-8272,

And finally, the third dimension, social dimension, indicates the policies towards social responsibility (Gaol, Hutagalung, Zakaria & Hasim, 2016). Improvement of the sustainable performance requires implementing sustainability in the supply chain management (Moktadir, Ali, Rajesh, & Paul, 2018). Health centers are not exceptions.

The supply chain management in the healthcare centers manages a flow of data, financial resources, goods and services (Yoon, Lee, & Schniederjans, 2016). However, there are many reasons why health centers should utilize the sustainability in their supply chain management (Balan & Conlon, 2018; Chen et al., 2013; Malik et al., 2016; Norazlan et al., 2014).

The first reason refers to environmental issues of health centers. The wastes of health care centers that are produced in various health care centers like hospitals, laboratories and etc. are considered as a serious threat for human health and environment, because there are dangerous toxic elements including pathological, medical, chemical and radioactive materials in the hospital wastes with a variety of other wastes. their collection, separation and excretion have special sensitivity in terms of environment and human health (Nemathaga, Maringa, & Chimuka, 2008; Patil & Pokhrel, 2005). For instance, an average of 6700 tons of waste is produced per day in the US health centers. 259 to 401 million dollars per year are spent for disposal of this volume of waste (Pasqualini Blass, da Costa, de Lima, & Borges, 2017). Another example was presented in a research by Karlsson et al. (2005). According to this study, a Swedish health center could consume 242,000 cubic meters of water, 37 GWh of energy per day, and 1,330 tons of biodegradable waste, 127 tons of industrial waste, 123 tons of hazardous waste, 164 tons of paper waste, and 14 tons of glass annually for 15,000 patients. Pasqualini Blass et al., (2016) believe that following the goals of environmental sustainability in healthcare centers not only reduces the environmental effects of their activities, but also it increases the quality of service delivery. How to dispose the hospital wastes in the procedure of supply chain is one of the important issues to reduce costs and to achieve environmental goals (Unger & Landis, 2016).

The second reason refers to social issues of health centers such as the social responsibility. (Gaol et al., 2016). the commitment of management to the values of the society and the commitment of the organization to the interests of customers, staffs and other stakeholders are called the social responsibility of the company (Ahi & Searcy, 2013). Lega et al., (2013) also mention to the importance of management activities in the area of health care and know their performance as a significant part in achieving to the social sustainability. With the review of 37 different studies they recognized that the sustainable performance of the health care system is related to the management methods, leadership, characteristics of the manager as well as management attitudes and approaches.

The final reason refers to economic problems of health centers. Health centers play major roles in macro health and medical policies in terms of economic sustainability. On the one hand, they are considered as organizations that need to make the effective use of their own resources; and on the other hand, they should provide medical service areas such as villages where are difficult to receive service. Therefore, the capacity of health centers was studied for providing long-term or sustainable financial status. (Augurzky, Engel, Schmidt, & Schwierz, 2012). Unger & Landis, (2016) also mention to the costs that are in the area of health care and state that the managers of this area are seeking opportunities, especially in the issue of supply chain, to increase their performance. In their study, they have investigated the effects of production and using sanitation and medical equipment on the environment through supply chain and have designed a model using the method of evaluating lifecycle that not only helps the health care centers to achieve environmental goals, but also it has positive effects on economic dimension.

Efforts of health centers at the sustainability are commendable, but these efforts are the beginning of a path to sustainability. The realization of sustainability in health centers requires a clear vision and practical plan (Podein & Hernke, 2010); hence, as noted above, the implementation of sustainable supply chain management is an important step to achieve sustainability in health centers. (Balan & Conlon, 2018; Chen et al., 2013; Malik et al., 2016; Norazlan et al., 2014). Because is a concept that realized the friendly behavior with environment in the traditional supply chain of companies (Diabat, Kannan & Mathiyazhagan, 2014). It is also known as a way of balancing short-term and long-term plans. The

applications respond to financial, economic, and environmental demands (Hassini, Surti, & Searcy, 2012; Slawinski & Bansal, 2011). According to Ahi & Searcy, (2013), sustainable supply chain management can be interpreted as follows: “Creating a coordinated supply chain considering the economic, social and environmental considerations through effective and efficient management of the initial material flow, data and stock that leads to the production of goods and services in order to meet demands of beneficiaries, to improve profitability, to obtain competitive advantage and to long term sustainability of the company.”

According to previous studies, the first step in implementing the sustainable supply chain management is to identify and analyze barriers. Jia et al. (2018) studied barriers to implementing sustainable supply chain management in different countries. Control and supervision of sustainability are inappropriate in Bangladesh. In China, there is a knowledge gap between senior government officials and lower-level officials about the sustainable supply chain management. Sustainability standards are not well implemented in South Africa and Indonesia. Official corruption often hinders the implementation of sustainable supply chain management in Brazil. Silvestre et al. (2017) studied the role of official corruption as an obstacle to the implementation of sustainable supply chain management. In this research, the corruption is known the "petty" and "grand" corruption.

Luthra & Haleem (2015) showed the relationship between barriers of implementing sustainable supply chain management in India automobile industry using hierarchal structural model. The results showed “Political instability” as the most important barrier in hierarchy of barriers and “Unawareness among society about social practices” in the lowest level of the hierarchy. Al Zaabi et al. (2013) also classified the barriers of implementing sustainable supply chain management in India industries in three levels that in the first level, “Too high cost for disposable of hazardous wastes”, in the second level “Inadequate industrial self-regulation” and in the third level “Complex in design to reduce consumption of resources and energy” are the most important barriers of each level. Morali & Searcy, (2012) in a review study recognized three important barriers in implementing sustainable supply chain management as required resources, lack of knowledge on the concept of sustainability and risk management and monitoring.

The introduction section presented the importance of implementing the sustainable supply chain management and identifying its barriers. Health centers move towards improving their service quality and achieving triple sustainability goals by implementing the sustainable supply chain management. However, none of previous studies have identified and modeled barriers to implementation of sustainable supply chain management in health centers (Balan & Conlon, 2018; Chen, Preston, & Xia, 2013; Malik, Abdallah, & Hussain, 2016; Norazlan et al., 2014). Due to the importance of identifying these barriers, the non-recognition and analysis of them will bring failure to implement the sustainable supply chain management (Moktadir et al., 2018; Silvestre et al., 2018). Accordingly, the present study aimed to identify and model barriers to the implementation of sustainable supply chain management in health centers. Based on this objective, the present study answered the following questions. What are the barriers to implementation of sustainable supply chain management in medical health? How are interpretative structural models of barriers to implementation of sustainable supply chain management in health centers?

The paper structure is as follows. The necessity, objectives and questions of research were presented in the introduction section. As mentioned, the research objective was to identify and model barriers to the implementation of sustainable supply chain management in health centers. So, In order to achieve the barriers on the implementation of sustainable supply chain management, the similar researches were firstly investigated and explored with library method and the barriers of implementing sustainable supply chain management were identified in health care centers and 15 cases were verified by experts. These barriers are shown in table 1. The identified barriers were analyzed using the Interpretive Structural Modeling (ISM); and results were finally discussed.

2- Research method

This research used interpretive structural modeling to identify the relations between 15 barriers identified in implementation of sustainable supply chain management in health care centers.

2-1- Interpretive structural modeling

Warfield in year 1947 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 (Warfield, 1974). Therefore, in the interpretive structural approach that is an interactive learning process, a set of elements or components are 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 (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013). In addition, the interpretive structural modeling is the best approach to solve the existing complexity in communications between different components (Jia, Diabat & Mathiyazhagan, 2015). Many studies have used interpretive structural modeling approach to explain the complexities of the relations between different components of the sustainable supply chain management, for example, in the researches related to the barriers of sustainable supply chain management (Al Zaabi et al., 2013; Luthra & Haleem, 2015). Analyzing the SSCM practices in the mining and mineral industry by ISM approach (Jia et al., 2015).
ISM steps are described below (Adopted from Al Zaabi et al., 2013):

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

Step 2: From Barriers identified instep1, a contextual relationship is established among Barriers to identify which pairs of Barriers should be examined.

Step 3: A structural self-interaction matrix (SSIM) is developed for Barriers, indicating pair-wise relationships among the Barriers 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 relationships stated in the reachability matrix, a directed graph is drawn and transitive links 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 figure 1.

Table 1. The barriers identified in implementation of sustainable supply chain management in health care centers

Barrier	Description	Relevant literature
1- Political instability	Indicated the lack of success of disciplinary framework and policies related to it in order to develop and expand the opportunities of sustainability in each country.	Borgonovi & Compagni, 2013; Luthra & Haleem, 2015; Agyemang et al 2018
2- Lack of sustainability standards and appropriate regulations	Regulations and standards of sustainability are frameworks within which organizations should work. These regulations and standards are imposed by the government and legislative institutions; hence, they are mandatory pressure of sustainability for organizations imposing from the outside.	Al Zaabi et al., 2013; Frondel, Horbach, & Rennings, 2008; Luthra & Haleem, 2015; Luthra, Mangla, Xu, & Diabat, 2016; Zhu & Geng, 2013; Moktadir et al 2018
3- Lack of top management commitment to initiate sustainability efforts	The top management commitment refers to an extent to which a top manager is interested in the sustainability and is willing to implement the sustainable supply chain management.	Al Zaabi et al., 2013; Bacudio et al., 2016; Jayant & Azhar, 2014; Luthra & Haleem, 2015; Luthra et al., 2016; Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013; Zhu & Geng, 2013; Mathiyazhagan et al., 2017
4- Organizational culture resistance to change	The culture of resistance to changes indicates the inappropriate and ineffective communication between staff, institutional roles, internal policies, etc. Culture of resistance may be caused by the individual nature. People have numerous reasons to work with previous methods and roles.	Bacudio et al., 2016; Luthra & Haleem, 2015; Meath, Linnenluecke, & Griffiths, 2016; Moktadir et al 2018
5- Lack of IT implementation	Non-use of information and communication technology for the economic growth and increasing the social responsibility. These technologies indicate environmental effects of organizational activities in a supply chain.	Al Zaabi et al., 2013; Garde et al., 2007; Jayant & Azhar, 2014; Kimaro & Nhampossa, 2007; Mathiyazhagan et al., 2017
6- Lack of collection and analysis for data of material/energy flow	Lack of collected and analyzed data from the flow of materials and energy leading to energy saving and reduced pollution.	Luthra, Kumar, Garg, & Haleem, 2015; Zhu & Geng, 2013
7- Lack of technology and infrastructure readiness	Lack of technologies that control environmental pollution and increase the resource recovery.	Garde et al., 2007; Luthra et al., 2015; Mathiyazhagan et al., 2013; Moktadir et al 2018
8- lack of skilled human resources	Lack of expertise and experience that people of the organization should have in the field of sustainability, especially environmental sustainability.	Luthra et al., 2016; Mathiyazhagan et al., 2013; Morali & Searcy, 2013; Zhu & Geng, 2013; Mathiyazhagan et al., 2017, Dubey et al., 2017
9- Lack of knowledge among SC members	Lack of knowledge about the sustainability of supply chain members encourages organizations to maintain the status quo. In other words, it emphasizes on maintaining current relationships among members of a chain. This prevents achievement of sustainable supply chain management and does not increase the sustainability level.	Jayant & Azhar, 2014; Luthra & Haleem, 2015; Morali & Searcy, 2013; Moktadir et al 2018
10- Lack of an institutional support for integration, coordination and communication	This barrier indicated an incompetent management of a symbiosis network that avoids its development. The incompetent management that occurs in the unequal distribution of interests and resources	Bacudio et al., 2016; Carter & Rogers, 2008
11- Unawareness among society about social practices	indicates the role of non-governmental organizations (NGOs) and groups supporting the environment that should seriously think about sustainability issues and problems through establishing campaigns	Hba et al., 2016; Luthra & Haleem, 2015
12- Lack of trust among SC members	The collaboration is one of the key elements of sustainable supply chain management that in one hand, it has an important role in the supply chain management to increase competitive advantage and on the other hand, it is considered as a key element to increase the performance of organizations in the field of sustainability. What prevents the occurrence of collaboration between the members of supply chain is the lack of trust that finally avoids the entrance of sustainability to the sustainable supply chain management	Bacudio et al., 2016; Luthra & Haleem, 2015, Beske & Seuring, 2014
13- Lack of knowledge among stakeholders about sustainable products and sustainability	Lack of green/sustainable knowledge among stakeholders about the sustainability products and service that meet basic needs. These products and service provide better quality of life, have less pollution, and meet future needs.	Luthra et al., 2016; Podein & Hernke, 2010
14- Lack of government support to adopt environmental friendly policies	The sustainable supply chain management implementation, especially in terms of environmental aspect, requires high investment. However, the return on investment is very low in the short term. The government support is possible through the allocation of credit or special funds in this field. Lack of appropriate policies and financial support at macro levels of health centers to achieve environmental sustainability hinder the sustainable supply chain management implementation.	Mathiyazhagan et al., 2013; Mathiyazhagan et al., 2017; Agyemang et al 2018
15- lack of support from patients	Lack of customers' (patients) awareness and demand for receiving sustainable service leads to the indifference about the sustainability.	Luthra & Haleem, 2015; Luthra et al., 2015; Luthra et al., 2016; Mathiyazhagan et al., 2013; Agyemang et al 2018;

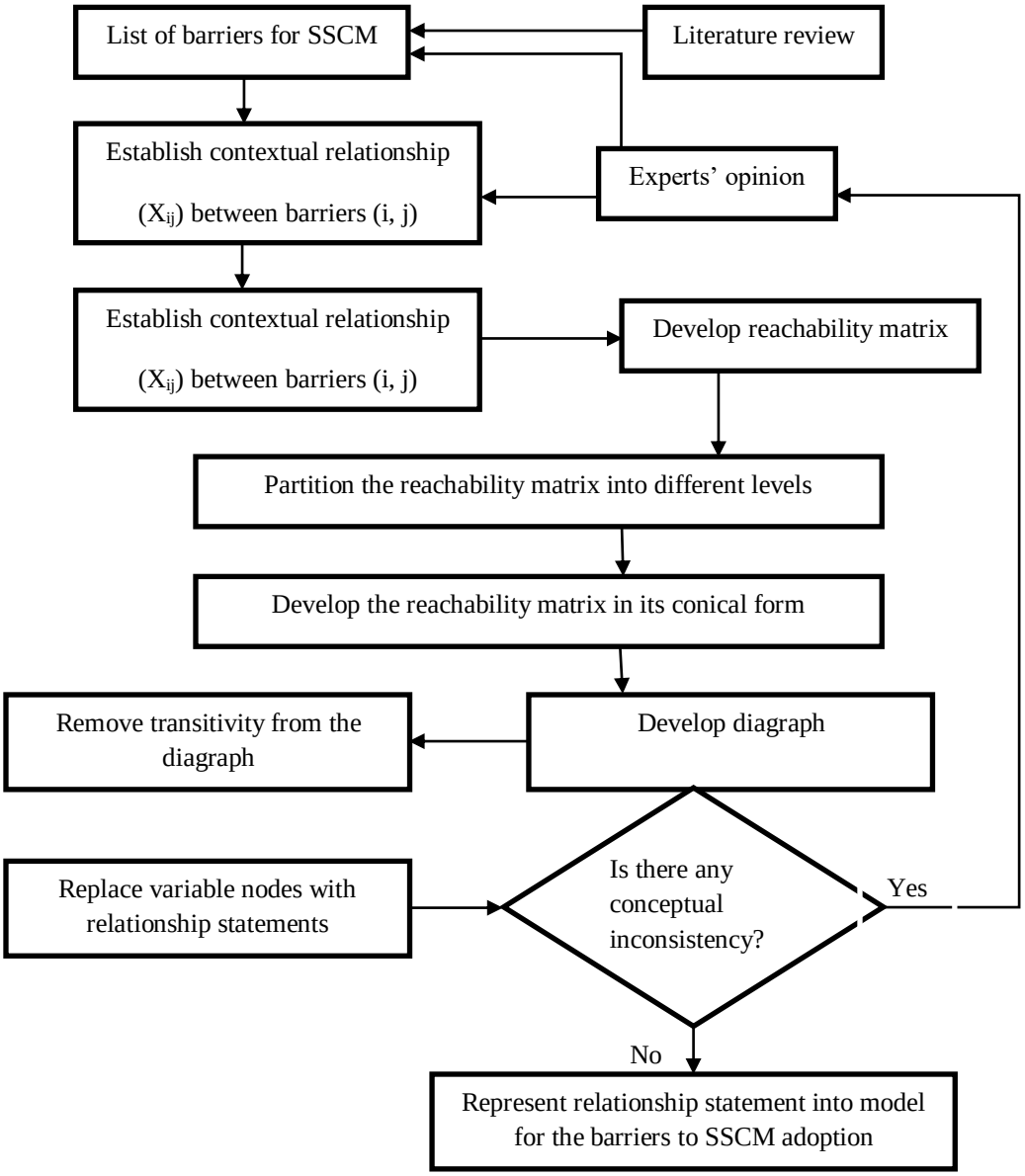

Fig. 1. Flow diagram for preparing the ISM model for barriers
(modified from Jia et al., 2015, and Al Zaabi, Al Dhaheri & Diabat, 2013)

2-2- Data collection

In the present study, the set of barriers to sustainable supply chain management was first identified based on theoretical principles and similar studies. A preliminary questionnaire was then designed based on identified barriers and distributed among 45 health and medical experts. This number of experts was identified by snowball sampling method. A total of 14 questionnaires were returned according to the researcher follow-up. Based on results of this questionnaire, 15 components were finally identified as barriers to sustainable supply chain management in health centers (table 1). After identifying and finalizing barriers to implementation of sustainable supply chain management in health centers, the Interpretative Structural Modeling (ISM) questionnaire was designed based on identified barriers, and

then distributed among experts. In this phase, 12 out of 45 distributed questionnaires were returned. Respondents biographic structures were as follows: 9 males and 3 females; 3 respondents with bachelor and 9 ones with master's degree; 3 ones with work experience of 5-10 years, 3 ones with a work experience of 11- 15 years; and 6 ones with a work experience of more than 16 years. Self-Interaction Matrix of barriers was formed by collecting ISM questionnaires and reviewing responses based on frequency of responses. A group judgment is made when all respondents' answers are integrated. A textual relationship with "leads to" type was selected for analyzing barriers meaning that a barrier leads to another barrier. Accordingly, a textual relationship was developed between barriers to the implementation of sustainable supply chain management in health centers.
Step-by-step procedure in ISM methodology (adopted from Jia et al., 2015):

Step 1: Attributes for the system under consideration are listed.

Step 2: Contextual relationship is established among attributes regarding which attributes pairs are to be examined.

Step 3: A Structural Self-Interaction Matrix (SSIM) is developed for attributes, indicating pair-wise relationships among attributes of the system under consideration.

2-3- Structural self-interaction matrix (SSIM)

Keeping in mind the contextual relationship for each variable, the existence of a relation between any two barriers (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the barriers (i and j):
V: Barrier i will help achieves barrier j;
A: Barrier j will help achieve barrier i;
X: Barrier i and j will help achieve each other; and
O: Barriers i and j are unrelated.
The SSIM for the barriers in the implementation of sustainable supply chain is given in Table 2.

2-4-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 barriers, shown in table 4, is obtained by incorporating the transitivity's 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.

2-5-Level partitions

The reachability and antecedent set (Warfield, 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 in achieving 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 study, the 15 barriers, along with their reachability set, antecedent set, intersection set and levels, are presented in table 5.

3-Formation of ISM based model

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

Table 2. Structural self-interaction matrix

Barriers	15	14	13	12	11	10	9	8	7	6	5	4	3	2
1	V	A	A	V	O	A	A	A	O	O	V	V	A	A
2	O	X	O	V	A	A	V	A	V	V	A	O	V	
3	V	A	V	V	O	A	A	X	A	X	V	V		
4	A	A	A	V	A	A	A	A	O	O	V			
5	V	V	A	V	V	A	A	A	A	V				
6	O	A	A	A	O	O	A	O	A					
7	V	O	A	A	A	A	A	V						
8	V	A	V	V	A	A	V							
9	V	O	V	V	A	O								
10	V	V	V	V	V									
11	V	V	V	O										
12	O	V	A											
13	A	V												
14	V													

Table 3. Initial reachability matrix

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	0	0	1	1	0	0	0	0	0	0	1	0	0	1
2	1	1	1	0	0	1	1	0	1	0	0	1	0	1	0
3	1	0	1	1	1	1	0	1	0	0	0	1	1	0	1
4	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
5	0	1	0	0	1	1	0	0	0	0	1	1	0	1	1
6	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
7	0	0	1	0	1	1	1	1	0	0	0	0	0	0	1
8	1	1	1	1	1	0	0	1	1	0	0	1	1	0	1
9	1	0	1	1	1	1	1	0	1	0	0	1	1	0	1
10	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1
11	0	1	0	1	0	0	1	1	1	0	1	0	1	1	1
12	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0
13	1	0	0	1	1	1	1	0	0	0	0	1	1	1	0
14	1	1	1	1	0	1	0	1	0	0	0	0	0	1	1
15	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1

3-1-MICMAC analysis

Matriced Impacts ‘croises-multipication 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 et al., 2015).

Table 4. Final Reachability Matrix

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
3	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
4	0	1	0	1	1	1	1	0	0	0	1	1	0	1	1
5	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
6	1	0	1	1	1	1	0	1	0	0	0	1	1	0	1
7	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
12	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1
13	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
15	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1

Table 5. Level partition

Barriers	Reachability set	Antecedent set	Intersection set	Iteration no. and level
4	2 4 5 6 7 11 12 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	2 4 5 6 7 11 12 14 15	I
5	1 2 3 4 5 6 7 8 9 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 11 12 13 14 15	I
6	1 3 4 5 6 8 12 13 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 3 4 5 6 8 12 13 15	I
12	1 2 3 4 5 6 7 8 12 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 2 3 4 5 6 7 8 12 14 15	I
15	1 4 5 6 7 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 4 5 6 7 12 13 14 15	I
1	1 2 7 11 13 14	1 2 3 7 8 9 10 11 13 14	1 2 7 11 13 14	II
2	1 2 3 7 8 13 14	1 2 3 7 8 9 10 11 13 14	1 2 3 7 8 13 14	II
7	1 2 3 7 8 9 11 13 14	1 2 3 7 8 9 10 11 13 14	1 2 3 7 8 9 11 13 14	II
13	1 2 3 7 8 11 14	1 2 3 7 8 9 10 11 13 14	1 2 3 7 8 11 14	II
14	1 2 3 7 8 9 13 14	1 2 3 5 7 8 9 10 11 13 14	1 2 3 7 8 9 13 14	II
3	3 8 9 11	3 8 9 10 11	3 8 9 11	III
8	3 8 9 11	3 8 9 10 11	3 8 9 11	III
9	3 8 9 11	3 8 9 10 11	3 8 9 11	III
11	3 8 9 11	3 8 9 10 11	3 8 9 11	III
10	10	10	10	IV

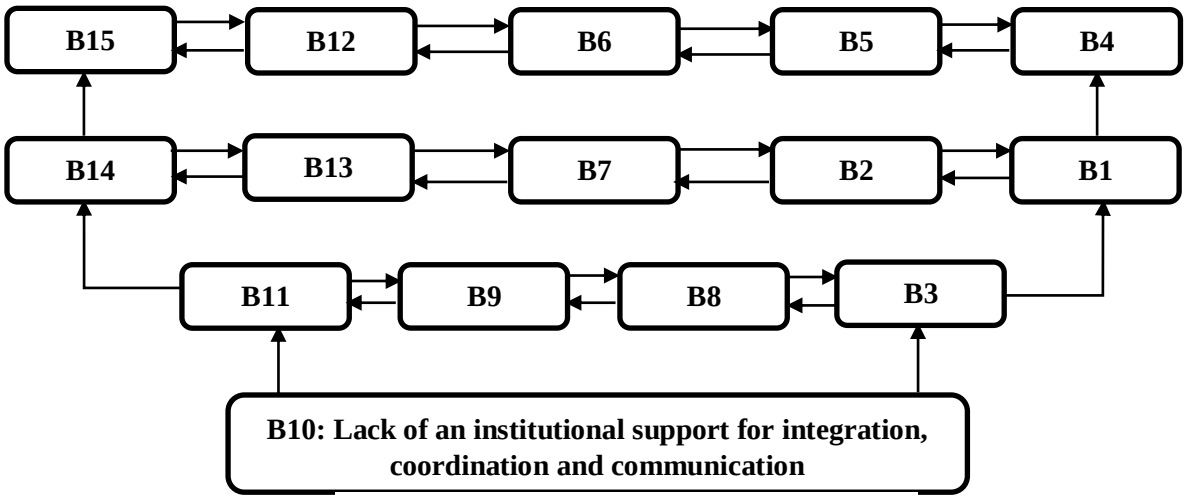

Fig. 2. ISM formation for barriers of SSCM

The purpose of MICMAC analysis is to analyze the drive 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):

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.

1. Dependent Quadrant: This category includes enablers which have weak driving power, but strong dependence power. They are placed in Quadrant-II.
2. Linkage Quadrant: These have strong driving power and dependence power and are placed in Quadrant-III. They are unstable and so action on them will affect others and include a feedback effect on them.
3. Independent Quadrant: These have strong driving power but weak dependence power and are represented in Quadrant-IV.

It can be observed that a variable with a very strong driving power, called key variable, falls into the category of independent or linkage criteria. The driver power and dependence power of each of these barriers is shown in Table 6. More details of the final full ISM model for the barriers are given in Fig. 3.

Table 6. Dependence power and driving power

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Driving power
1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	11
2	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	13
3	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	14
4	0	1	0	1	1	1	1	0	0	0	1	1	0	1	1	9
5	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	14
6	1	0	1	1	1	1	0	1	0	0	0	1	1	0	1	9
7	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	14
8	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	14
9	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	14
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
11	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	14
12	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	11
13	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	13
14	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	13
15	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	9
Dependence power	14	13	12	15	15	15	14	12	9	1	11	15	13	14	15	

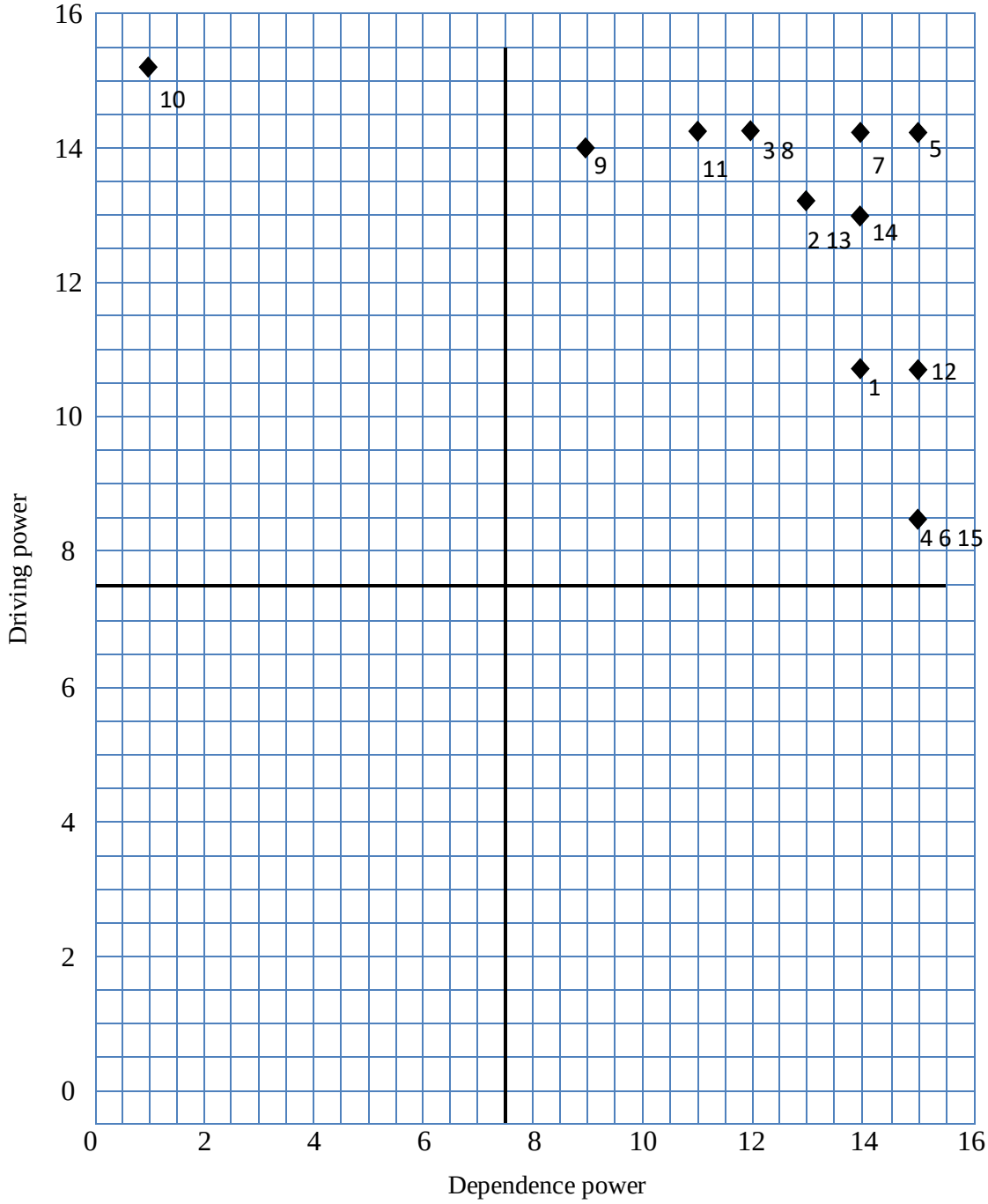

Fig. 3. Driving Power and Dependence Power diagram

4-Results

Considering the importance of the supply chain management in the health care centers and the importance of sustainability in these centers, this research tried to study the barriers of implementing sustainable supply chain management in the health care centers. The relation of 15 identified barriers was explained using interpretive structural modeling. This analysis helps to implement the sustainable supply

chain management in the health care centers through identification of important barriers. Moreover, with obtaining the driving power and dependence power through MICMAC analysis, an attitude is developed about the relative importance and dependency of these barriers. Some of the main findings of this study are summarized here:

- There are not any independent barriers (Quadrant-I). The independent barriers have poor driving power and dependence power and do not affect the system a lot. Such barriers in this research show that all identified barriers are important.
- The dependent barriers do not also exist in this research (Quadrant-II). This class of barriers that are after independent barriers have high dependence power and little driving power.
- Fourteen barriers were identified as the linkage barriers (Quadrant-III). The barrier Lack of knowledge among SC members (B9) is the dominant one after barrier Lack of an institutional support for integration, coordination and communication (B10) because it has the driving power of 14 and the dependence power of 9. Morali & Searcy., (2012) recognizes the need to the human and financial resources and not understanding the concept of sustainability as the barriers to realize the sustainable supply chain management. Therefore, on one hand, Lack of knowledge among SC members (B9) (Luthra & Haleem, 2015) and On the other hand the lack of skilled human resources (B8) (Mathiyazhagan et al., 2013) prevents the implementation of sustainable supply chain management. The lack of skilled human resources like barrier B9 has driving power of 14, but its dependence power is 12. Health centers need to attract human resources, who are familiar with sustainability and its importance, in order to facilitate the implementation of sustainable supply chain management. They also need to deal with supply chain members in a sustainable way to facilitate sustainability changes throughout a supply chain.

The other barriers that have the driving power of 14 include B5, B7, B3 and B11. The Unawareness among society about social practices (B11) that has the dependence power of 11. the importance of the role of non-governmental organizations (NGOs) in creating tendency towards implementing sustainable supply chain management is undeniable (Morali & Searcy, 2012). Luthra et al. (2015) and Moktadir et al. (2018) also pointed out this barrier to the implementation of sustainable supply chain management. According to Agyemang et al. (2018), non-governmental organizations (NGOs) should cooperate in the implementation of sustainable supply chain management; hence, a framework should be created in the society and especially by these organizations in order to play the social responsibility role in the supply chain management of health centers.

Considering the correlation existing between the performance of management and sustainability, the role of management is also undeniable in realization of sustainability, especially in the health care area (Lega et al., 2013). Of the barriers for implementing sustainable supply chain management is the Lack of top management commitment to initiate sustainability efforts (B3) (Al Zaabi et al., 2013). In this research, B3 has the dependence power of 12. In the other research like the research carried out by Luthra & Haleem., (2015) in the field of implementing sustainable supply chain management or the research by Bacudio et al., (2016) in the field of industrial symbiosis has mentioned to the lack of the support of senior managers. Mathiyazhagan et al. (2017) also pointed out the key importance of senior managers' roles. Senior managers of health centers should allocate resources to implement the sustainable supply chain management. Senior managers of health centers should know technical and scientific advances of the sustainable supply chain management.

In this research considers the lack of the use of information technology with the dependence power of 15 along with the lack of technology and infrastructure preparation (B7) with the dependence power of 14 as the barriers of implementing sustainable supply chain management in the health care centers.

About the barriers to the use of information technology (B5), it should be noted that the barrier namely the "non-use of information technology capacities" faces a number of challenges in providing sustainable services in health centers. These challenges are particularly evident in developing countries (Kimaro & Nhampossa, 2007). For the barrier namely the lack of technology and infrastructural readiness (B7), old

infrastructures hinder the implementation of green technologies (Luthra, Kumar, Garg & Haleem, 2015), and consequently, the implementation of sustainable supply chain management will become difficult (Mathiyazhagan et al., 2013). Therefore, health centers need to define and develop technologies and infrastructures that can be updated along with knowledge changes. Furthermore, they should be easily changed when technological advances are made and readily be adapted to changing business requirements and processes. (Garde et al., 2007).

The barriers B14, B13 and B2 have the driving power of 13. The barriers B13 and B2 are considered as the similar barriers, because in addition to the same driving power and dependence power of 13, they have been placed in Level partitions to each other. Luthra et al. (2016) also pointed out the lack of knowledge among stakeholders about sustainable products and service (B13) leading to hindered sustainable production and consumption. Stakeholders' current and future needs should be considered in the provision of healthcare services.

The B2 that is the Lack of sustainability standards and appropriate regulations prevents the implementation of sustainable supply chain management (Al Zaabi et al., 2013). The standards and rules should be usually provided by legislator entities of the society, but the Lack of government support to adopt environmental friendly policies (B14) not only prevents the realization of environmental sustainability (Mathiyazhagan et al., 2013), but also it prevents the implementation of supply chain management in the health care centers..

The government and other relevant institutions should adopt laws and standards about the sustainability, especially the environmental sustainability. They should also provide infrastructures for their operation. In countries such as China, there is a greater flexibility in legal requirements for the environmental sustainability (Zhu & Geng, 2013). The experience of some developed countries such as Germany indicates that strict rules for the environment lead to the implementation of effective environmental management practices (Frondel, Horbach & Rennings, 2008). In the present study, the barrier B2 avoids the realization of sustainable supply chain management in health centers. Therefore, legislative institutes of society, especially the government, should impose laws and standards and monitor their implementation in order to implement sustainable supply chain management in health centers.

Of the barriers that have little importance for the implementation of sustainable supply chain management in the health care centers are the barrier political instability (B1) with the driving power of 11 and dependence power of 14, and barrier B12 with the driving power of 11 and dependence power of 15. The realization of political sustainability in the health care area requires that the political forces move towards the coordination and identification of convergence points in order to enhance health, hygiene and care in the society. In addition, the way of political sustainability may be paved through opportunities that the government creates to develop consensus both between different parties and government layers (Borgonovi & Compagni, 2013).

The barrier to cooperation is a key sustainable supply chain management category that on the one hand plays an important role in the supply chain management to increase competitive advantages, and on the other hand, is a key in increasing the performance of organizations in terms of sustainability. The distrust prevents the cooperation of supply chain members and it ultimately prevents the sustainability from entering into a sustainable supply chain management; hence, the lack of trust among supply chain members (B12) is a barrier to the implementation of sustainable supply chain management. Agyemanga et al. (2018) pointed out that the level of trust should increase among supply chain members. Members can rely on benefits of their operations in a supply chain after increasing the trust. In the present study, the "distrust" barrier prevents the cooperation in the supply chain management of health centers.

The least important barriers that have little driving power and are heavily dependent (dependence power of 15), are barriers of B6, B4 and B15. These barriers are placed in in ranking beside each other in the same level. The implementation of sustainable supply chain management requires numerous changes throughout the organization; therefore the cooperation of staffs in the sustainability is considered as a serious challenge (Dubey et al., 2016). In addition, the Organizational culture resistance to change (B4) is considered as the major barrier to achieve environmental sustainability in the supply chain management

(Jayant & Azhar, 2014). Luthra & Haleem (2015) also considered this barrier among barriers to the implementation of sustainable supply chain management. Health centers need to motivate employees to accept changes in the implementation of sustainable supply chain management.

Zhu and Geng., (2013) in the explanation of factors and barriers effective on the better performance of supply chain in the organizations in order to realize ESER program (energy saving and reducing the pollution), mention to Lack of collection and analysis for data of material/energy flow (B6). In this research, health centers should also improve planning to achieve environmental goals in a supply chain through information analysis of material and energy flow.

At last, in this research, the last barrier is the lack of support from patients (B15) that has the highest level of dependency. The unwillingness of customers towards ways of sustainability has been mentioned in the explanation of the barriers on the realization of sustainable production and consumption (Luthra et al., 2016). The lack of the support from customers is also one of the barriers of implementing sustainable supply chain management (Luthra & Haleem, 2015).

- The only key barrier that is placed in the (Quadrant-IV) is the Lack of an institutional support for integration, coordination and communication (B10) that is considered as the most important barrier of implementing sustainable supply chain management in the health care centers. The institutional barriers in addition to industry symbiosis are also important in the realization of environmental dimension of sustainability in the supply chain management. Because there is disagreement between policy makers when determining strategy and goal and on the other hand, there is the need to the structural preparation for implementation (Li et al., 2015). Craig and et al., (2008) also mention to the importance of institutional norms in the adjustment of a framework for sustainable supply chain management. They believe that procedures, structures and even institutional forms change due to the environmental issues. Similarly, the structures of supply chain will be changed as the consequence of these changes. If an institutional support does not occur, these changes will not have any outcome other than defeat.

5- Discussion and conclusions

The issues and problems of sustainability in different organizations, especially sustainability in the supply chain management, have become increasingly important. The health care centers are no exemption and should move towards its implementation in their activities due to the various advantages and reasons that is the consideration of sustainable supply chain management. In this research, considering the complexity of the issue of sustainable supply chain management, it was tried to design a conceptual analysis in order to identify the relations of the barriers of implementing sustainable supply chain management using the ideas of experts in the health care centers. The research model was designed using the interpretive structural modeling that is an appropriate approach to recognize the complex relations of the members of a system. The results of this research have significant contributions in the implementation of sustainable supply chain management in the health care centers, because identification of the barriers and understanding relations between them is the first level of implementation of sustainable supply chain management in the health care centers. The attempts to implement sustainable supply chain management in the health care centers will be failed without attention to these barriers. Therefore, using this approach creates a proper space to decision making about this issue both for managers of the health care centers and other beneficiaries. These results indicate the application of research knowledge for managers and decision makers in health centers.

The 15 identified barriers are placed in level 4 in the ranking and there is no barrier in the first and second quarter in MICMAC analysis. This means that all identified barriers have relative importance. The lack of institutional support for coordination of communications and integration is in the fourth level of the barriers that is the infrastructure of the research model. Also, in level three there are four barriers namely the lack of commitment of senior management for initial attempts of sustainability, the lack of knowledge among the members of supply chain, the lack of expert human resources and unawareness of

society about social ways. These barriers along with barrier 10 (B10) are of the most important barriers in implementing sustainable supply chain management in the health care centers considering the ranking, driving power and dependency.

These important identified barriers show that all beneficiaries should collaborate and have coordination in order to implement sustainable supply chain management, since on one hand, the importance of management role in barriers B10 and B3 have been shown and on the other hand, it is mentioned to the expertise and knowledge of staffs in the field of sustainability in B8 and finally, it determines the importance of society attention (B11) in implementing sustainable supply chain management. In addition to these cases, considering the results of MICMAC analysis indicated the proximity of other barriers to these barriers and any change in each of these barriers affects the other barriers, too. These results explain practical uses of the obtained model. Health centers should, in the first step, work on low levels of model according to power of influence and dependence of each barrier to eliminate barriers.

For future research, researchers are suggested applying the presented components of study at other time and places to test the generalizability of tools in the present research. They are also suggested examining the relevance and prioritization of barriers by other methods.

References

Agyemang, M., Zhu, Q., Adzanyo, M., Antarciuc, E., & Zhao, S. (2018). Evaluating barriers to green supply chain redesign and implementation of related practices in the West Africa cashew industry. *Resources, Conservation and Recycling*, 136, 209-222. https://doi.org/10.1016/j.resconrec.2018.04.011

Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production*, 52, 329-341. https://doi.org/10.1016/j.jclepro.2013.02.018

Al Zaabi, S., Al Dhaheri, N., & Diabat, A. (2013). Analysis of interaction between the barriers for the implementation of sustainable supply chain management. *The International Journal of Advanced Manufacturing Technology*, 68(1-4), 895-905. https://doi.org/10.1007/s00170-013-4951-8

Augurzky, B., Engel, D., Schmidt, C. M., & Schwierz, C. (2012). Ownership and Financial Sustainability of German Acute Care Hospitals. *Health Economics*, 21(7), 811-824. https://doi.org/10.1002/hec.1750

Bacudio, L. R., Benjamin, M. F. D., Eusebio, R. C. P., Holaysan, S. A. K., Promentilla, M. A. B., Yu, K. D. S., & Aviso, K. B. (2016). Analyzing barriers to implementing industrial symbiosis networks using DEMATEL. *Sustainable Production and Consumption*, 7, 57-65. https://doi.org/10.1016/j.spc.2016.03.001

Beske, P., & Seuring, S. (2014). Putting sustainability into supply chain management. Supply Chain Management: An International Journal, 19(3), 322-331. https://doi.org/10.1108/SCM-12-2013-0432

Balan, S., & Conlon, S. (2018). Text Analysis of Green Supply Chain Practices in Healthcare. *Journal of Computer Information Systems*, 58 (1), 30-38. https://doi.org/10.1080/08874417.2016.1180654

Barbosa-Póvoa, A. P. (2009). Sustainable Supply Chains: Key Challenges. *Computer Aided Chemical Engineering*, 27, 127-132. Elsevier. https://doi.org/10.1016/S1570-7946(09)70242-1

Borgonovi, E., & Compagni, A. (2013). Sustaining Universal Health Coverage: The Interaction of Social, Political, and Economic Sustainability. *Value in Health*, 16(1), S34-S38. https://doi.org/10.1016/j.jval.2012.10.006

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International journal of physical distribution & logistics management*, 38(5), 360–387.

Chen, D. Q., Preston, D. S., & Xia, W. (2013). Enhancing hospital supply chain performance: A relational view and empirical test. *Journal of Operations Management*, 31(6), 391-408. https://doi.org/10.1016/j.jom.2013.07.012

Diabat, A., Kannan, D., & Mathiyazhagan, K. (2014). Analysis of enablers for implementation of sustainable supply chain management – A textile case. *Journal of Cleaner Production*, 83, 391-403. https://doi.org/10.1016/j.jclepro.2014.06.081

Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017). Sustainable supply chain management: framework and further research directions. *Journal of Cleaner Production*, 142(2), 1119-1130. https://doi.org/10.1016/j.jclepro.2016.03.117

Frondel, M., Horbach, J., & Rennings, K. (2008). What triggers environmental management and innovation? Empirical evidence for Germany. *Ecological Economics*, 66(1), 153-160. https://doi.org/10.1016/j.ecolecon.2007.08.016

Gaol, F., Hutagalung, F., Zakaria, A., & Hasim, Z. (2016). *Knowledge, Service, Tourism & Hospitality*. CRC Press. https://doi.org/10.1201/b21184

Garde, S., Hullin, C. M., Chen, R., Schuler, T., Granz, J., Knaup, P., & Hovenga, E. J. (2007). Towards Sustainability of Health Information Systems: How Can We Define, Measure and Achieve It? *Medinfo 2007: Proceedings of the 12th World Congress on Health (Medical) Informatics; Building Sustainable Health Systems*, 1179.

Hassini, E., Surti, C., & Searcy, C. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics*, 140(1), 69-82. https://doi.org/10.1016/j.ijpe.2012.01.042

Hba, R., Bakkas, A., Manouar, A. E., & Idrissi, M. A. J. (2016). Eco-Strategy: Towards a New Generation Managerial Model Based on Green IT and CSR. *arXiv:1605.03107 [cs]*.

Hussain, M., Awasthi, A., & Tiwari, M. K. (2016). Interpretive structural modeling-analytic network process integrated framework for evaluating sustainable supply chain management alternatives. *Applied Mathematical Modelling*, 40(5-6), 3671-3687. https://doi.org/10.1016/j.apm.2015.09.018

Jayant, A., & Azhar, M. (2014). Analysis of the Barriers for Implementing Green Supply Chain Management (GSCM) Practices: An Interpretive Structural Modeling (ISM) Approach. *Procedia Engineering*, *97*, 2157-2166. https://doi.org/10.1016/j.proeng.2014.12.459

Jia, F., Zuluaga-Cardona, L., Bailey, A., & Rueda, X. (2018). Sustainable supply chain management in developing countries: An analysis of the literature. *Journal of Cleaner Production*, 189, 263-278. https://doi.org/10.1016/j.jclepro.2018.03.248

Jia, P., Diabat, A., & Mathiyazhagan, K. (2015). Analyzing the SSCM practices in the mining and mineral industry by ISM approach. *Resources Policy*, 46, 76-85. https://doi.org/10.1016/j.resourpol.2014.04.004

Karlsson, M., & Pigretti Öhman, D. (2005). Material consumption in the healthcare sector: Strategies to reduce its impact on climate change—the case of Region Scania in South Sweden. *Journal of Cleaner Production*, 13(10-11), 1071-1081. https://doi.org/10.1016/j.jclepro.2004.12.012

Khan, M., Hussain, M., Gunasekaran, A., Ajmal, M. M., & Helo, P. T. (2018). Motivators of social sustainability in healthcare supply chains in the UAE—Stakeholder perspective. *Sustainable Production and Consumption*, 14, 95-104. https://doi.org/10.1016/j.spc.2018.01.006

Kimaro, H., & Nhampossa, J. (2007). The challenges of sustainability of health information systems in developing countries: comparative case studies of Mozambique and Tanzania. *Journal of Health Informatics in Developing Countries*, 1(1).

Lega, F., Prenestini, A., & Spurgeon, P. (2013). Is Management Essential to Improving the Performance and Sustainability of Health Care Systems and Organizations? A Systematic Review and a Roadmap for Future Studies. *Value in Health*, 16(1), S46-S51. https://doi.org/10.1016/j.jval.2012.10.004

Luthra, S., & Haleem, A. (2015). Hurdles in Implementing Sustainable Supply Chain Management: An Analysis of Indian Automobile Sector. *Procedia - Social and Behavioral Sciences*, 189, 175-183. https://doi.org/10.1016/j.sbspro.2015.03.212

Luthra, S., Kumar, S., Garg, D., & Haleem, A. (2015). Barriers to renewable/sustainable energy technologies adoption: Indian perspective. *Renewable and Sustainable Energy Reviews*, 41, 762-776. https://doi.org/10.1016/j.rser.2014.08.077

Luthra, S., Mangla, S. K., Xu, L., & Diabat, A. (2016). Using AHP to evaluate barriers in adopting sustainable consumption and production initiatives in a supply chain. *International Journal of Production Economics*, 181, 342-349. https://doi.org/10.1016/j.ijpe.2016.04.001

Malik, M. M., Abdallah, S., & Hussain, M. (2016). Assessing supplier environmental performance: Applying Analytical Hierarchical Process in the United Arab Emirates healthcare chain. *Renewable and Sustainable Energy Reviews*, 55, 1313-1321. https://doi.org/10.1016/j.rser.2015.05.004

Mathiyazhagan, K., Govindan, K., NoorulHaq, A., & Geng, Y. (2013). An ISM approach for the barrier analysis in implementing green supply chain management. *Journal of Cleaner Production*, 47, 283-297. https://doi.org/10.1016/j.jclepro.2012.10.042

Mathiyazhagan, K., Haq, A. N., Mohapatra, A., & Srinivasan, P. (2017). Application of structural equation modelling to evaluate the barrier relationship for green supply chain management implementation. *International Journal of Business Performance and Supply Chain Modelling*, 9(2), 87-116. https://doi.org/10.1504/IJBPSCM.2017.085487

Meath, C., Linnenluecke, M., & Griffiths, A. (2016). Barriers and motivators to the adoption of energy savings measures for small- and medium-sized enterprises (SMEs): the case of the ClimateSmart Business Cluster program. *Journal of Cleaner Production*, 112, 3597-3604. https://doi.org/10.1016/j.jclepro.2015.08.085

Moktadir, M. A., Ali, S. M., Rajesh, R., & Paul, S. K. (2018). Modeling the interrelationships among barriers to sustainable supply chain management in leather industry. *Journal of Cleaner Production*, 181, 631-651. https://doi.org/10.1016/j.jclepro.2018.01.245

Morali, O., & Searcy, C. (2013). A Review of Sustainable Supply Chain Management Practices in Canada. *Journal of Business Ethics*, 117(3), 635-658. https://doi.org/10.1007/s10551-012-1539-4

Nemathaga, F., Maringa, S., & Chimuka, L. (2008). Hospital solid waste management practices in Limpopo Province, South Africa: A case study of two hospitals. *Waste Management*, 28(7), 1236-1245. https://doi.org/10.1016/j.wasman.2007.03.033

Norazlan, A. N. I., Roslan, M. H., Habidin, N. F., & Zainudin, M. Z. (2014). The Development of Sustainable Supply Chain Management and Sustainable Performance in Malaysian Healthcare Industry. *International Journal of Ethics in Engineering & Management Education*, 1(2), 51-55.

Pasqualini Blass, A., da Costa, S. E. G., de Lima, E. P., & Borges, L. A. (2017). Measuring environmental performance in hospitals: A practical approach. *Journal of Cleaner Production*, 142, 279-289. https://doi.org/10.1016/j.jclepro.2016.07.213

Pasqualini Blass, A., Gouvea da Costa, S. E., Pinheiro de Lima, E., & Borges, L. A. (2016). Measuring environmental performance in hospitals: a framework and process. *Measuring Business Excellence*, 20(2), 52-64. https://doi.org/10.1108/MBE-03-2015-0011

Patil, G. V., & Pokhrel, K. (2005). Biomedical solid waste management in an Indian hospital: a case study. *Waste Management*, 25(6), 592-599. https://doi.org/10.1016/j.wasman.2004.07.011

Podein, R. J., & Hernke, M. T. (2010). Integrating Sustainability and Health Care. *Primary Care: Clinics in Office Practice*, 37(1), 137-147. https://doi.org/10.1016/j.pop.2009.09.011

Silvestre, B. S., Monteiro, M. S., Viana, F. L. E., & de Sousa-Filho, J. M. (2018). Challenges for sustainable supply chain management: When stakeholder collaboration becomes conducive to corruption. *Journal of Cleaner Production*, 194, 766-776. https://doi.org/10.1016/j.jclepro.2018.05.127

Slawinski, N., & Bansal, P. (2011). Managing the Time Paradox in Business Sustainability. *Academy of Management Proceedings*, 2011(1), 1-6. https://doi.org/10.5465/AMBPP.2011.65870485

Unger, S., & Landis, A. (2016). Assessing the environmental, human health, and economic impacts of reprocessed medical devices in a Phoenix hospital's supply chain. *Journal of Cleaner Production*, 112, *Part 3*, 1995-2003. https://doi.org/10.1016/j.jclepro.2015.07.144

Warfield, J. N. (1974). Developing Interconnection Matrices in Structural Modeling. *IEEE Transactions on Systems, Man, and Cybernetics, SMC*, 4(1), 81-87. https://doi.org/10.1109/TSMC.1974.5408524

Yoon, S. N., Lee, D., & Schniederjans, M. (2016). Effects of innovation leadership and supply chain innovation on supply chain efficiency: Focusing on hospital size. *Technological Forecasting and Social Change*, 113, 412-421. https://doi.org/10.1016/j.techfore.2016.07.015

Zhu, Q., & Geng, Y. (2013). Drivers and barriers of extended supply chain practices for energy saving and emission reduction among Chinese manufacturers. *Journal of Cleaner Production*, 40, 6-12. https://doi.org/10.1016/j.jclepro.2010.09.017

Annex 1

.

Title of research:
Analysis of the barriers of implementing sustainable supply chain management in healthcare centers using interpretive structural modeling (ISM)
Please complete the following details.
1- Sex: Male □ Female □
2. Education: Associate degree □ Bachelor's degree □ Master's Degree and higher □
3. Work experience: less than 5 years □ 5 to 10 year's □ 11 to 15 year's □ over 16 year's □

Use the following four symbols to determine the relationship between two obstacles

	This means A is a prerequisite for B (A → B)
	This means that A is a follower of B (B → A)
	This meant A and B are co-requisite. A and B give output and input to each other (A↔B)
	This means A and B are irrelevant. Neither A, nor B do not give input to each other.

A \ B		1 Political instability	2 Lack of sustainability standards and appropriate regulations	3 Lack of top management commitment to initiate sustainability efforts	4 Organizational culture resistance to change	5 Lack of IT implementation	6 Lack of collection and analysis for data of material/energy flow	7 Lack of technology and infrastructure readiness	8 lack of skilled human resources	9 Lack of knowledge among SC members	10 Lack of an institutional support for integration, coordination and communication	11 Unawareness among society about social practices	12 Lack of trust among SC members	13 Lack of knowledge among stakeholders about sustainable products and sustainability	14 Lack of government support to adopt environmental friendly policies	15 lack of support from patients
1	Political instability															
2	Lack of sustainability standards and appropriate regulations															
3	Lack of top management commitment to initiate sustainability efforts															
4	Organizational culture resistance to change															
5	Lack of IT implementation															
6	Lack of collection and analysis for data of material/energy flow															
7	Lack of technology and infrastructure readiness															
8	lack of skilled human resources															
9	Lack of knowledge among SC members															
10	Lack of an institutional support for integration, coordination and communication															
11	Unawareness among society about social practices															
12	Lack of trust among SC members															
13	Lack of knowledge among stakeholders about sustainable products and sustainability															
14	Lack of government support to adopt environmental friendly policies															
15	lack of support from patients															