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Research Paper

Prioritize the Dimensions of Agile Hospital Supply Chain with Combination of Interpretive Structural Modeling and Analytic Network Process

Alireza Hatam Siahkal Mahalle[1*], Mohammad Reza Mehregan[2], Shahrokh Yousefzadeh[3]

1. Department of Management, Economic and Accounting, Payam-e Noor University, Tehran, Iran.
2. Department of Management, School of Management, University of Tehran, Tehran, Iran.
3. Department of Neurosurgery, School of Medical, Guilan Road Trauma Researches Center, Guilan University of Medical Science, Rasht, Iran.

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Running Title Dimension of Agile Hospital Supply Chain

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ABSTRACT

Background: Hospital Supply Chain Management (SCM) agility requires finding the main and effective dimensions, prioritizing, communicating between them and analyzing these dimensions in relation to each other.

Objectives: The purpose of this study was to identify different dimensions of the hospital SCM agility, proposing a model of the hospital SCM agility and determining the relationships between dimensions of agility, and prioritizing, analyzing, and interpreting dimensions of the hospital SCM agility.

Materials & Methods: This cross-sectional study was performed on the physicians, nurses and staff working at public hospitals affiliated to Guilan University of Medical Sciences. Delphi technique was used to determine the dimensions of agility, interpretive-structural modeling approach was used for analysis. Network analysis was used to prioritize the dimensions of agility.

Results: In the literature review 16 dimensions of agility were identified. The final model of agile supply chain management has 8 levels; cost reduction placed at the highest level and organizational leadership commitment was at the lowest level. Cost reduction dimensions were the highest priority and organizational culture was the lowest priority in the final network analysis.

Conclusion: Agile supply chain management has very important and complex elements. Neglecting to monitor their changes can cause irreparable and profound damage to the medical sector. Interpretive-structural approach and network analysis create a constructive and effective method to model, analyze, and prioritize the dimensions of agile supply chain management.

Keywords: Supply chain management, Agility, Interpretive-structural modeling, Delphi Techniques, Analystic network process

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*** Corresponding Author:**
Alireza Hatam Siahkal Mahalle, PhD.
Address: *Department of Management, Economic and Accounting, Payam-e Noor University, Tehran, Iran.*
Tel: *+98 (936) 4141430*
E-mail: *alireza.hatam.ha@ut.ac.ir*

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1. Introduction

The healthcare industry is now faced with different challenges such as the growing competition, technological innovation, changes in the market environment, and customer demand. In addition, the most important obstacles to the improvement of performance and profitability in medical centers are the increased prices of hospital services, slow data supply in the chain, low quality of supply chain inputs, supply chain intermediation, and increasing patient expectations of quality in hospital services [1]. The diversity of service options, joint venture opportunities, high-quality initiatives, and constant emphasis on service quality improvement have caused substantial developments in the performance of healthcare providers [2].

Recently, the healthcare industry has also been faced with other challenges such as the increased patient expectations, growing competition between medical centers for the attraction of more patients, and the supply of better health and medical services [3]. Many studies have recently analyzed the effects of hospital Supply Chain Management (SCM) on the performance of medical centers and the quality of services [4]. Oliver and Weber (1982) introduced the concept of SCM [5], which refers to the process of integrating the activities in a chain through improved relations in order to achieve competitive advantages. It is also defined as the integration of organizational units along the supply chain and the flow of materials, information, and financial data to meet customer demand and improve competitiveness [6]. When companies and organizations work with their partners, the SCM helps them meet the unpredictable demand of end-users [7, 8]. The accelerated growth and recent challenges in the healthcare industry necessitate adopting novel approaches that help companies and organizations respond to the customer needs more quickly and agilely. The term "agility" means the ability to move quickly and think boldly and cleverly [9]. The supply chain agility is a novel concept on which many organizations and companies have recently focused and used as a way of responding more quickly to the changing business environment and improve the quality of their services. Technically speaking, agility refers to any responses to the high levels of complexity and uncertainty in advanced markets [10].

According to Naylor et al., agility means the use of market knowledge to take advantage of profitable opportunities in a rapidly changing market. The supply chain agility is a concept that aims to boost the ability of a manufacture or service system to respond to customer demand more quickly [11].

The uncertainty of medical processes and activities would require the healthcare industry to improve its agility to adapt to ever-changing and new situations [12]. As a result, researchers have been motivated to identify the factors affecting the supply chain agility to provide the necessary conditions for the establishment of systems in healthcare organizations. Hence, such organizations can achieve higher levels of flexibility to respond to environmental conditions and act as a dynamic network of members, the structure of which successively changes with environmental changes [13]. An agile supply chain can increase the loyalty and satisfaction of medical staff and also retain and motivate the staff to provide better services for patients. This process finally increases the revenues of hospitals and medical centers [14, 15]. Public hospitals, which are directly managed by governments, especially in developing countries, usually fail to perform as expected, and internal management reforms have shown ineffective measures to improve the performance of such hospitals and medical centers [16]. Since there are complex relationships between dimensions and processes affecting the agility of supply chains, it is essential to develop a systematic method for determining the relationships and weight dimensions in a multiple network within the supply chain. For this purpose, certain models should be developed to structure this complexity and then examine the relationships between dimensions of the supply chain. Interpretive Structural Modeling (ISM) is a method for exploring relationship among items in a system, especially economic and social systems. First introduced by Warfield, ISM employs mathematics, computer science, and expert views to design large and complex systems [17].

Based on some concepts and principles of the graph theory, ISM structures and describes the complex patterns of conceptual relationships between a set of interrelated variables and factors in an organized comprehensive model [18]. Developed by Saaty in 1971, the Analytical Network Process (ANP) aims to structure the decision-making process based on a scenario resulting from multiple interdependent factors. It is impossible to organize many decision-making issues in a hierarchy, for they are subject to the dependence or interaction of higher-level and lower-level elements. Furthermore, a hierarchical system has a linear top-down structure, whereas a network extends in all directions [17]. Many studies have identified and ranked the factors affecting the agility of a supply chain and proposed an ISM-based model of hospital SCM agility [19-24]. Considering the

diversity of medical staff working in hospitals and medical centers as well as the existing research limitations, this study adopts ISM to identify and analyze different dimensions of the hospital SCM agility and then prioritize them through the ANP. Therefore, the main objectives of this study are as follows: 1- identifying different dimensions of the hospital SCM agility, 2-proposing a model of the hospital SCM agility and determining the relationships between dimensions of agility, and 3- prioritizing, analyzing, and interpreting dimensions of the hospital SCM agility. The significance of this study lies in the multilevel and complex relationships between different dimensions of the hospital SCM agility.

2. Materials and Methods

This mixed-methods research employed ISM and ANP to propose a hospital SCM agility model and also prioritize its different dimensions. The statistical population consisted of all physicians, nurses, and other medical staff working in public hospitals of Rasht, Iran within the 2020–2021 period. In the qualitative section, keywords such as supply chain management, agile supply chain management, agility, hospital agile supply chain, dimensions of supply chain management, and dimensions of the hospital supply chain were searched on reputable scientific databases, e.g., ScienceDirect, PubMed, ResearchGate, ProQuest, Google Scholar, and SID to identify and extract the dimensions of the hospital SCM agility. A total of 45 papers were extracted in the initial search. Due to the multiplicity of dimensions of the hospital SCM agility, the most important dimensions of agility were extracted and summarized after the elicitation of views and suggestions presented by professors of the Department of Management, University of Tehran, and Guilan University of Medical Sciences on agile SCM and hospital SCM agility (Table 1).

The Delphi technique was then adopted to achieve a consensus on the views and comments of experts regarding the extracted dimensions. The expert panel members were selected from the following groups through snow-

Table 1. Dimensions of hospital supply chain agility

Row	Dimensions of Hospital Supply Chain Agility	References
1	Productivity	[2, 25-27]
2	Patient satisfaction and understanding	[2, 28-33]
3	Development of human resources and training of staff skills	[2, 28, 32, 34]
4	Quality management of services and continuous improvement	[2, 28, 29, 32, 35]
5	Human resource management and staff satisfaction	[2, 25-27, 34]
6	Acceptance of new technology and presentation of new ideas	[2, 25-27, 29, 32, 35]
7	Commitment of the organization leadership	[2, 25-27, 36, 37]
8	Strategic planning	[2, 25-27, 32, 38]
9	Knowledge management	[39-42]
10	Organizational Culture	[2, 25, 36, 37]
11	Development of organizational communication and integration of information management	[2, 28, 29, 30, 35, 46]
12	Process management, process integration and organizational transformation	[28, 31, 32, 35, 43]
13	reduction in costs	[28, 29, 32, 43, 44]
14	Monitoring, demand response and market sensitivity	[25, 28, 29, 32, 34, 35, 38, 45]
15	Speed in providing services	[25, 28, 29, 35, 38, 43, 45]
16	flexibility	[25, 28, 34, 38, 44, 45]

ball sampling: 1- Physicians, nurses, and other medical staff working in public hospitals of Rasht, Iran, with at least 5 years of experience in strategic and educational departments of Guilan University of Medical Sciences, 2- Professors of Guilan University of Medical Sciences, 3- Hospital managers with more than 10 years of experience, and 4- Researchers working on the research subject at Guilan University of Medical Sciences. An electronic questionnaire of the selected dimensions of agility was then developed and sent to members of the expert panel to evaluate their performance. The items of this questionnaire were scored on a 5-point Likert scale (5: very great importance, 4: great importance, 3: moderate importance, 2: low importance, and 1: very low importance). After the expert panel members were selected, the Delphi technique was repeated three times to achieve a consensus of experts. The questionnaires were distributed and collected electronically in each round. In the first round, the expert panel was asked to weight the dimensions of the hospital SCM agility extracted from the literature. In the second round, the views and comments of the expert panel were collected, and the required corrections were made. In the third round, the expert panel was asked once again to review the dimensions of the hospital SCM agility and provide their relevant comments. The Delphi technique was discontinued after the desired consensus was achieved in the third round. To determine the degree of consensus between members of the expert panel, Kendall's coefficient of concordance was calculated for the views and comments of the expert panel in the third round. There were 35 members in the expert panel (N=35), and Kendall's coefficient of concordance was reported 0.619 at an error level below 0.01. Given the size of Delphi panel was 10, Kendall's coefficient=0.619 was significant [39].

Before the implementation of ISM, a panel of 15 experts was asked to determine the effects of variables on each other based on a 4-point scale (0: no effect, 1: small effect, 2: moderate effect, 3: great effect). A questionnaire consisting 16×16 matrix dimensions of hospital SCM agility was developed and distributed among the experts. In addition, a master of human resources management (HRM) briefed the experts on how to fill out the questionnaire. The experts could complete the questionnaire anonymously, and they were also assured that all of their information would be kept confidential. A cross-effect matrix questionnaire was employed to determine the effects of variables on each other based on the views of the expert panel. For this purpose, 15 experts from Guilan University of Medical Sciences, who were experienced in hospital management, were selected as the members of the expert panel. The results related to agility dimensions were then analyzed in MicMac, an efficient interpretive-structural analysis system that determines the relationships between variables and factors and provides a graph of their causal relationships. It also determines the indirect effects of variables and factors and, finally, categorizes them based on their effects or dependence [47]. To perform the ANP in this study, 15 experts were asked to complete the questionnaires related to the objective-centered ranking of dimensions and the dimension-centered ranking of dimensions (a network of relationships). The dimensions of the SCM agility were then prioritized in the following step: 1- model development and problem structuring through ISM, 2- development of a pairwise comparison matrix (PCM) and priority vectors for which the experts were asked to rank the dimensions of SCM agility based on a 9-point scale from 1: lowest importance to 9: highest importance, 3- development of a supermatrix, which can restrict the coefficients to calculate all priorities and thus the interactive cumulative effect of each factor on others), and 4- prioritization of the hospital SCM agility dimensions. All these steps were performed in SuperDecisions-3.2.

3. Results

The expert panel consisted of 35 members; 24 (68.6%) were male and 11 (31.4%) were female. Regarding to the age group 8, 15, and 12 members of the expert panel were aged 31–40, 41–50, and over 50 years, respectively. In terms of educational attainment, 15 members (42.9%) were specialists, whereas and 8 members (12.9%) were physicians. Moreover, 5 (14.3%), 6 (17.1%), and 1 (2.9%) members had PhDs, master's degrees, and a bachelor's degree, respectively. All participants were working in the staff, executive, and medical departments of Guilan University of Medical Sciences. A cross-effect matrix questionnaire was used to determine the mutual effects of variables based on the views of 15 expert panel. Table 2 presents the cumulative cross-effect matrix for a panel of 15 experts. In this matrix, each factor in a row can affect another factor in a column. The numbers represent the sum of the scores given by the experts based on a 4-point scale from 0 to 3.

Bolanos et al. [48] compared the figures in the table of the previous step on a single numerical scale to find the scale number in the initial access matrix. The scale number was calculated using the formula M=2×n, where n denotes the number of respondents, and M represents the scale number, which was obtained 30. If the corresponding number in the table is larger than the scale

Table 2. Cumulative cross-effects matrix (n=15)

Interpretive-structural Modeling	Commitment of the Organization Leadership	Development of Human Resources and Training of Staff Skills	Human Resource Management and Staff Satisfaction	Process Management, Process Integration and Organizational Transformation	Strategic Planning	Organizational Culture	Knowledge Management	Flexibility	Quality Management of Services and Continuous Improvement	Acceptance of New Technology and Presentation of New Ideas	Speed In Providing Services	Development of Organizational Communication and Integration of Information Management	Monitoring, Demand Response and Market Sensitivity	Patient Satisfaction and Understanding	Productivity	Reduction in Costs
Commitment of the organization leadership	0	30	31	30	33	32	25	40	31	42	31	26	24	30	32	28
Development of human resources and training of staff skills	15	0	20	33	40	28	24	35	40	32	30	35	31	35	33	32
Human resource management and staff satisfaction	20	32	0	15	17	15	20	40	31	42	31	35	40	32	35	35
Process management, process integration and organizational transformation	15	32	31	0	35	25	20	40	30	26	42	35	31	34	36	30
Strategic planning	16	42	43	35	0	33	25	38	31	30	40	38	36	42	43	31
Organizational Culture	15	18	20	25	23	0	21	32	31	25	36	18	16	35	19	20
Knowledge management	16	18	15	16	15	16	0	17	20	21	25	18	19	20	18	20
Flexibility	19	42	42	32	43	23	21	0	35	40	42	41	35	30	31	34
Quality management of services and continuous improvement	17	16	16	18	20	32	20	38	0	18	32	36	41	42	36	31
Acceptance of new technology and presentation of new ideas	20	18	18	16	35	18	18	42	32	0	41	35	32	42	30	31
Speed in providing services	21	20	21	20	35	20	22	32	42	30	0	35	30	32	42	30
Development of organizational communication and integration of information management	25	24	19	24	20	24	25	42	35	25	40	0	41	35	30	31
Monitoring, demand response and market sensitivity	18	17	20	23	21	17	16	32	35	26	42	35	0	35	40	42
Patient satisfaction and understanding	19	19	23	22	16	22	20	41	36	41	42	36	31	0	43	35
Productivity	20	21	25	17	18	21	18	19	17	20	21	25	18	19	0	42
Reduction in costs	18	16	18	16	19	17	16	16	19	17	20	21	25	18	19	0

Table 3. Final access matrix after calculating the scale number

Interpretive-structural modeling	Dimensions Code	Commitment of the Organization Leadership	Development of Human Resources and Training of Staff Skills	Human Resource Management and Staff Satisfaction	Process Management, Process Integration and Organizational Transformation	Strategic Planning	Organizational Culture	Knowledge Management	Flexibility	Quality Management of Services and Continuous Improvement	Acceptance of New Technology and Presentation of New Ideas	Speed in Providing Services	Development of Organizational Communication and Integration of Information Management	Monitoring, Demand Response and Market Sensitivity	Patient Satisfaction and Understanding	Productivity	Reduction in costs
Dimensions code		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Commitment of the organization leadership	A	0	1	1	1	1	1	0	1	1	1	1	0	0	1	1	0
Development of human resources and training of staff skills	B	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1
Human resource management and staff satisfaction	C	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Process management, process integration and organizational transformation	D	0	1	1	0	1	0	0	1	1	0	1	1	1	1	1	1
Strategic planning	E	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1
Organizational Culture	F	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0
Knowledge management	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flexibility	H	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1
Quality management of services and continuous improvement	I	0	0	0	0	0	1	0	1	0	0	1	1	1	1	1	1
Acceptance of new technology and presentation of new ideas	J	0	0	0	0	1	0	0	1	1	0	1	1	1	1	1	1
Speed in providing services	K	0	0	0	0	1	0	0	1	1	1	0	1	1	1	1	1
Development of organizational communication and integration of information management	L	0	0	0	0	0	0	0	1	1	0	1	0	1	1	1	1
Monitoring, demand response and market sensitivity	M	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1
Patient satisfaction and understanding	N	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1
Productivity	O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Reduction in Costs	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4. classification of the access matrix

Row	Dimensions	Output Set	Input set	Joint Set	Level
1	reduction in costs		B,C,D,E,H,I,J,K,L,M,N,O		1
2	Productivity		A,B,C,D,E,H,I,J,K,L,M,N		2
3	flexibility	B,C,D,E,I,J,K,L,M,N	A,B,C,D,E,F,I,J,K,L,M,N	B,C,D,E,I,J,K,L,M,N	3
3	Quality management of services and continuous improvement	F,H,K,L,M,N	A,B,C,D,E,F,H,J,K,L,M,N	F,H,K,L,M,N	3
3	Speed in providing services	E,H,I,J,L,M,N	A,B,C,D,E,F,H,I,J,L,M,N	E,H,I,J,L,M,N	3
3	Development of organizational communication and integration of information management	H,I,K,M,N	B,C,D,E,H,I,J,K,M,N	H,I,K,M,N	3
3	Monitoring, demand response and market sensitivity	H,I,K,L,N	B,C,D,E,H,I,J,K,L,N	H,I,K,L,N	3
4	Acceptance of new technology and presentation of new ideas	E,N	A,B,C,E,N	E,N	4
4	Patient satisfaction and understanding	J	A,B,C,D,E,F,J	J	4
5	Development of human resources and training of staff skills	D,E	A,C,D,E	D,E	5
5	Organizational Culture		A,E		5
6	Human resource management and staff satisfaction		A,D,E		6
7	Process management, process integration and organizational transformation	E	A,E	E	7
7	strategic planning	D	A,D	D	7
8	Commitment of the organization leadership	*****	*****	*****	8

number, the new cell in the table is filled with 1; otherwise, the cell is filled with 0. In fact, the scale number is the cutting point where values higher than or equal to the scale number are expressed by 1 and indicate the effects of row factors on the column factors. For example, the number 1 at the intersection of row A with column B, which is given a value of 30 in Table 2, is represented by number 1 in Table 3, considering the scale number (number 30), indicating the effect of organizational leadership commitment on human resource development and staff training. Table 3 demonstrates the finalized matrix.

To determine the relationships and classify the dimensions, it is necessary to extract a set of outputs and a set of inputs for each dimension of the matrix. The outputs include a dimension and the dimensions it affects, whereas the inputs include a dimension and other dimensions affecting it. The scale number indicates the effects of row variables on the column variables. The resultant sets are employed to classify the dimensions. The dimensions with similar sets of outputs and two-way relationships are placed at the top of the hierarchy. Table 4 demonstrates the classification of the access matrix. To determine the level of each dimension, the output set must be equal to the common set. For example, a common set was obtained in the fourth row by examining the commonality of the input and output dimensions. In fact, the fourth row was obtained due to the similarity of the output set (E, N) to the common set (E, N) in the fourth round.

Figure 1 indicates the final model of the hospital SCM agility. According to this model, lower levels should be considered a basis to achieve higher productivity and reduce costs in the eighth level. In other words, lower levels are the basis for achieving higher levels.

According to Figure 1, the final model of hospital SCM agility consisted of 8 levels; "cost reduction" and "leadership commitment" account for the highest level

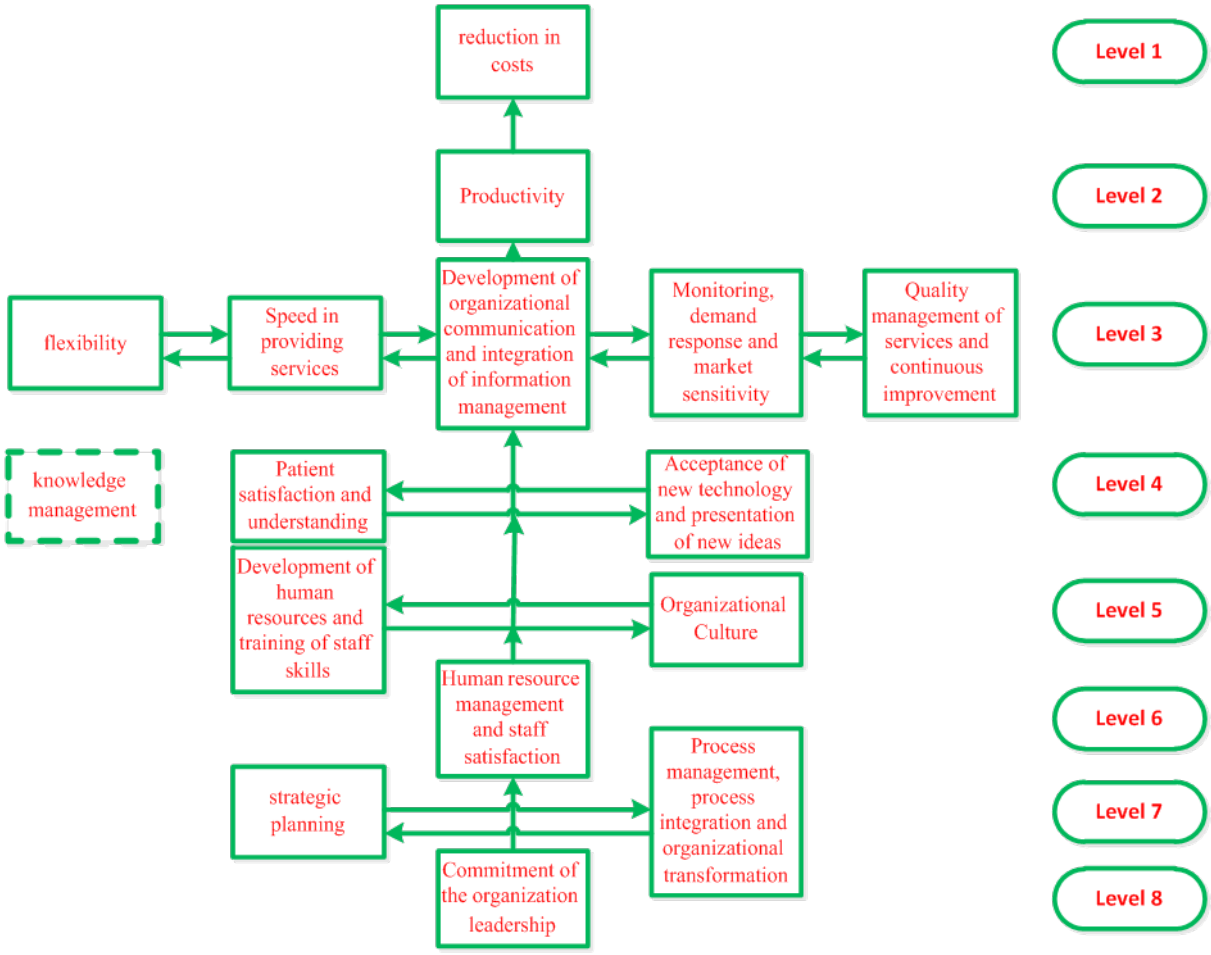

Figure 1. The final interpretive-structural model of agile hospital supply chain management

and the lowest level of this model, respectively. After leadership commitment", as the cornerstone of supply chain agility, "process management", "process integration", "organizational transformation", and "strategic planning", which interact with each other. The sixth level is occupied with "HRM and employee satisfaction", revealing the importance of HRM in the supply chain agility. Level 5 includes "organizational culture" and "human resource development and training", which emphasizes the major role of staff training and development as well as organizational culture in the hospital SCM agility. "Acceptance of new technology" and "patient satisfaction and understanding" make the fourth level. These two variables not only interact with each other but also emphasize the importance of customer satisfaction and new technology in the hospital SCM agility. The third level consists of "quality management", "development of organizational communication and integration of information management", "speed of service delivery", and "flexibility", which play major roles in improving the productivity and reducing the costs of hospitals. "Knowledge management" was added to the model separately because its independent nature restricts its interaction with other variables.

Finally, the ANP was employed to prioritize different dimensions of the hospital SCM agility. For this purpose, a hierarchical diagram of dimensions of hospital SCM agility was extracted from the ISM, and the relationships in this network were determined. The dimensions were then compared with the goal and to each other two by two (pairwise comparison). All these steps were performed in SuperDecisions-3.2. Figure 2 and Table 5 provide the hierarchical diagram as well as the ANP results of goal-centered prioritization and final prioritization.

According to Table 5, the internal relationships were not taken into account in the goal-centered prioritization of dimensions of the hospital SCM agility, although they were considered in the final prioritization of the dimensions. Known as the most common way of presenting the results, the normal column actually shows the priority of each option based on the pairwise comparison. The values of the ideal column are obtained by dividing each

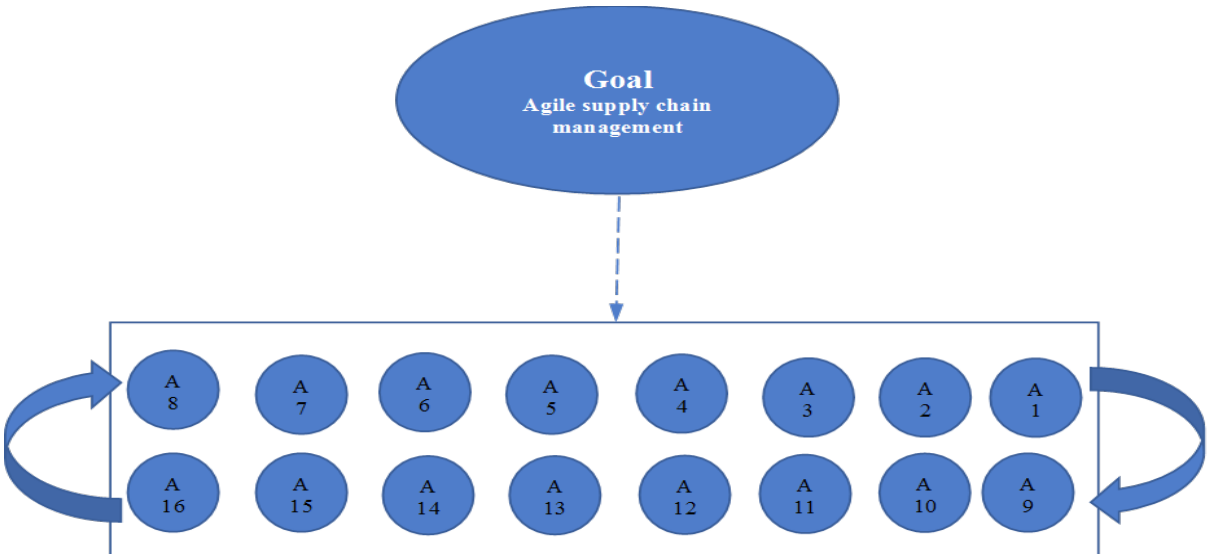

Figure 2. Hierarchical diagram and internal relations of agility dimensions of hospital supply chain

Table 5. Results of network analysis by prioritization of the goal and final prioritization of the network

Agile Hospital Supply Chain Management		Prioritization of the Goal		Final Prioritization of Network Analysis		
Dimensions of Hospital Supply Chain Agility		**Normalized**	**Ideal**	**Ideal**	**Normalized**	**Final rank**
Commitment of the organization leadership	A1	0.3153262	1	0	0	-
Development of human resources and training of staff skills	A2	0.0137518	0.0436113	0.046825	0.009991	13
Human resource management and staff satisfaction	A3	0.0130537	0.0413974	0.051468	0.010982	12
Process management, process integration and organizational transformation	A4	0.030625	0.0971217	0.067225	0.014344	11
strategic planning	A5	0.0570206	0.1808306	0.219846	0.046909	10
Organizational Culture	A6	0.0162924	0.0516683	0.011918	0.002543	14
knowledge management	A7	0.0108655	0.034458	0	0	-
flexibility	A8	0.1218528	0.386434	0.877523	0.18724	2
Quality management of services and continuous improvement	A9	0.0493926	0.1566395	0.239634	0.051131	8
Acceptance of new technology and presentation of new ideas	A10	0.0570807	0.1810211	0.206511	0.044064	9
Speed in providing services	A11	0.0678434	0.2151531	0.377152	0.080474	5
Development of organizational communication and integration of information management	A12	0.0591578	0.1876081	0.35531	0.075813	6
Monitoring, demand response and market sensitivity	A13	0.0695132	0.2204485	0.330385	0.070495	7
Patient satisfaction and understanding	A14	0.0763134	0.2420142	0.482793	0.103015	3
Productivity	A15	0.0218681	0.0693506	0.420044	0.089626	4
reduction in costs	A16	0.0200429	0.0635624	1	0.213373	1

value on the normal column by the largest value on this column. Accordingly, the selected option is always given a value of 1. The final ANP results indicated that "cost reduction", with a weight of 0.213373, and "organizational culture", with a weight of 0.002543, were ranked as the highest and the lowest priority, respectively.

4. Discussion

This study aimed to prioritize the dimensions of the SCM agility in public hospitals of Rasht, Iran, through the ISM and the ANP. For this purpose, the main dimensions of the hospital SCM agility were extracted from the research literature. The results indicate that "leadership commitment" underpins the hospital SCM agility. In fact, it is the leadership commitment and support that can underlie further agility of higher levels in an organization. The seventh level of the model proposed in this study consisted of "process management", "process integration", "organizational transformation", and "strategic planning". These variables not only interact with each other but also play major roles in SCM agility. Considering today's highly complex environment, it is necessary to provide a suitable platform for the implementation of agility programs in order to increase the hospital SCM agility. In other words, the optimization of processes in a hospital can provide conditions for the execution of agility plans. In addition, long-term and strategic planning can help organizations improve their agility and develop programs for their future. Hospitals and medical centers need to be completely intelligent and accurate in process optimization and strategic planning.

This is consistent with the findings of some previous studies that reported the great effects of appropriate strategic planning on the supply chain agility [18, 21]. The sixth level of the model consisted of "HRM and employee satisfaction". According to the results, it can be concluded that continuous training for employees is among the main prerequisites for the SCM agility. Appropriate HRM principles and methods can enhance the efficiency and effectiveness of employees, something which can ultimately improve organizational performance and productivity. The HRM can be generally defined as the art of appointing the right manpower to the right job. It also seeks to establish and maintain good internal relationships throughout an organization and its various managerial levels. A fair HRM system can increase the job satisfaction and organizational commitment of employees. Different studies have emphasized the role of ergonomic factors in the workplace in the effectiveness of hospitals and medical centers. A better understanding of biological and ergonomic factors can help us develop effective systems increase the quality of patient care and staff safety and welfare [49].

Various studies have indicated that many potential barriers to trust should be eliminated in order to improve the agility of supply chains. Therefore, the SCM is closely related to issues such as cooperation, satisfaction, trust, and organizational climate [18, 50, 51]. "Organizational culture" and "human resource development and training" were the variables in the fifth level. Human resources development is the process of modernizing knowledge and improving skills, attitudes, and understanding of employees in order to comply with the changing trends of the global economy and strengthen the abilities and performance of employees. It can generally be stated that "human resource development and training", as an activity and process, plays a key role in identifying the hidden capabilities of the hospital employees and developing their skills and technical knowledge in order to prepare them to face possible challenges. Organizational culture also plays a major role in this regard. The interactions of these variables pave the way for the development of other dimensions of agility at higher levels. In fact, a rich organizational culture can make it possible to achieve teamwork, creativity, proper communication, social and organizational functions, and organizational productivity [8, 52, 53]. The fourth level in the proposed model consisted of "acceptance of new technology and ideas" and "patient satisfaction and understanding". The acceptance of new technology and ideas regarding healthcare services and creativity in the delivery of services to patients can lead to patient satisfaction and understanding. In a hierarchical model of agility, recruitment and development of human resources, on the one hand, and appropriate strategic planning and facilitated processes, on the other hand, can improve agility and creativity in service delivery [8, 18, 21, 53].

The third level of the model consisted of "quality management", "development of organizational communication and integration of information management", "speed of service delivery", and "flexibility". The key to the success of SCM is the coordination and integration of all existing institutions and partners of a supply chain [54]. Different studies have shown that "service quality management" both affects and is affected by hospital SCM agility [55]. In line with the findings of this study, Raisidi (2020) demonstrated the role of flexibility in the supply chain agility [56]. The main challenge of healthcare services in the SCM is to improve the performance of hospitals and medical centers in the delivery of better services. Healthcare services supply chains are similar to supply chains in other sectors and industries in terms

of processes, customers, and managerial structures [57]. There is a clearly close relationship between information technology (IT) and e-business and the coordination and integration of operational processes. Many studies have corroborated the major role that IT plays in SCM practices [58, 59]. That is why many studies on the healthcare supply chain have focused on the role of e-commerce technologies in hospital SCM [60]. Consistent with the findings of this study, Vafaei et al. showed that computer-based technologies, flexibility, relationships with suppliers, application of modern technologies, partnerships, market sensitivity, and demand response were the seven variables that affected the hospital SCM agility and brought competitive advantages for hospitals and medical centers [61]. Moreover, Ashraf et al. reported a positive and significant correlation between e-government and organizational agility [62]. Studies have shown that the use of an SCM system can be among the main factors reducing costs [63].

After empowered human resources are recruited, it is necessary to provide facilities to improve agility, one of the most important of which is IT. Nowadays, it is necessary to use the Internet and electronic technologies instead of traditional means of communication and correspondence. Another item needed in this regard is the development of a system that quickly detects major changes. Flexibility or quick adaption to environmental conditions is another prerequisite to agility improvement. Since the integration of more processes in a supply chain can further improve its agility, the whole supply chain needs a comprehensive plan. Accordingly, all components of a supply chain should harmoniously move toward the goal and avoid any conflicts that might disrupt the process of responding to customer needs. This can ultimately boost productivity and mitigate costs, the two goals which are at the top of the proposed model [18, 21, 34, 35, 38, 39, 45]. "Knowledge management", known as the independent variable in this study, was not added to the model because it both affects and is affected by the hospital SCM agility very negligibly.

Different studies have shown the importance of knowledge management in the supply chain agility [26, 40-42]. In this study, the ANP was employed to prioritize different dimensions of agility. The results showed that "cost reduction" and "organizational culture" were ranked the first and the fourteenth, respectively. According to Table 5, the dimensions of the hospital SCM agility were prioritized first in terms of the goal. It was then finalized in general. The prioritization results indicated that "leadership commitment" was ranked first in goal-centered prioritization. Consistent with the ISM results, this finding indicates that leadership commitment is the cornerstone of hospital SCM agility. Previous studies have emphasized the role of leadership commitment in the supply chain agility [2, 27, 36, 39, 61]. Considering the internal relationships between agility dimensions, data analysis, and expert views, ANP showed that all the studied dimensions were of top priority for agility. Therefore, adequate attention to these dimensions can ensure the agility of hospital supply chains. Many studies corroborate the findings of this study [18, 26, 34, 60, 61]. "Knowledge management" obtained the rank zero in the final prioritization, something which is consistent with the findings of ISM. Many other studies have discussed the role of knowledge management in the supply chain agility [38, 39, 45].

The study findings can be applied by hospitals and medical centers that seek to achieve an agile supply chain in dynamic and complex environments. Although the supply chain agility has long been discussed in industries and service organizations, it has apparently been dealt with inadequately in hospitals and medical centers. The literature was reviewed in this study to identify the main dimensions of the SCM agility. Future studies are recommended to use factor analysis to identify the dimensions of the SCM agility. Recent global events such as the COVID-19 pandemic have emphasized the importance of the hospital SCM agility in responding quickly to future crises. Therefore, this study can be an effective step toward analyzing the resilience of the hospital supply chains at the time of different crises such as epidemics and pandemics. This study was conducted on public hospitals; future studies are recommended to analyze private hospitals and medical centers and compare their results with the findings of this study.

5. Conclusion

This study showed that an SCM agility model should be viewed from a systematic and comprehensive perspective. Agile supply chain management has very important and complex elements. Neglecting to monitor their changes can cause irreparable and profound damage to the medical sector. Interpretive-structural approach and network analysis create a constructive and effective method to model, analyze, and prioritize the dimensions of agile supply chain management

Ethical Considerations

Compliance with ethical guidelines

In this research, all ethical considerations, including the condition of trust and honesty, obtaining informed consent from the participants, and maintaining the confidentiality of the participants' identity information, were observed, and people were allowed to leave the study without harm or loss at any stage of the research.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

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